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8.0 WATER

8.1 Introduction

This chapter of the EIAR considers and assesses any potential effects on the surrounding hydrological and hydrogeological environment resulting from the Proposed Development, both the Mine Development and the further development of the Community Sports Complex.

The Mine Development includes the excavation at the Knocknacran West Open-Cast Mine, the restoration of the Knocknacran Open-Cast Mine and the continuation of use of the Knocknacran Processing Plant. It also includes the construction of a Cut-and-Cover Tunnel under R179 and a temporary diversion of the R179 during construction. To enable development of the Knocknacran West Open-Cast Mine, the demolition of one residential house and three unoccupied houses and sheds will also be required.

Mining activities have been ongoing since 1988 at the adjacent Knocknacran Open-Cast Mine and since 2007 at the underground Drummond Mine. The gypsum mined from Knocknacran West is a replacement for the gypsum currently mined from Knocknacran which will be exhausted by 2027. Knocknacran Open-Cast Mine will undergo closure and restoration once Knocknacran West Open-Cast is operational, Drummond Mine is currently permitted to continue until 2032.

All historical and current extraction activities at the Site have occurred beneath the water table. Groundwater entering the existing Drumgoosat underground workings (beneath the Knocknacran West site) is pumped from a borehole to a series of settlement ponds which drain through an oil interceptor prior to being discharged to an existing licenced receiving water discharge point on the River Bursk. Groundwater and surface water entering the existing Knocknacran Open-Cast Mine is pumped from a sump located on the existing pit floor and routed through the same settlement ponds, interceptor and discharge point. Groundwater from the adjacent operating underground Drummond Mine also passes through the same settlement ponds, interceptor and discharge point . The settlement ponds and interceptor are located within the Application Site. It is proposed to retain the existing permitted pumping, treatment and discharge system for the duration of this development.

8.2 Legislative and Policy Context

This section addresses the legislation and guidance that has been considered when preparing this chapter, and key policy context relevant to the water environment that has guided the focus of the assessment. The overarching EIA legislation under which this assessment is required is addressed separately in Chapter 2.0, Scope and Methodology.

8.2.1 Legislation and Guidance

In addition to the Regulations that underpin the Environmental Impact Assessment (EIA) process (see Chapter 2.0, Scope and Methodology), this assessment has been made with cognisance to relevant guidance, advice and legislation relating to the water environment, which have been used to steer the focus of the baseline information collection, the categorisation of receptor sensitivities, and the mitigation measures that have been included.

- The Local Government (Water Pollution) Act 1977 (as amended) and associated Statutory Instrument Regulations made under that Act outline the general prohibition of entry of polluting matter to water, the requirement to licence both trade and sewage effluent discharges, licencing of water abstractions, controlling discharges to aquifers, and notification of accidental damages;

- The European Union (EU) Water Framework Directive (WFD) (2000/60/EC) is the European legislation that establishes a framework for the protection of groundwater and surface water, including the establishment of river basin districts, the requirement to prevent further deterioration by preventing or limiting inputs of pollutants into groundwater, reducing pollution and promoting sustainable water use. The Groundwater Daughter Directive (GWDD) (2006/118/EC) sits beneath the WFD and relates to water protection and management. It establishes measures to prevent and control groundwater pollution, including criteria for assessing good chemical status and identifying trends; and
- The WFD and GWDD has been transposed into Irish law by means of many Regulations. These Regulations cover governance, the shape of the WFD characterisation, monitoring and status assessment programmes in terms of assigning responsibilities for the monitoring of different water categories, determining the quality elements and undertaking the characterisation and classification assessments. They include, but are not limited to, the following:

  - European Communities (Water Policy) Regulations 2003 and its subsequent amendments;
  - European Communities Environmental Objectives (Surface Waters) Regulations, 2009 and its subsequent amendments;
  - European Communities Environmental Objectives (Groundwater) Regulations, 2010 and its subsequent amendments; and
  - European Communities (Technical Specifications for the Chemical Analysis and Monitoring of Water Status) Regulations 2011.

Many of these regulations contain threshold values or environmental quality standards which, when exceeded, can reflect a degradation in water quality. A degradation in water quality can be reflective of negative effects caused by the development, but it should be noted that a poor water quality can be naturally occurring due to the environmental setting.

- The EU Directive on the Assessment and Management of Flood Risks (2007/60/EC) is transposed into Irish law by the European Communities (Assessment and Management of Flood Risks) Regulations 2010 and its subsequent amendment. The aim of the legislation is to reduce the adverse consequences of flooding on human health and the environment, and it outlines the requirements for flood risk assessments to be completed as part of the planning process.

Guidance relating to the EIA process that has been used to guide the assessment of potential impacts to the water environment and the identification of relevant mitigation include:

- Environmental Protection Agency Ireland (EPA) Advice Notes for Preparing Environmental Impact Statements (Draft, September 2015);

- EPA Guidelines on the Information to be Contained in Environmental Impact Assessment Reports, Environmental Protection Agency (2022);

- Department of Housing, Planning and Local Government Guidelines for Planning Authorities and An Bord Pleanála on carrying out Environmental Impact Assessment (August 2018);

- Land contamination risk management (LCRM) (October 2020), formerly Contaminated Land Report (CLR) 11 Model Procedures for the Management of Contaminated Land (2004), which presents guidance on the management of land contamination and the risk assessment needed to estimate its severity. The guidance details the concept of source-pathway-receptor linkages and the use of generic assessment criteria that are used in this assessment;

- National Roads Authority (NRA) Guidelines on Procedures for Assessment and Treatment of Geology, Hydrology and Hydrogeology for National Road Schemes (2009) in relation to aspects to be considered and assessment approach (including relative receptor importance and cross discipline interactions);
- NRA Guidelines for the Creation, Implementation and Maintenance of an Environmental Operating Plan (2007) in relation to impact mitigation;
- Institute of Geologists of Ireland (IGI) Guidelines for the Preparation of Soils, Geology and Hydrogeology Chapters of Environmental Impact Statements (2013);
- CIRIA C532: Control of water pollution from construction sites. Guidance for consultants and contractors (2001);
- CIRIA C741: Environmental Good Practice on Site (2015, Fourth Edition) in relation to source of impact and mitigation;
- CIRIA C750: Groundwater control – design and practice (2016, Second Edition);
- Scottish and Northern Irish Pollution Prevention Guidelines (PPGs) and Guidance for Pollution Prevention (GPPs) – these, although not Irish guidance, provide environmental good practice guidance for activities such as oil and chemical storage, works in or near water, works on construction sites, and dealing with spills and pollution incidents; and
- 3rd Cycle Draft Newry, Fane, Glyde and Dee Catchment Report (HA 06), Catchment Science & Management Unit, EPA (August 2021). A summary report of the water quality assessments for the catchments.

8.2.2 National and Local Policy

The National Planning Framework (Project Ireland 2040) includes National Policy Objective 60 to “Conserve and enhance the rich qualities of natural and cultural heritage of Ireland in a manner appropriate to their significance”.

At a national level, the River Basin Management Plan (RBMP) for Ireland 2018-2021 (Department of Housing, Planning and Local Government, 2018) outlines the measures that will be taken to improve the water quality in Ireland’s groundwater and surface water. This plan focuses on the following priorities:

- Ensuring compliance with relevant EU legislation;
- Preventing deterioration;
- Meeting the objectives for designated protected areas;
- Protecting high-status waters; and,

- Implementing targeted actions and pilot schemes in focused sub-catchments aimed at targeting waterbodies close to meeting their objectives and addressing more complex issues that will build knowledge for the next cycle in the RBMP.

The draft River Basin Management Plan 2022 -2027 is under public consultation at the time of writing of this EIAR and has not yet been implemented but has been considered within the EIAR.

The Monaghan County Council Development Plan 2019-2025 has incorporated the relevant policies and objectives for the area. The eastern side of the existing Knocknacran Open-Cast Mine and the eastern side of the proposed Knocknacran West Open-Cast Mine site are noted as being within the 'Rural Area Under Strong Urban Influence' for Carrickmacross. Specific policies relating to the protection of the water environment and management of surface water and groundwater include the following in the Development Plan:

- WPP 1: In assessing applications for developments, the Council will consider the impact on the quality of surface waters and will have regard to targets and measures set out in the River Basin Management Plan for Ireland 2018-2021 and any subsequent local or regional plans.

- WPP 2: In assessing applications for development, the planning authority shall ensure compliance with the European Communities Environmental Objectives (Surface Waters) Regulations, 2009 (S.I. No 272 of 2009) and the European Communities Environmental Objectives (Groundwater Regulations, 2010 (S.I. No. 9 of 2010).

- WPP 3: To protect known and potential groundwater reserves in the county. In assessing applications for developments, the planning authority will consider the impact on the quality of water reserves and will have regard to the recommended approach in the Groundwater Protection Response Schemes published by GSI. The employment of the methodology identified in the 'Groundwater Protection Scheme Reports for County Monaghan public supply sources' (available at www.gsi.ie) and 'Guidance on the Authorisation of Discharges to Groundwater' (available at www.epa.ie) will be required where appropriate.

- WPP 4: To require submission of a water protection plan and detailed site drainage plans with all planning applications. Maps of sensitive areas waters, a Water Protection Plan Checklist (Appendix 7) and latest waterbody status information at www.catchments.ie will assist in the preparation of plans at application stage.

- WPP 16: To support the implementation of the relevant recommendations and measures as outlined in the relevant River Basin Management Plan, and associated Programmes of Measures, or any such plans that may supersede same during the lifetime of the plan. Proposals for development should not have an unacceptable impact on the water environment, including surface waters, groundwater quality and quantity, river corridors and associated woodlands. Also, to have cognisance of, where relevant, the EU's Common Implementation Strategy Guidance Document No. 20 which provides guidance on exemptions to the environmental objectives of the Water Framework Directive.

- EIP1: To require all applications for extractive development to submit the following as part of the planning applications;

d) Details of water courses, water table depth and hydrological impacts, natural and cultural heritage impacts, traffic impact and waste management.

8.3 Assessment Methodology and Significance Criteria

This section presents the method used to assess the impacts and effects of the proposed activities at the Site on the water environment, and to identify potential secondary effects from changes to the water environment. It establishes the stages of the assessment, and the qualitative criteria used to assess impact magnitude and determine the level of effect significance.

8.3.1 Technical Scope

The technical scope of this assessment is to consider the potential impacts and effects that the Proposed Development (as detailed in Chapter 3.0, Project Description) may have on the water environment. The assessment considers the potential sources of change resulting from potential future activities at the Site on hydrological and hydrogeological receptors. It considers water levels, flow regimes, water resources and uses, water quality, flood risk and water management.

The objectives of the hydrological and hydrogeological assessment for the proposed extraction of gypsum from the Knocknacran West Open-Cast Mine and Community Sports Complex are to:

- Identify any potential impacts of the Proposed Development on the surface water and groundwater environment during development and operation;
- Identify any mitigation measures that may be required to avoid, remediate or reduce significant negative adverse impacts;
- Assess any significant residual impacts and cumulative impacts of the Proposed Development; and
- Determine any potential impacts of the Proposed Development on the surface water and groundwater environment following eventual closure and restoration of the mine site.

8.3.2 Temporal and Geographical Scope

The temporal scope of the assessment covers the baseline conditions (as the Site is at present and drawing on information as far back as the 1980s), construction, operation and closure project phases for the Proposed Development. Temporally, the construction phase for the Community Sports Complex is ca. 2 years, while the Mine Development is ca. 1 year, there will be overlap of 1 year between these development phases. The operational phase for the Mine Development is ca. 30-35 years, depending on market conditions, while the Community Sports Complex will operate in perpetuity. The closure and restoration phase of the Mine Development begins after the operational phase has ceased.

Once the Knocknacran West Open-Cast Mine is operational, the existing Knocknacran Open-Cast Mine will be in restoration, extraction will have ceased. The existing underground Drummond Mine is currently permitted until 2033.

It is noted that phased restoration is also proposed throughout the operational life of the Mine Development (in the Knocknacran Mine), the final restoration/closure phase is considered as a separate phase after extraction activities have ceased.

The geographical study area for the assessment covers the area within the Site boundary along with the surrounding area between the villages of Drumgoosat to the north and Cabra to the south. However, where deemed appropriate, the buffer zone has been increased to allow for identification of downstream or downgradient hydraulic connectivity with off-site water features or users that may be affected by changes associated with the Site activities.

8.3.3 Available Information

The hydrological and hydrogeological impacts associated with the Proposed Development at the Application Site were assessed by means of a number of field inspections, and a desk study of the Site and its surroundings (including a review of available information and reports). There have been a number of previous hydrogeological investigations associated with the Site, and there is a database of hydrogeological monitoring spanning ca. 40 years. There are also a number of technical references available which contain important information, including the Geological Survey of Ireland's (GSI) on-line publications.

The information used to compile this report includes previous hydrogeological investigations, mapping datasets, timeseries monitoring data and reports, and is presented in the relevant Sections below. The key data sources are:

- GSI online mapping datasets;
- Location of third party wells (Golder 2019 survey);
- Environmental monitoring wells – location and geological zone of monitoring, monthly water level data and monthly water chemistry data;
- Drummond mine outflow to the southeast lagoons (DMO1) – daily flow data from January 2010 to August 2021; and
- Drumgoosat dewatering well – flow measurements from October 2017 to August 2021.

Several pertinent reports are available for the area. Key reports and their conclusions are summarized as follows:

- Piteau Associates (2021b). Knocknacran West pit lake model and restoration plan.
  - Provides an assessment of the future hydrogeology of the Knocknacran West Open-Cast Mine at the time of completion of mining and during the closure period.
- Piteau Associates (2021a). Drummond Mine – potential for future groundwater inflows.
  - Description of the hydrogeology of the Drummond Mine and assessment of the risk of potential future inflows to the mining area.
- Piteau Associates (2020a). Hydrogeology study of Enagh Bog.
  - Description of the hydrology and hydrogeology of the Enagh Bog and Drummond Mine area, also including data from historical and current mining operations.

- Piteau Associates (2020b). Hydrogeology study of Knocknacran Open-Cast and Drumgoosat and Drummond Underground mines.
    - Description of the hydrology and hydrogeology of the gypsum mining district, including data from historical and current mining operations.
- Minerex (2019a). Annual Groundwater Monitoring Report for Mine and Processing sites for 2018.
    - Presentation of the data collected through 2018 and its interpretation as part of the GSG environmental permit conditions.
- Minerex (2019b). Drummond Mine Water Ingress: Assessment of Impact on Groundwater Resources - Rev 1, June 2019 Doc. Ref.: 1632-2093 (Rev 3).
    - Presentation of the data collected in relation to the intersection of Drummond Mine Fault in 2018, revaluation of the conceptual model and recommendations regarding management of the water.
- SLR (2019). Drummond Mine Dewatering Plan (2019 to 2020) SLR Ref: 190311.501.00545.0004.
    - Water management plan for the GSG site (not only Drummond Mine) including dewatering projections, storage and treatment requirements.
- Golder Associates Ltd (2017). Knocknacran Environmental Impact Statement.
    - Geology and water chapters outlining the current and anticipated conditions at the site in relation to previous development projects.
- Cavan County Council (2011a). Establishment of groundwater source protection zones – Kingscourt Water Supply Scheme, Mullantra Borehole (May 2011).
    - Hydrogeological conceptual model and groundwater supply source zone definition.
- Cavan County Council (2011b). Establishment of groundwater source protection zones – Kingscourt Water Supply Scheme, Descart Boreholes (April 2011).
    - Hydrogeological conceptual model and groundwater supply source zone definition.
- Brady Shipman Martin (2003). Drummond Mine Environmental Impact Statement.
    - Geology and water chapters outlining the current and anticipated conditions at the site in relation to previous development projects.

8.3.4 Qualitative Assessment Method

The assessment of potential effects has been undertaken in line with the EPA's 2022 Guidelines on the Information to be Contained in EIARs and adapted where necessary to take account of additional guidance identified in the legislative review (Section 8.2.1 above). The assessment is supported by the available baseline condition information, historical records of site activities, previous hydrological and hydrogeological studies, historical monitoring data and recent monitoring and survey data collected to supplement the historical dataset. The assessment follows a staged approach. A summary of the stages involved is included below:

1) Confirm baseline conditions for the Site – using available recent monitoring data supported by historical monitoring data where available. Develop a conceptual site model by consideration of available records and data sets, site reports and published information.

2) Confirm the key receptors and their value/importance.

3) Qualitatively characterise the magnitude of impacts on the receptors – describe what potential changes may occur to each receptor as a result of the Site activities, identify source-pathway receptor linkages, and assign the magnitudes of impact. This stage takes into account embedded design mitigation, good practice in construction environment management and pollution prevention.

4) Determine the initial effect significance of each potential impact on each sensitive receptor.

5) Consider the need for mitigation measures if it is considered necessary to reduce the initial magnitude of the impact and associated effect significance further.

6) Assess the residual impact magnitude and residual effect significance after all mitigation measures are applied.

7) Identify any monitoring that may be required to measure the success of the mitigation measures.

Stages 1 and 2 have been completed using available information specific to the Site, published literature and guidance, historical records, datasets and studies and additional monitoring data collected specifically to support this EIAR chapter. For the identification of receptor value/importance that completes Stage 2, and for the description of impact magnitude (Stage 3), a common framework of assessment criteria and terminology has been used based on the EPA's 2022 Guidelines on the Information to be Contained in EIARs and adapted based on the additional guidance outlined in Section 8.2.1, such as those by the NRA and IGI. The descriptions for value (sensitivity) of receptors are provided in Table 8.1 and the descriptions for magnitude of impact are provided in Table 8.2.

The potential for an impact to have occurred at a receptor has been determined using the understanding of the baseline environment and its properties, and consideration of whether there is a feasible linkage between a source of impact and each receptor (i.e. a conceptual site model). This follows the method of preliminary risk assessment that is widely presented in some of the guidance documents listed in Section 8.2.1, such as the LCRM guidance.

Table 8.1: Environmental Value (Sensitivity) and Descriptions

Value (Sensitivity) of Receptor / Resource	Typical Description
High	High importance and rarity, national scale, and limited potential for substitution. For example: Global/European/National designation - or supports an internationally important feature. WFD river designation of 'High' and in hydraulic connectivity with the Site. Human health receptors. Regionally important aquifer with multiple wellfields. Inner source protection area for a regional resource.

	Regionally important potable water source supplying >2500 homes (surface water or aquifer). Floodplain protecting more than 50 residential or commercial properties or nationally important infrastructure (e.g. motorways/national roads) from flooding.
Medium	Medium or high importance and rarity, regional scale, limited potential for substitution. For example: Regionally important sites. Regionally important aquifer. WFD river designation of 'Good' or 'Moderate'" and in hydraulic connectivity with the Site. Outer source protection area for a regional resource. Locally important potable water source supplying >1000 homes (surface water or aquifer). Floodplain protecting between 6 and 50 residential or commercial properties or regionally important infrastructure (e.g. regional roads) from flooding.
Low	Low or medium importance and rarity, local scale. For example: Locally important aquifer. WFD river designation of 'Poor' or 'Bad' and in hydraulic connectivity with the Site. Outer source protection area for a local resource. Local potable water source supplying >50 homes (surface water or aquifer). Floodplain protecting between 2 and 5 residential or commercial properties or locally important infrastructure (e.g. local roads) from flooding.
Negligible	Very low importance and rarity, local scale. Environmental equilibrium is stable and is resilient to impacts that are greater than natural fluctuations, without detriment to its present character. Poorly productive aquifer. Any WFD river quality designation not in hydraulic connectivity with the Site. Local potable water source supplying <50 homes (surface water or aquifer). Floodplain protecting up to 1 residential or commercial properties from flooding.

Table 8.2: Magnitude of Impact and Typical Descriptions

Magnitude of Impact (change)		Typical Description
High	Adverse	Loss of resource and/or quality and integrity of resource; severe damage to key characteristics, features or elements. Significant harm to human health - death, disease, serious injury, genetic mutation, birth defects or the impairment of reproductive functions. Significant harm to buildings/infrastructure/plant - Structural failure, substantial damage or substantial interference with any right of occupation. Significant pollution of the water environment, which is defined by: • A breach of, or failure to meet, any statutory quality standard for the water environment at an appropriate pollution assessment point. • A breach of, or a failure to meet, any operational standard adopted by EPA for the protection of the water environment. • Pollution results in an increase in treatment required for an existing drinking water supply. • Pollution results in an increased level of treatment required of water abstracted for industrial purposes.

		• Pollution results in deterioration in the status of a waterbody, failure to meet good status objectives defined by the Water Framework Directive, or failure of a protected drinking water area to meet its objectives as defined by the Water Framework Directive. • There is a significant and sustained upwards trend in concentration of pollutants in groundwater being affected by the land in question. There is a material and adverse impact on the economic, social and/or amenity use associated with a particular water environment.
	Beneficial	Large scale or major improvement of resource quality; extensive restoration; major improvement of attribute quality.
Medium	Adverse	Loss of resource, but not adversely affecting the integrity; partial loss of/damage to key characteristics, features or elements.
	Beneficial	Benefit to, or addition of, key characteristics, features or elements; improvement of attribute quality.
Low	Adverse	Some measurable change in attributes, quality or vulnerability; minor loss of, or alteration to, one (maybe more) key characteristics, features or elements.
	Beneficial	Minor benefit to, or addition of, one (maybe more) key characteristics, features or elements; some beneficial impact on attribute or a reduced risk of negative impact occurring.
Negligible	Adverse	Very minor loss or alteration to one or more characteristics, features or elements.
	Beneficial	Very minor benefit to or positive addition of one or more characteristics, features or elements.

The assessment of magnitude of the impact considers whether the change that causes the impact is positive or negative, and whether the impact is direct or indirect, short- medium- or long-term, temporary or permanent, and if it is reversible.

For the purposes of this assessment, a direct impact is one that occurs as a direct result of the Proposed Development and is likely to occur at or near the development itself. Indirect impacts (or secondary/tertiary impacts) are those where a direct impact on one receptor has another knock-on impact on one or more other related receptor(s) (e.g. the Proposed Development results in a change in groundwater quality, which then has an indirect impact on surface water quality and/or users of the water, such as human health or ecology). Indirect impacts can occur within the study areas or away from the Proposed Development.

For the purposes of this assessment, the following definitions of duration have been used:

- Temporary – effect likely to last less than 1 year without intervention;
- Short term – effect likely to last 1 to 7 years without intervention;

- Medium term – effect likely to last 7 to 15 years without intervention;
- Long term – effect likely to last 15 to 60 years without intervention; and
- Permanent – effect likely to last over 60 years without intervention.

An irreversible impact is defined as a change to the baseline that would not reverse itself naturally. Such impacts are usually long-term or permanent and irreversible, such as changes to the groundwater flow regimes caused by changes to the properties of the subsurface.

A reversible impact is defined as a change to the baseline conditions that would reverse naturally once the source of the impact is exhausted, removed or has stopped. For example, impacts to groundwater quality from contamination only last as long as the source of the impacts is present. If it is removed, groundwater quality may naturally improve or could be remediated.

8.3.5 Significance Criteria

The approach followed to derive effects significance from receptor value and magnitude of impacts (Stage 4) is shown in Table 8.3. Where Table 8.3 includes two significance categories, supporting evidence is provided in the topic chapters to support the reporting of a single significance category. A description of the significance categories used is provided in Table 8.4.

Table 8.3: Significance Matrix

	Magnitude of Impact (Degree of Change)				
		Negligible	Low	Medium	High
Environmental value (Sensitivity)	High	Slight	Slight or moderate	Moderate or large	Profound
	Medium	Imperceptible or slight	Slight or moderate	Moderate	Large or profound
	Low	Imperceptible	Slight	Slight	Slight or moderate
	Negligible	Imperceptible	Imperceptible or slight	Imperceptible or slight	Slight

Table 8.4: Significance Categories and Typical Descriptions

Significance Category	Typical Description
Profound	An effect which obliterates sensitive characteristics.
Large	An effect which, by its character, magnitude, duration or intensity alters a significant proportion of a sensitive aspect of the environment.
Moderate	An effect that alters the character of the environment in a manner that is consistent with existing and emerging baseline trends.
Slight	An effect which causes noticeable changes in the character of the environment without affecting its sensitivities.
Imperceptible	An effect capable of measurement but without significant consequences.

Following the assessment of the level of effect significance, mitigation measures are presented that will be used to further avoid, prevent or reduce the magnitude of the potential impact. If necessary, the significance of the effect taking into account the mitigation measures is then assessed to give the residual effect significance.

Residual effects of 'large' or 'profound' significance are considered to be 'significant' for the purposes of this assessment.

The effects of the Proposed Development are also considered cumulatively with those that could foreseeably result from other known developments in the assessment study area that are going through the planning process.

8.4 Baseline

The Application Site is currently a mixture of former agricultural lands; an existing open-cast mine, comprising exposed faces with gypsum, stockpiles of previously extracted material (overburden and interburden), areas of restoration; an existing processing facility with associated infrastructure and a construction area for the recently permitted (Reg. Ref. 20/365) initial development of the Community Sports Complex.

8.4.1 Climate

Reported mean annual precipitation for the Site area is about 979 mm based on the rain gauge located close to the Knocknacran open-cast mine site (Met Éireann "Kingscourt Gypsum" gauge) between 1990 and 2020 (Table 8.5). The mean annual precipitation recorded at the Met Éireann "Carrickmacross" weather station, approximately 10 km north-east of the Kingscourt Gypsum gauge, is 920 mm/year (between 1990 and 2021). Dunsany synoptic station (45 km south of the site) has an annual average potential evapotranspiration of 514 mm (2019 to 2021).

Table 8.5 summarizes the monthly mean values for precipitation and evaporation. As is typical in Ireland, the wettest months coincide with the months of lowest potential evapotranspiration (October to January). The driest months with highest potential evapotranspiration are May, June, July and August.

The existing topography in the vicinity of the Site is undulating in nature, and varies in level from approximately 40 to 70 m OD. The lowest topographic point close to the Site is the River Bursk (ca. 25 OD). This forms the overall hydrogeological base level for the district.

Table 8.5: Average Monthly Mean Precipitation and Average Potential Evapotranspiration

Month	Precipitation (mm/mon)	Potential Evapotranspiration (mm/mon)
January	91.3	11.3
February	81.7	17.7
March	70.6	32.3
April	66.6	49.2
May	64.1	78.1
June	72.0	84.9
July	78.0	87.1
August	85.1	67.3
September	71.2	45.6
October	101.5	25.2
November	99.9	9.1
December	97.3	9.4
Total	**979.3**	**514.5**

8.4.2 Geology

The geology underlying the Application Site is presented and discussed in detail in Chapter 7.0 (Land, Soils and Geology). The Application Site area is located within the Kingscourt Outlier, a half-graben structure formed of Carboniferous and Permo-Triassic rocks. The Kingscourt Fault forms the western boundary of the Kingscourt Outlier. The stratigraphy and geological structures have a dominant north-south strike.

The bedrock consists of the Kingscourt Gypsum Formation, which is described as consisting of mudstone with gypsum and anhydrite of Permian age. There is evidence of post-depositional weathering or solution (karst) on the upper surfaces of the gypsum beds as seen in the western part of the deposit currently exposed in the Knocknacran Open-Cast Mine. However, no developed cave systems have been encountered in either the current open-cast mine or adjacent underground workings. There is no evidence from the underground workings at Drummond or Drumgoosat to suggest major north-south trending graben structures are important water-bearing features. Rather, the available data suggests they are barriers to groundwater flow across their strike plane.

Dolerite sills occur in the Permo-Triassic sequences at Kingscourt, with the principal intrusion in the Middle Mudstone between the two gypsum units/beds. A secondary intrusion is generally restricted to the Lower Mudstone but is known to occasionally cross-cut the Lower Gypsum in some areas. The sills are interpreted as having been hydrothermally altered as they were intruded, resulting in susceptibility to weathering and thereby acting as potential conduits for water where altered.

The Application Site is underlain by grey brown podzolic and associated gley soils, which have generally originated from limestone glacial till. The soils are predominantly underlain by tills derived from Lower Palaeozoic rocks. The depth of overburden across the Application Site where it has not been stripped or re-worked is variable in thickness, reflecting the nature of the drumlin landscape.

8.4.3 Mining

The output of gypsum from the Monaghan-Cavan area increased with the opening of an underground mine at Drumgoosat located to the north of the existing Knocknacran open-cast mine in the 1950s. On closure in 1989, the output from Drumgoosat was replaced by gypsum from the existing Knocknacran open-cast mine. The workings at Drumgoosat extracted Upper and Lower Gypsum Units. They are up to 100 m below ground level (bgl) and have an aerial extent of ca. 72.3 ha. Pumping records for the mine during historical operations indicate groundwater inflows were seasonally variable between ca. 20 m³/d in September to ca. 870 m³/d in March. Following the period of active mining, the Drumgoosat workings were used seasonally to store excess water from adjacent mining activities up to the time of the subsidence event in September 2018. The north-western part of the existing Knocknacran open-cast was partially underlain by workings from the Drumgoosat underground mine.

Planning permission for an underground mine at Drummond to the south of the existing Knocknacran open-cast was subsequently secured, with the mine coming into full production in 2005. The mine workings extend to ca. 155 m bgl and currently have an aerial extent of ca. 31 ha. Historic inflows to the Drummond Mine were between ca. 1,400 and 2,200 m³/d. In June 2018, the mine workings intersected a fracture zone associated with the Drummond Mine Fault. Inflows from the fault were initially estimated to be around 4,100 m³/d but have since reduced to a seasonal range between about 2,500 and 4,000 m³/d. The workings at Drummond are confined to the Lower gypsum Unit, with extraction taking place using the room and pillar mining method.

The existing Knocknacran Open-Cast Mine extracts Upper and Lower Gypsum Units. The overall Application Site area is ca. 140.4 ha[1], of which the proposed Knocknacran West Mine comprises ca. 54.3 ha, ca. 24.6 ha comprises the processing plant, ca. 8.6 ha will comprise the Community Sports Complex and ca. 51.5 ha will comprise the restoration area for the existing Knocknacran Mine. Geological strata exposed in the open-cast include the Upper and Lower Gypsum Units, and overburden and interburden, in the form of mudstones and intrusions of dolerite (Section 8.4.2 above). Since the open-cast at Knocknacran has been operational it has included mining into the southeastern part of the Drumgoosat workings. Estimates of sump pumping rates from Knocknacran mine are seasonally between about 10 m³/d in September (groundwater flow only) and 950 m³/d in April (mostly surface water runoff).

Inflows to the historic and current mining operations (Drumgoosat, Knocknacran and Drummond) are pumped into the site water management system and routed to a licenced discharge point on the River Bursk. The licence states that a maximum of 12,240 m³/day can be discharged. The discharge of mine water is automatically adjusted depending on the available flow and assimilative capacity in the receiving river to ensure that water quality standards are not breached.

Excess water during the summer months (when the assimilative capacity of the River Bursk is lower) was previously pumped into the Drumgoosat Mine for temporary storage. Following the subsidence event of September 2018, no more water has been pumped into the Drumgoosat workings. A water management plan that reduces the rate of discharge from the old Drumgoosat workings when required and a discharge licence revised by the EPA to allow additional discharge volumes has reduced the need for any seasonal storage of water. Where needed on any exceptional short-term basis, the substantial sump in the Knocknacran open-cast pit is now used for temporary water storage. Water levels in Drumgoosat have been

[1] The red line area encompasses a small area of the R179 (ca. 1.4 ha) which accounts for the slight discrepancy in total site area.

reduced in a controlled manner to aid in the long-term stability of the underground workings by a dewatering borehole located on the Knocknacran site.

8.4.4 Surface Water - Hydrology

The three primary local surface water courses in the area of the Proposed Development are (**Error! Reference source not found.**):

- Magheracloone Stream which runs north to south along the western boundary of the Site;
- River Bursk (also known as River Rahans) which runs north to south in an artificially straightened channel along the eastern boundary and which receives discharge from the Site; and
- River Lagan (also known as the River Glyde) which receives water from both the Magheracloone and Bursk and flows from west to east to the south of the Site.

The Corduff Stream rises in an area above the Drumgoosat Mine and flows north-east to meet the River Bursk (WFD reach "GLYDE_030"). The River Bursk then flows towards Lough Fea and on to the River Lagan (**Error! Reference source not found.**). A drainage area of about 0.45 km^2 currently contributes to the Corduff Stream within the proposed open-cast mine site. The catchment area of the River Bursk to its inflow point to Rahan's Lough is approximately 30 km^2 (Table 8.6), with the catchment captured by the open-cast representing 1.5% of the total drainage area. The proportion of catchment is small so the effect on streamflow in the Corduff Stream and River Bursk is negligible. The Corduff Stream is ephemeral where it leaves the Drumgoosat site boundary. The Bursk flows south into Bursk Lough, then Rahans Lough (Raffan's Lough), and then into the River Lagan. Bursk Lough is also fed by Descart Lough. The overall drainage pattern in the area is principally northwest-southeast or north-south as defined by divides set by the local topography (**Error! Reference source not found.Error! Reference source not found.**).

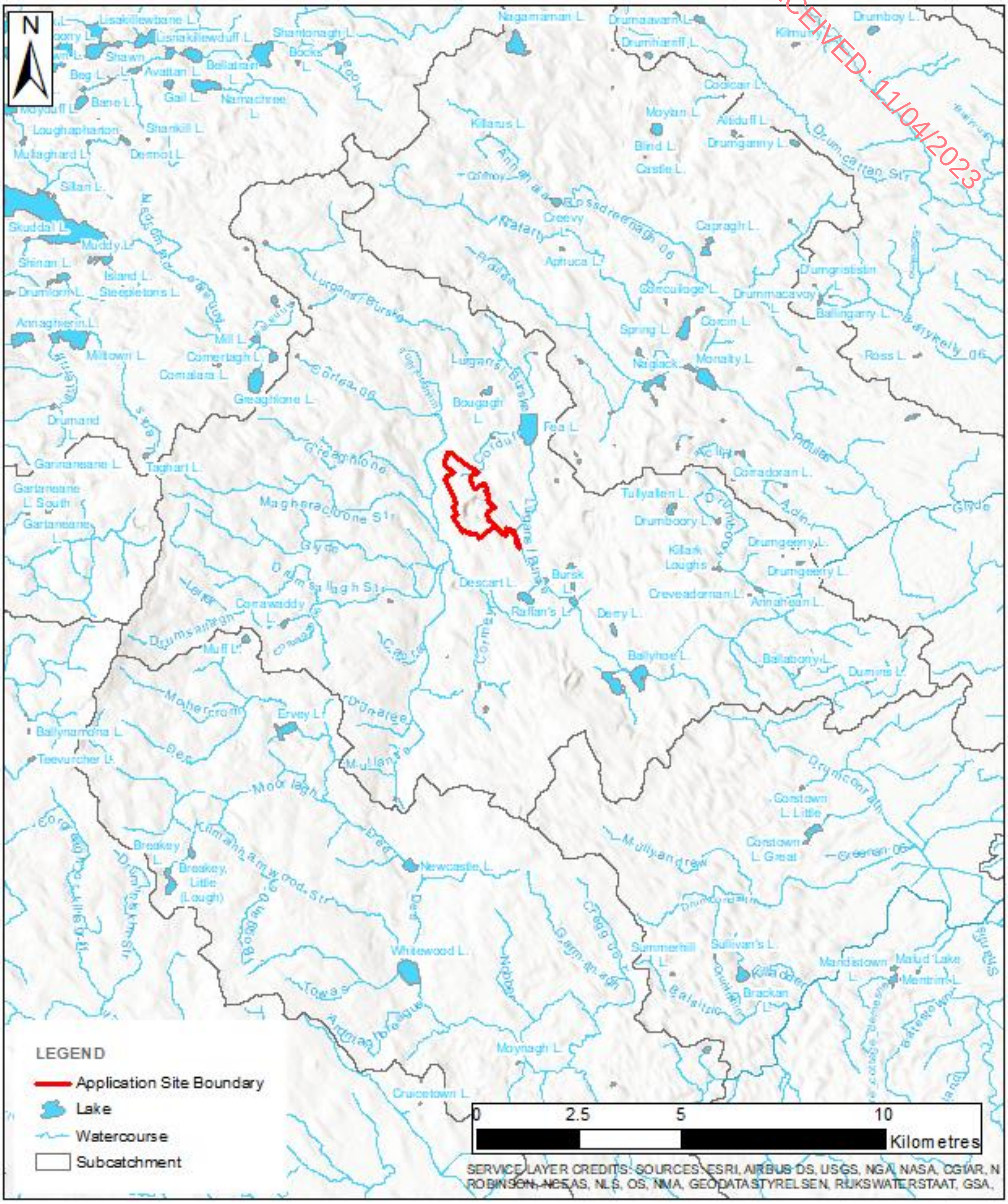

Figure 8.1: Overall surface water drainage pattern

Table 8.6: Estimated Surface Flows

Waterbody	Catchment Area (km²)	Annual Flow (Mm³/year)	Data Source
River Bursk	30	7 – 9	Daily flow measurements taken by SGMI (2007-2021)
Lagan River	144	109	OPW gauging station at Aclint Bridge
Glyde River	270	140	OPW gauging station at Tallanstown

A hydrological report on the Corduff and Magheracloone streams was produced by Piteau Associates following survey work undertaken in June and July 2022. Data were collected from 2 sampling locations on the Corduff Stream and 4 locations on the Magheracloone/Lagan Stream (Figure 8.2). The flow results are shown in Table 8.7, below. For the Corduff Stream, the monitoring results confirm that summer flow only occurs downstream of the planned Knocknacran West development area, and that the stream in the development area is ephemeral and contributes little (if any) stream flow. The waters from a historical excavated clay pit located ca. 1 km downstream of the development site are not thought to be directly connected to the Corduff Stream, but it is possible that outflow from the pit to the stream may occur during the winter months or following periods of rainfall.

The survey work shows that the Corduff Stream is an ephemeral stream, with negligible flows being recorded during drier months. The report indicates that the Corduff currently shows elevated levels (no assimilative capacity) of ammonia and phosphate. Both are related to agricultural practices.

The interaction between the Corduff Stream and the shallow geology/hydrogeology is noted in Section 3 of the report (Appendix 8.1) which states the following:

"The soils of the Corduff catchment are typically fine loamy drift with siliceous stones, overlying a till subsoil derived from Lower Palaeozoic sandstones and shales. The overburden is mapped as having and has a moderate permeability, although the eastern side of the catchment has low permeability till. Overburden thickness across the area varies due to the drumlin landscape. Alluvial deposits have been mapped along the line of the Corduff channel in the upper catchment (first 1-2 km), and peat deposits in the lower catchment. The presence of peat above a medium permeability subsoil shows the shallow water table is close to surface in this area, as would be expected due to the proximity to Lough Fea."

For the Magheracloone/Lagan stream, flows are significantly impacted by the presence of alluvial sediments upstream and downstream of the sampling locations, and also significant growth of wet reeds and grasses. Also noted was the accessibility of livestock to the Magheracloone/Lagan with livestock using the stream for drinking during both sampling events.

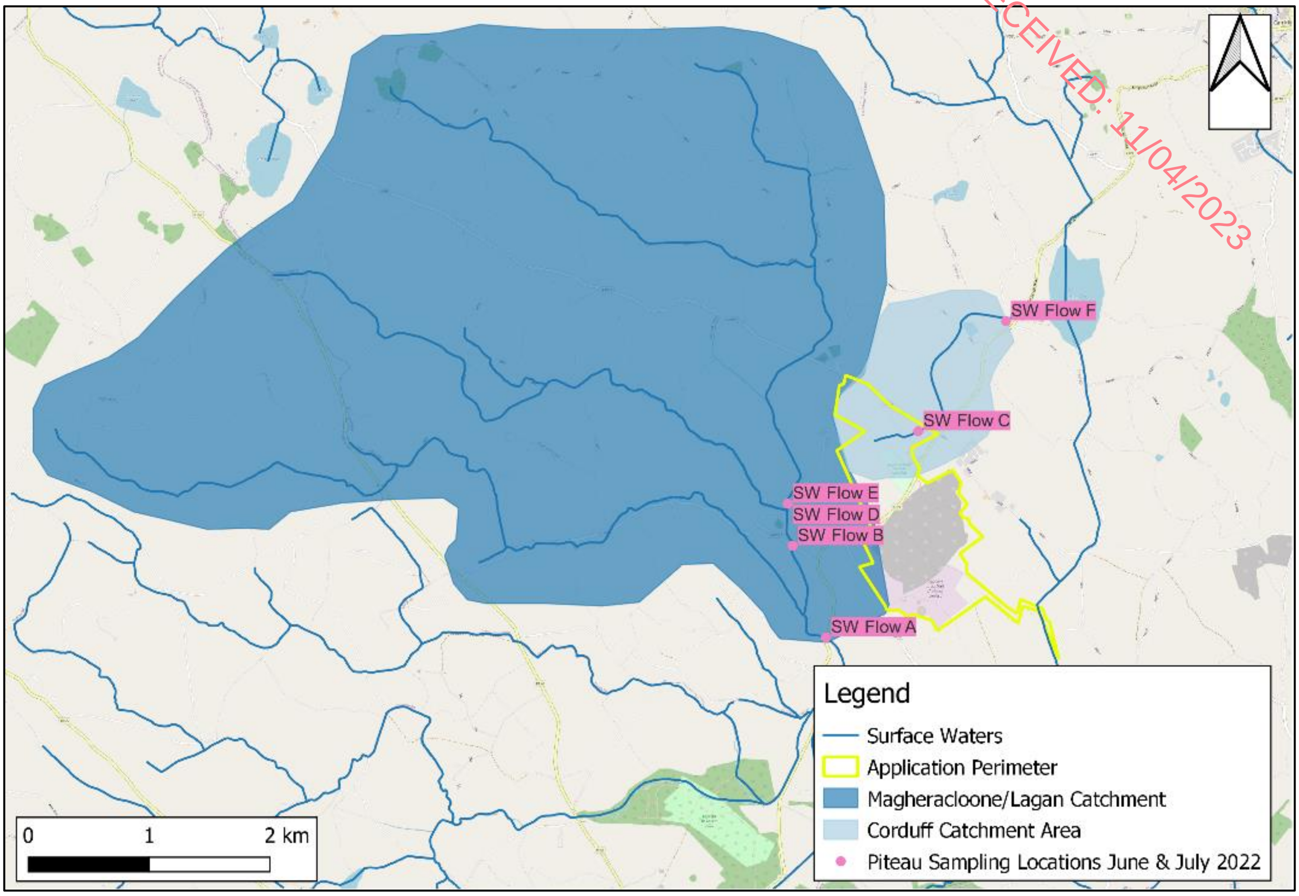

Figure 8.2: Catchment areas and sampling locations on the Magheracloone/Lagan and Corduff streams

Table 8.7: June and July 2022 sample locations and measure flow rates

Sample locations				Flow (L/s)		Comments
ID Code	Stream	X	Y	13/6/2022	14/7/2022	
SW Flow A	Magheracloone/ Lagan	680152	798762	56	47	Overgrown. Cattle Watering D/S
SW Flow B	Magheracloone/ Lagan	679877	799520	57	31	Overgrown. Cattle Watering D/S
SW Flow D*	Magheracloone /Lagan	679837	799868	42	30	Overgrown. Deep sediment bed
SW Flow E*	Magheracloone /Lagan	679837	799868	42	30	Overgrown. Deep sediment bed
SW Flow C	Corduff	680915	800466	0.04	N/A**	Jug & timer used to measure flow.
SW Flow F	Corduff	681642	801377	5	2.5	Overgrown. Potential eutrophication

**SW Flow D and E are duplicate samples.*
*** There was insufficient flow from this location to accurately measure a volumetric discharge.*

Historical flow measurements taken over a 3 year period between December 2003 and December 2006 show the River Bursk to be perennial in nature. The River Bursk is understood to be fed by groundwater throughout the year, with a rapid increase (and subsequent decrease) in flow levels during times of heavy rainfall.
The Bursk drainage area is low lying, with the loughs along its course have the following areas and elevations:

- Lough Fea is ca. 30 ha in area, with an elevation of ca. 32 m OD;
- Bursk Lough is ca. 2 ha in area, with an elevation of ca. 25 m OD;
- Rahans Lough is ca. 17 ha in area, with an elevation of ca. 24 m OD; and
- Descart Lough is ca. 6 ha in area, with an elevation of ca. 26 m OD.

8.4.4.1 Surface Water Quality

EPA biological surveying assigns a water quality index to the rivers, where Q5 and Q4-5 is '*high*', Q4 is '*good*', Q3-4 is *'moderate'*, Q3 and Q2-3 are *'poor*' and Q2, Q1-2 and Q1 are *'bad'.* Figure 8.3 presents the locations (Cormey, Tobermannan and Ballyhoe Bridges) of the biological survey points and the last recorded results.

River waterbody WFD Status for the period 2016 – 2021 is given as 'good' for the River Lagan and River Bursk (EPA, 2023). More recent Q value station data is available for some stations on the River Lagan from 2020 monitoring carried out by the EPA, including at Magheracloone Stream and Cormey Bridge. Cormey Bridge had a Q value of 4 in 2020 and achieved 'good' status while Magheracloone Stream had a Q value of 3 and achieved 'poor' status in 2020. Based on the most recently recorded Q values, it appears that there is no deterioration in the Q value of the river downstream of the mine water discharge point, that the discharge is not creating impacts to biological water quality and that the existing operation is having no deleterious effect on the quality of the receiving water.

The Lagan River (which becomes the Glyde) is not a designated Salmonid Water under the European Community Regulations for the Quality of Salmonid Waters (1988). However, the river is a valuable salmonid fishery with most of the salmonid spawning and nursery habitats located upstream of Cormey Bridge and salmonid nursery and adult habitats located largely downstream of this bridge. The River Bursk has good salmonid habitats immediately downstream of Lough Fea.

An aquatic survey was undertaken in September 2022 on the Corduff Stream (Appendix 8.2). The survey focused on both instream and riparian habitats at each aquatic sampling location which coincide with the two flow sampling locations noted shown on Figure 8.2 (SW Flow C and SW Flow F). Surveys at each of these sites included a fisheries habitat appraisal, macrophyte & aquatic bryophyte survey and biological water quality sampling (Q-sampling).

Biological water quality, based on Q-sampling, was calculated tentatively as Q2-3 (poor status) at the location coincident with SW Flow C on Figure 8.2 within the Knocknacran West site. No macro-invertebrate species of conservation value greater than 'least concern', according to national red lists, were recorded via Q-sampling. The summary of the existing condition of the Corduff Stream onsite is provided within Appendix 8.2 as *"Small, very heavily modified lowland stream that was heavily overgrown with commonly occurring macrophyte vegetation. The stream was historically straightened and deepened with no visible water flows, deep silt base and heavy enrichment, poor indicators of habitat quality. Of no inherent value to fish of high conservation value including salmonids, lamprey and European eel; no suitability for crayfish and none recorded; Q2-3 (poor status) water quality."*

The second sampling location the Corduff Stream is coincident with SW Flow F on Figure 8.2, and is located west of Lough Fea and the R179 road crossing. Biological water quality, based on Q-sampling, was calculated tentatively as Q2-3 (poor status). No macro-invertebrate species of conservation value greater than 'least concern', according to national red lists, were recorded via Q-sampling.

The summary of the existing condition of the Corduff Stream onsite is provided within Appendix 8.2 as *"small, heavily modified lowland stream but retaining some semi-natural characteristics including swift flowing water and coarse substrata locally. The stream was historically deepened and had a bed dominated by silt with heavy enrichment that are poor indicators of habitat quality. Of some lower value to lamprey given soft sediment burial habitat present; too enriched and silted to support a healthy salmonid population albeit some adult brown trout may exist (trout are known from Lough Fea & adjoining tributaries).Low suitability for eel but the presence of eel populations in Lough Fea may indicate the species presence in the Corduff Stream at site 2; no suitability for crayfish and none recorded; Q2-3 (poor status) water quality."*

The existing mine site (Knocknacran and Drummond mines and the plant site) is currently subject to an IE Licence (Reg. Ref. P0519-04). As part of the consideration for the review and revision of the limits of the discharge which were subsequently granted. The EPA Inspector's Report, issued on 7th October 2021, noted the following:

"Taken together along with the EPA biologists assessment, the above indicates that the current discharge is not impacting on the biological quality or on the drinking water quality of the River Bursk or the River Glyde into which it flows."

And

"Having assessed those potential effects, I have concluded as follows:

Assessment on discharges to water and river data has demonstrated that the discharges will not cause an exceedance of water quality standards and will ensure protection of aquatic life. Mine water discharges to the River Bursk will be mitigated through imposing emission limit values to ensure compliance with environmental quality standards."

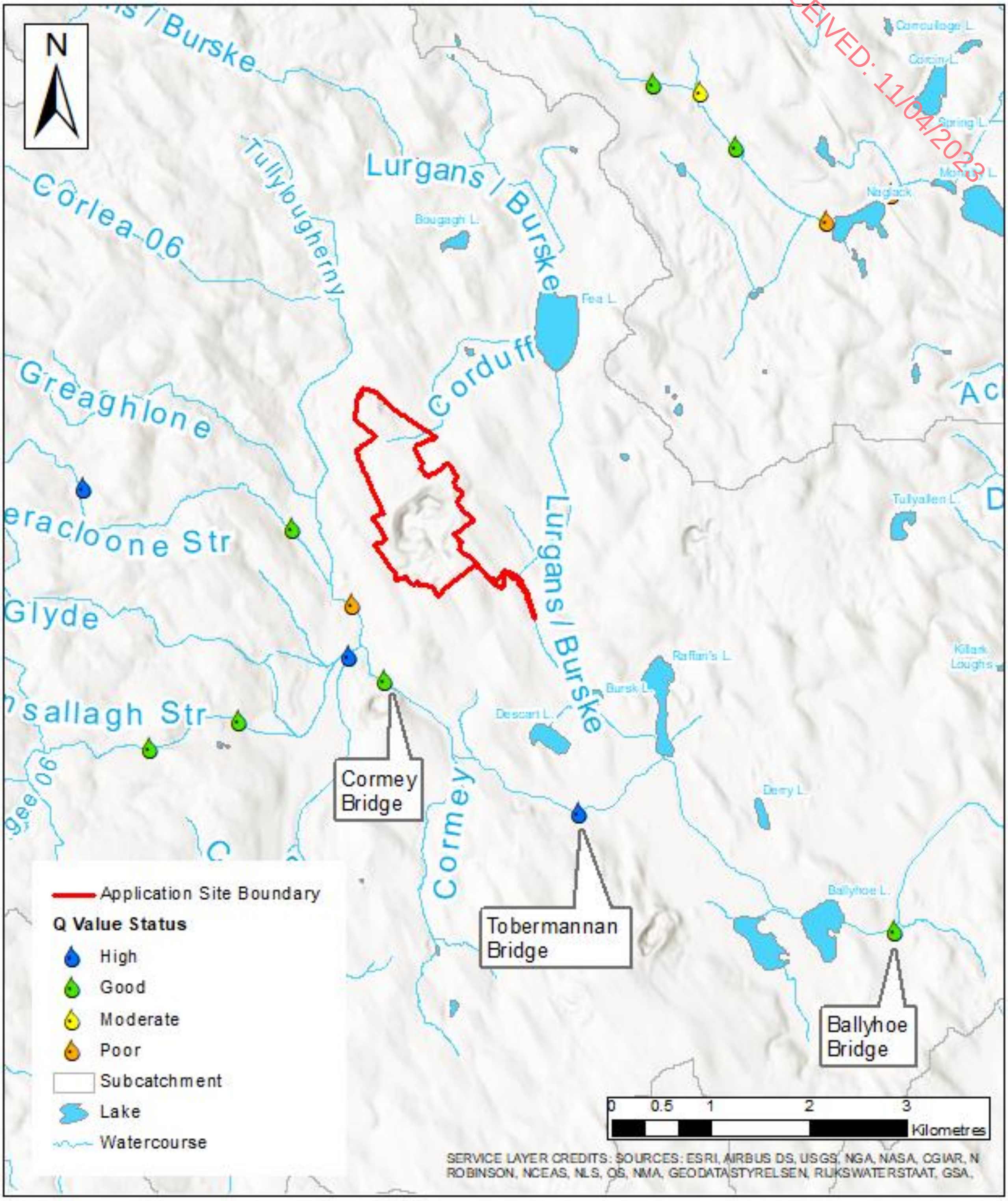

Figure 8.3: Biological (Q value) survey locations

8.4.4.2 Surface Water Monitoring

Regular surface water quality monitoring is carried out at 3 locations in accordance with the IE Licence P0519-04 (Figure 8.4):

i) MSE-1 (at outfall from holding tank to the River Bursk);

ii) B (baseline conditions in the River Bursk at 5 m upstream of the discharge point to the River Bursk); and

iii) CP-1 (conditions 70 m downstream of the discharge point to the River Bursk).

Electrical conductivity, sulphate and flow are monitored on a daily basis at MSE-1. Electrical conductivity and sulphate are monitored on a monthly basis at location B (5 m upstream of the discharge point). Electrical conductivity and sulphate are also monitored on a daily basis at compliance point CP-1 (70 m downstream of the discharge point).

An empirical relationship between electrical conductivity and sulphate was established as part of investigative studies for the development of the Drummond Mine and is presented below:

Electrical conductivity (µS/cm @ 20°C) x 0.636 + 174 = SO_4 mg/l

The Exceedance Limit Values (ELVs) as set out in IE Licence P0519-04 are: (i) flow: 12,240 m^3/day for MES-1; (ii) electrical conductivity: 1,370 µS/cm at 20°C (daily average for CP-1); and (iii) sulphate: 625 mg/l (daily average), 500 mg/l (monthly average), and 400 mg/l (annual average) for CP-1. IE Licence P0519-04 was granted in December 2021 after a licence review by the EPA, the previous licence (P0519-03) for the site had a sulphate ELV of 200 mg/l and electrical conductivity ELV of 1,000 µS/cm (at 20°C) at CP-1. P0519-03 was granted in July 2015 and was superseded in December 2021 by P0519-04.

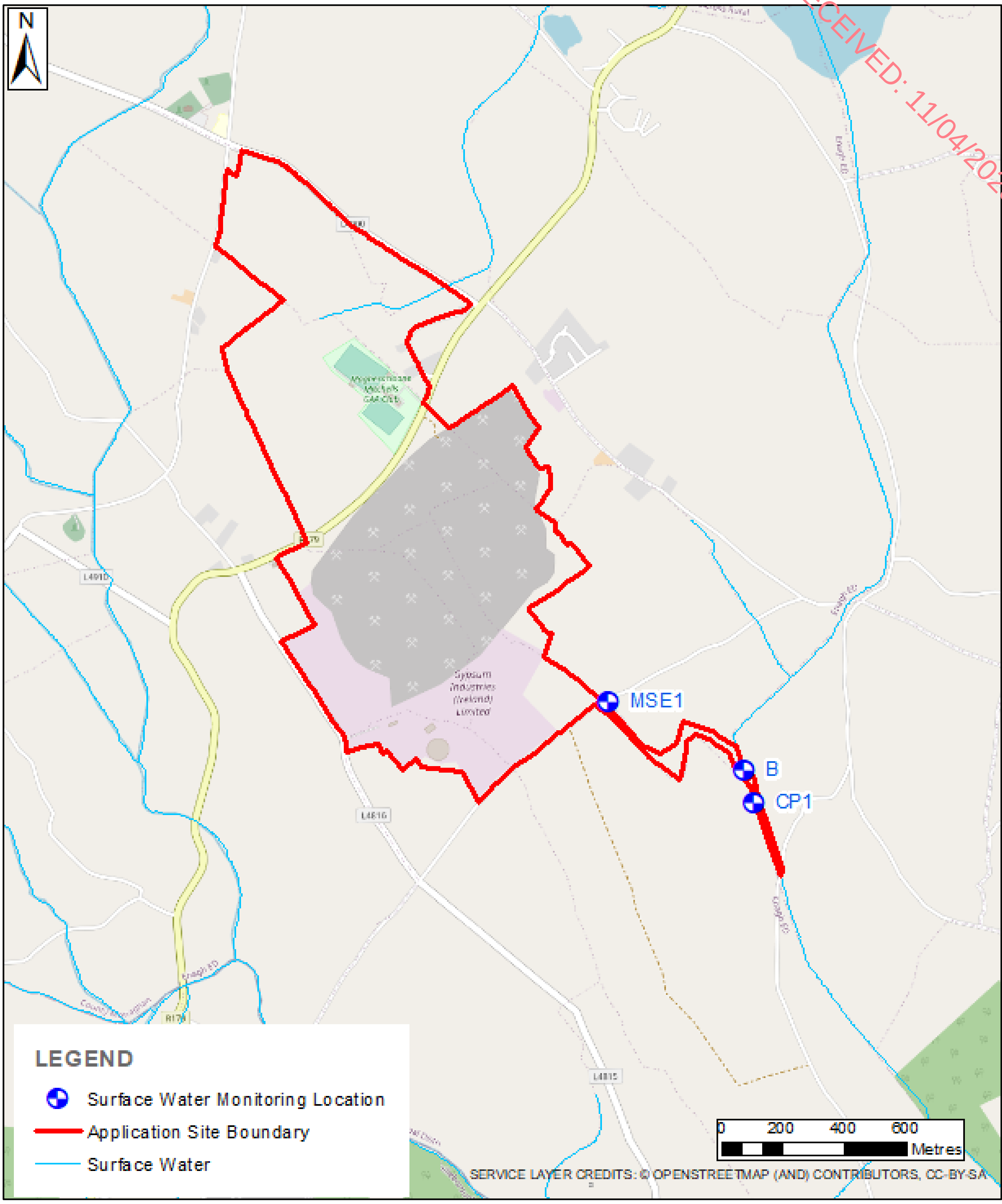

Figure 8.4: Surface water monitoring locations

Figure 8.5 presents a graph of the sulphate values measured at CP-1 for the period 2012 to January 2023.

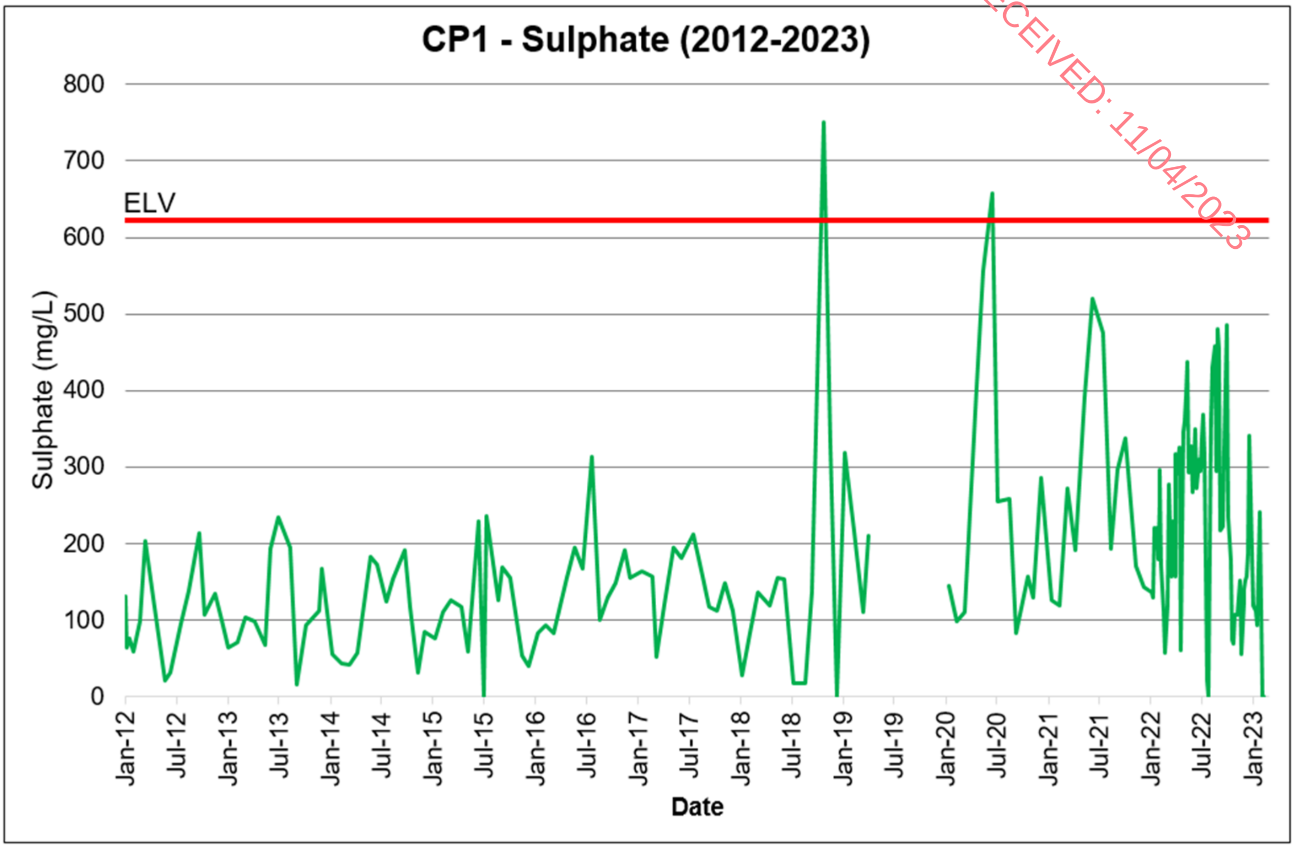

Figure 8.5: Graph showing sulphate levels at CP-1 for 2012 to January 2023

Sulphate values show a seasonal fluctuation, tending to increase during the summer months and decrease during the winter months (when flows are higher). Samples in excess of the ELV are attributed to recommissioning following periods of maintenance and the 2018 Drummond inflow (see following sections for further discussion on the inflow).

Suspended solids values measured at MSE-1 have been greater than 95% compliant with the discharge limit of 25 mg/l. One sample in excess of 1.5 times the ELV was reported in September 2015. This can also be attributed to recommissioning following a period of maintenance. Suspended solids values have also remained below the limit since the last licence revision.

Figure 8.6 presents a graph of the suspended solids at MSE-1 (measured weekly) for the period 2012 to January 2023.

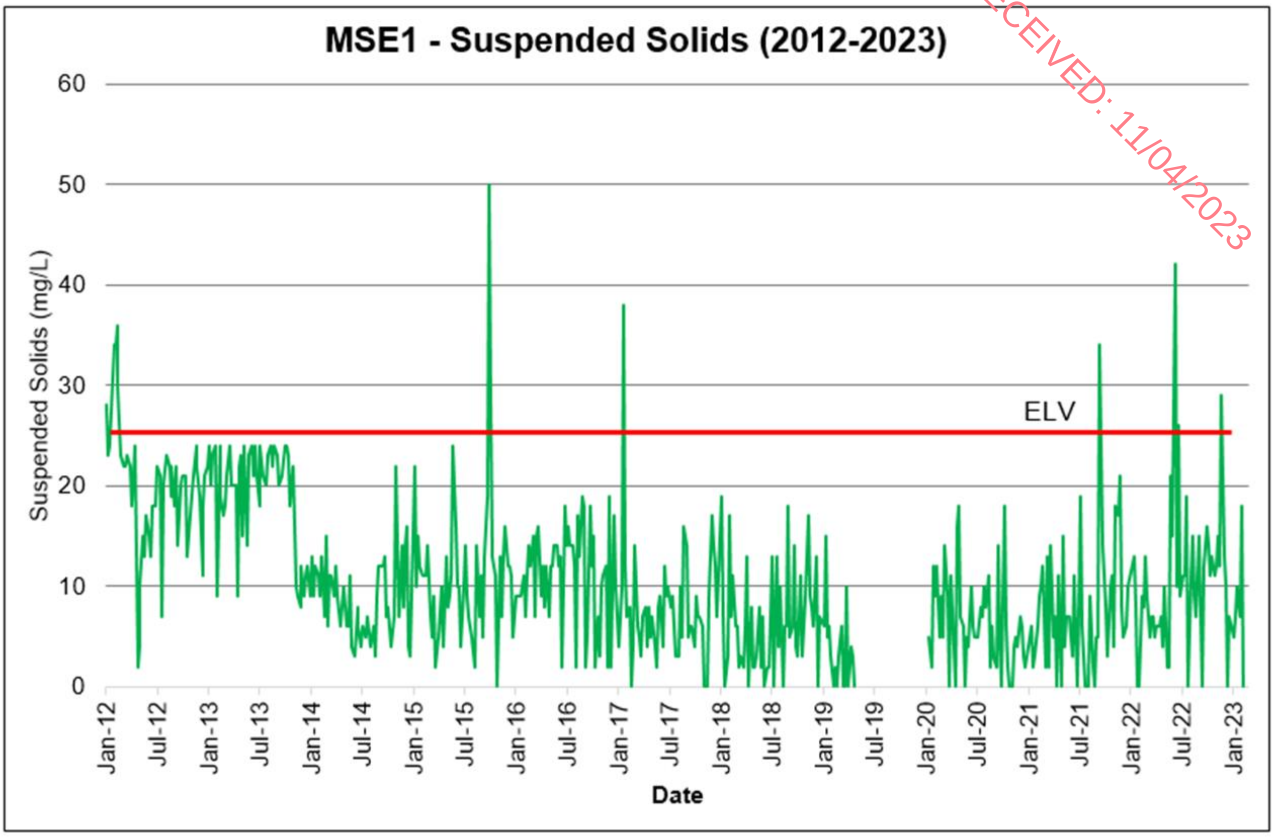

Figure 8.6: Graph showing suspended solids levels at MSE-1 for 2012 to January 2023

Periodic (non-continuous) monitoring is carried out by grab sample at these sampling points. The analytical programme uses a tiered approach, whereby some parameters are analysed continuously, daily, monthly, quarterly, and biannually at various locations. Sample analysis can include dissolved oxygen, suspended solids, settleable solids, electrical conductivity, pH, temperature, sulphate, barium, nitrate, ammonia, BOD, COD, total phosphorus, mineral oil, manganese, chloride and total metals (antimony, arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, tellurium, thallium, and tin). Specific sample analysis schedules are detailed for each location in IE Licence P0519-04. Summary statistics are prepared for the surface water monitoring results. The licence conditions specify that 95% of results should be below the ELV, with no result more than 1.5 times the ELV. Monitoring results for 2012 to 2016 reported minor exceedances in some years, usually in the summer months (June and July). The predominant parameter of concern is sulphate, which has a licence limit for surface water of 625 mg/L (daily average) at CP-1. In 2012, an environmental incident was reported, which led to a temporary exceedance of total phosphorous and suspended solids at MSE-1. This was due to a leaking pipe from the Drumgoosat Mine that became mixed with fines and entered the lagoons, resulting in the exceedance. The leaking pipe was repaired, and the exceedance was corrected within a few weeks.

Appendix 8.3 presents the analytical data for the five surface monitoring points associated with the mine water management system for 2012 to 2023 inclusive.

8.4.5 Groundwater - Hydrogeology

Groundwater is defined as water that moves through and is stored within sub-terrain geological strata. The groundwater flow in the region is controlled by the topography and the underlying bedrock geology.

8.4.5.1 Aquifers

The existing open-cast area at Knocknacran Mine sits within a 'poor' bedrock aquifer unit (Figure 8.7), as does the majority of the Plant Site, proposed Community Sports Complex, and eastern side of the Knocknacran West Open-Cast Mine site. The western side of the Knocknacran West Open-Cast Mine site sits within a bedrock aquifer that is considered to be a 'Locally Important Aquifer – bedrock which is generally moderately productive'. Another Locally Important bedrock aquifer unit occurs to the east in the area of the discharge from the mine site to the River Bursk.

8.4.5.2 Water Supply

Public Water Supply Schemes

Three public water supply schemes (PWS) are located within 7 km of the Application Area (Figure 8.7).

- Carrickmacross PWS (comprising the Monanny borehole, and the Nafferty spring and borehole);
- Kingscourt Mullantra PWS (BW01); and
- Kingscourt Descart PWS (BW02 and BW03).

Carrickmacross PWS

The Carrickmacross PWS (Figure 8.7) is a mixture of surface and groundwater supply based on a karst aquifer producing ca. 1,700 m^3/d. The Monanny borehole, and Nafferty spring and borehole, are located over 6 km to the northeast of the Application Site. The supplies do not have source protection reports but the EPA states that Monanny borehole is 97 m deep and derives groundwater from karstified limestone (the Milverton Group). The Milverton Group forms a hydraulically disconnected groundwater system from the lithologies underlying the Site.

Kingscourt Mullantra PWS

Groundwater well BW01 is located about 2 km to the southwest of the Site (Figure 8.7). Based on the source protection zone report, it is drilled to a depth of 120 m, with a screen located between 71 and 113 m bgl.

BW01 has a typical abstraction rate of around 375 m^3/d from the Kingscourt Sandstone Formation. The source zone protection report says that the majority of the sandstone aquifer footprint is confined by the overlying low and moderate permeability subsoil deposits. It is mainly recharged at areas of bedrock outcrop along the Kingscourt Fault scarp to the west of the borehole. This suggests that the borehole is not abstracting water from the mining area and that the mine workings do not affect water levels within the well.

The isolation from the existing mining areas is further supported by the statement in the report that the sandstone aquifer appears to be '*hydraulically isolated from the gypsum aquifer by the low permeability basal layer of the sandstone and upper strata of the gypsum. Where the two aquifers are juxtaposed by faulting, the gypsum appears to be sealed off by a low permeability "gouge" of marl.'*

Kingscourt Descart PWS

BW02 and BW03 are located around 3.5 km southeast of the Site (Figure 8.7). Based on the source protection zone report, the wells are drilled to depths of 19 and 91 m, respectively. Their static groundwater levels are at, or above, ground level (i.e. they are artesian).

Pumping test results show that both wells have potential yields of around 1,000 m^3/d or greater from the dolomitised Milverton Group limestone. The source protection zone report says that the limestone unit is karstified and mainly recharged at bedrock outcrop, and through karst features on Barley Hill, and where the overlying subsoils are thin. Barley Hill is to the south of the wells, so groundwater flow is northwards towards the wells and discharges to the Lagan River.

The nature of the geology and discussion in the source protection zone report suggests that the boreholes are not abstracting water from the mining area and are located within a hydraulically disconnected groundwater system.

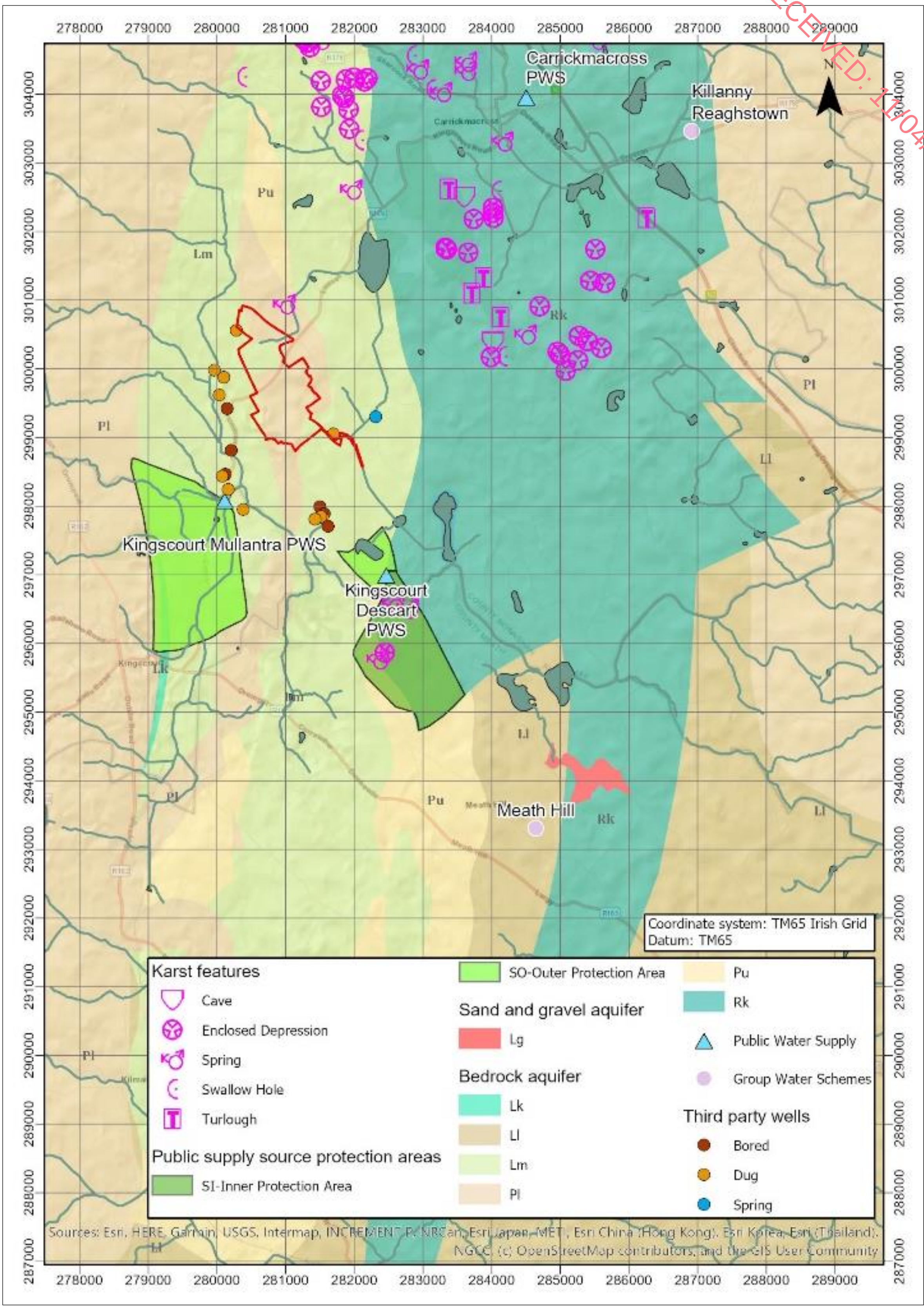

Figure 8.7: Bedrock Aquifer Map showing Aquifer Units and Groundwater Supplies (GSI)

Group Water Supply Schemes

In addition to the public water supplies, there are three group water schemes (GWS) within 10 km of the Site.

Magheracloone GWS

The closest private water supply scheme to the Site is Magheracloone Group Water Scheme, which supplies ca. 1,200 m^3/d of water to ca. 1,200 connections from its supply at Greaghlone Lough, ca. 4 km north of Drumgoosat Village. Properties in the vicinity of the mining area which do not have private supplies are connected to the Magheracloone GWS water supply network (Figure 8.8).

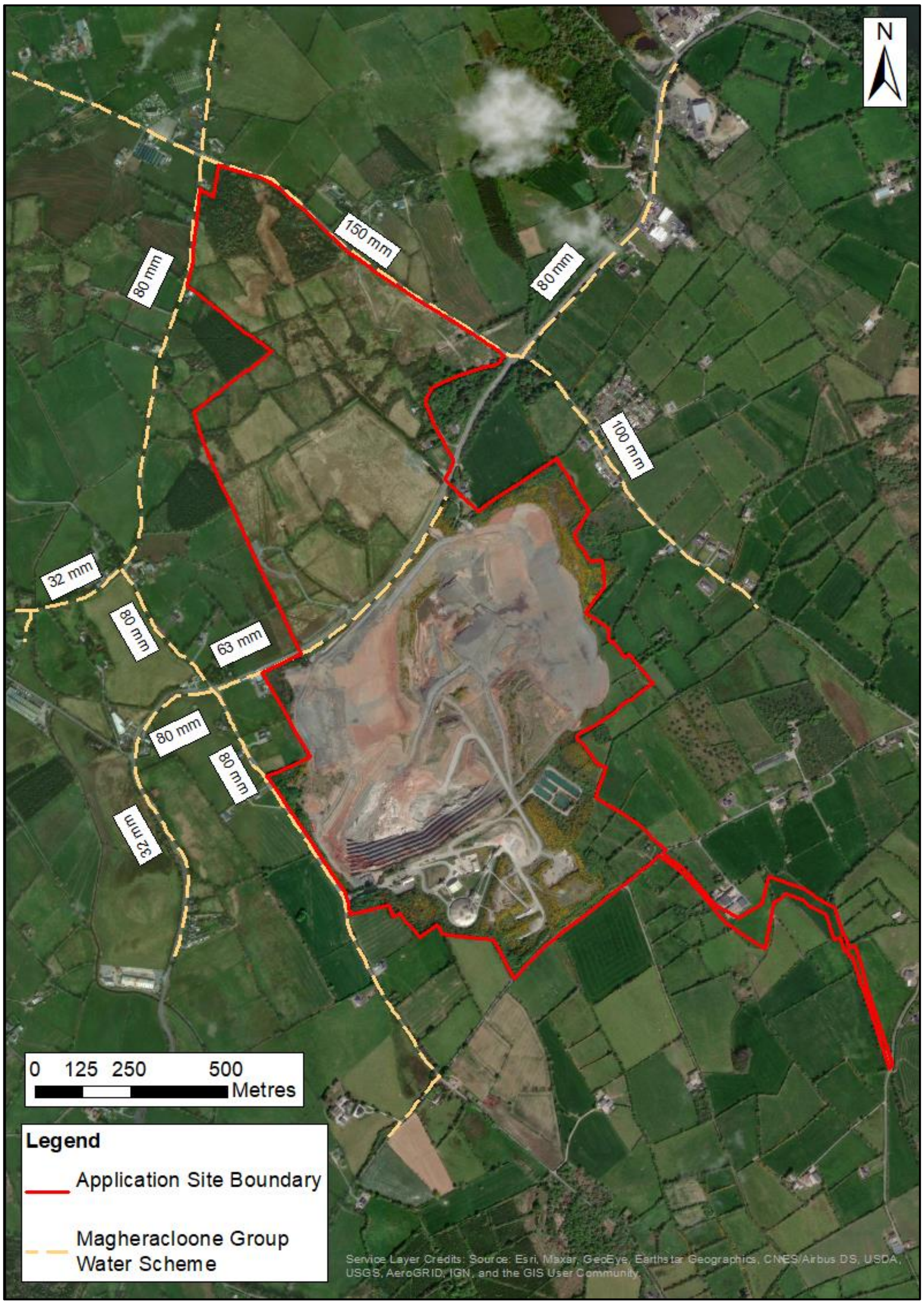

Figure 8.8: Magheracloone GWS water supply network in the vicinity of the Application Site

Greaghlone Lough is underlain by low permeability tills and lithologies of the Castlerahan Formation which is a poorly productive bedrock aquifer based on GSI mapping. The gypsum mining area is within a separate hydrogeological block and therefore does not have any hydraulic connection with the lough.

Meath Hill GWS

The Meath Hill GWS (Figure 8.7) is a groundwater source located ca. 7 km to the southeast (beyond Kingscourt Descart PWS). The borehole is located within the Tobercolleen and Lucan Formation (Carboniferous limestone) which forms an isolated 'locally important' aquifer between the 'poor' Ardagh Shale Formation to the west and 'regionally important' Milverton Group to the north and west. All available data and monitoring results suggest that there is no hydraulic connection with the gypsum mining areas.

Killanny Reaghstown GWS

Killanny Reaghstown GWS (Figure 8.7) abstracts groundwater from two boreholes in the regionally important Milverton Group aquifer ca. 7 km to the northeast of the site. As outlined in the source protection plan for the Kingscourt Descart PWS wells, boreholes of the Milverton Group do not abstract water from the mining area and are located within a hydraulically disconnected groundwater system.

Domestic Groundwater Supplies

The national well database compiled by the GSI contains records of 43 private and public wells located within 3 km of the proposed Knocknacran West open-cast. Of these, 6 wells are used for public water supply, with the remainder used for agricultural or domestic purposes (where usage is known).

During a survey completed in September 2019, 22 third-party wells (and springs) were recorded within 500 m of the Application Site (Figure 8.9). A total of 15 are listed as being in use, but none are currently monitored regularly. Most were originally constructed to supply water to local housing and farms; 8 are boreholes, 11 dug wells, 2 are springs and 1 is an unknown well type. One publicly accessible 'healing spring' was recorded. Table 8.8 presents the water levels recorded in the wells during the survey (coordinates are in Irish National Grid and heights are relative to Malin).

Table 8.8 shows that the three wells which are proximal to the Site and in use (numbers 6, 7 and 8) are shallow, with a depth range 3.3 and 5.4 m. They have reported water depths of between 1.9 and 3.37 m below ground. They are located at a distance of between 370 and 500 m from the license boundary.

Table 8.8: Domestic Well Survey - September 2019

Sampling Location	Easting	Northing	Elevation (m)	EOH (m)	EOH (mOD)	Bored/dug	Water Level (m OD)	Water Level Depth (m)
1	298242	280163	33.12	-	-	Dug	32.2	0.92
2	298464	280124	36.71	45.7	-8.99	Bored	34.73	1.98
3	298437	280075	37.1	-	-	Dug	35.24	1.86
4	298812	280207	32.85	-	-	Bored	31.36	1.49
5	299420	280147	36.46	30	6.46	Bored	33.68	2.78
6	299618	280033	34.31	4.4	29.91	Dug	32.41	1.9
7	299877	280100	37.17	5.4	31.77	Dug	33.8	3.37

Sampling Location	Easting	Northing	Elevation (m)	EOH (m)	EOH (mOD)	Bored/dug	Water Level (m OD)	Water Level Depth (m)
8	299981	279962	33.54	3.3	30.24	Dug	31.16	2.38
9	281019	300769	41.89	-	-	Bored	33.59	8.3
10	300559	280283	47.67	4.8	42.87	Dug	45.62	2.05
11†	299302	282311	28.59	-	-	Spring	28.59	-
12*†	282146	298941	-	1.05	-	Spring	-	0.42
13	297993	281497	35.04	-	-	Bored	24.32	10.72
14	299053	281693	41.65	6.0	35.65	Dug	40.65	1.0
15	297889	281562	36.53	-	-	Bored	24.43	12.1
16	297833	281539	34.3	4.7	29.6	Dug	32.3	2.0
17	297847	281516	33.56	45.7	-12.14	Dug	16.49	17.07
18	297809	281428	41.32	3.8	37.52	Dug	38.57	2.75
19	297707	281618	42	-	-	Bored	24.85	17.15
20*	282174	297089	-	-	-	Bored	-	16.55
21	297951	280382	38.42	5.4	33.02	Dug	35.42	3
22*	-	-	-	-	-	-	-	-

(Note: † Spring' * Not accessible for surveying)

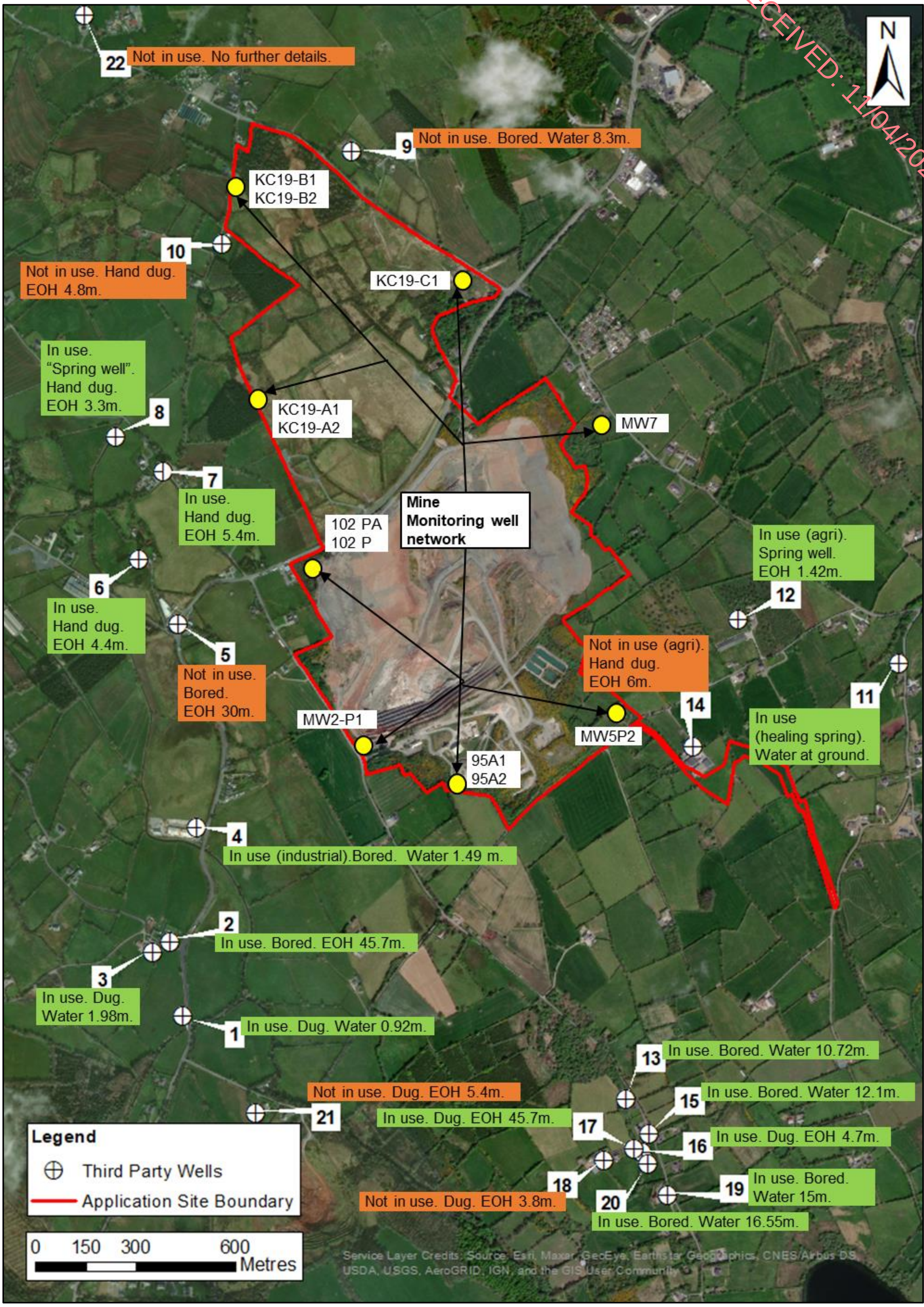

Figure 8.9: Third Party Wells within 500 m of the Site

8.4.5.3 Groundwater Basin

Groundwater basins have been defined by the GSI to determine the catchment areas and divides within areas, in a similar fashion to the river basins defined for surface water features. The Application Site occurs within the Louth Groundwater Basin (GWB) (IEGBNI_NB_G_019), which is characterized by '*poorly productive bedrock*'. The Application Site sits within the Neagh Basin River Basin District.

8.4.5.4 Bedrock Groundwater Units

The GSI has identified the following principal bedrock groundwater units in the area:

Kingscourt Sandstone Formation: Comprises Permo-Triassic sandstones to the west of the Site which are locally important aquifers ("bedrock which is generally moderately productive"). Drilling in the Kingscourt Sandstone Formation undertaken for a regional Kingscourt water supply shows well yields in the range of <10 m^3/day to day to >1,300 m^3/day. These well yields range between poor and excellent based on well yield classifications used by the GSI. The available data and monitoring results indicate no hydraulic connection between the Kingscourt Sandstone Formation and the mining area.

Namurian Sandstones and Carrickleck Sandstone Member: Namurian sandstones to the east of the site have also been classified as a locally important aquifer. The sandstones of the Namurian formation are poorly cemented and are often very weathered, which increases their permeability. Again, there is no indication of any hydraulic connection between the Namurian Formation and the mining area.

Milverton Group: Dinantian pure bedded limestones east of the Namurian sandstones are considered to be a regionally important karstified aquifer. The Milverton Group is remote from the mining area. The **Kingscourt Gypsum Formation** (central to the site) and the **Westphalian Shales** to the north are generally unproductive, except for local zones. Despite evidence of karstification within the gypsum units, which can potentially transmit groundwater over short distances, both units are classified as poor aquifers. In addition, the quality of water from the gypsum units may be unacceptable for human consumption as a result of high sulphate concentrations. The GSI describes these as *"bedrock which is generally unproductive except for local zones".*

Hydrogeological characterisation of the mine area (Minerex, 2019) also describes the Kingscourt Gypsum Formation gypsum and mudstone members as 'aquicludes'. Their low permeability restricts the flow of water between aquifer units, despite the evidence of local karstification in the gypsum. The dolerites which crosscut the formation tend to be altered in the locality of the Site (i.e. in many instances 'weathered' to 'free-diggable' doleritic sandy material). In places, the weathering process has created zones of enhanced permeability which is sufficient to support some localized flow over a small scale. The lateral extent of the dolerites along the eastern portion of the proposed open-cast is known from a number of boreholes and cross sections (details are provide in Figure 8.10 and Figure 8.11). Within the current Knocknacran open-cast, little seepage from doleritic material is observed which is consistent with compartmentalised and isolated groundwater flow.

Figure 8.10: Plan location for cross sections

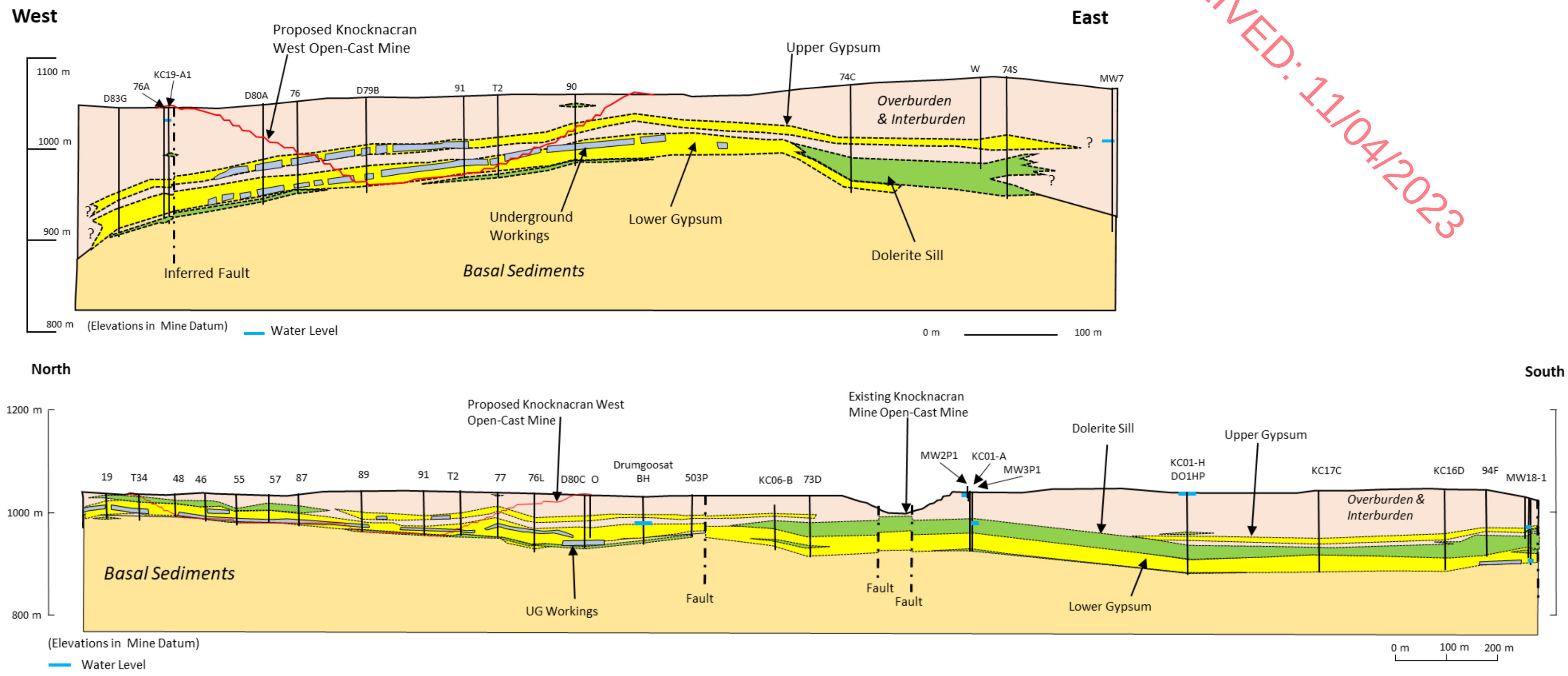

Figure 8.11: Cross section details

There are no mapped sand and gravel aquifers in the area. None have been identified in regional mapping and none have been identified locally during mining operations. However, the fluvial deposits that underlie the River Lagan between the Drummond Mine and the historical Cormey Mine may include some permeable horizons.

In summary, the gypsum deposits and the mudstones of the Kingscourt Gypsum Formation are essentially aquicludes and are compartmentalized, which restricts the flow of groundwater from one aquifer to another and are characterised by low permeability. The dolerites of the Kingscourt Gypsum Formation are characterised by minor and discontinuous local-scale flow where they have been altered in the vicinity of the Site.

8.4.5.5 Groundwater Vulnerability

'The vulnerability of groundwater depends on: (i) the time of travel of infiltrating water (and contaminants); (ii) the relative quantity of contaminants that can reach the groundwater; and (iii) the contaminant attenuation capacity of the geological materials through which the water and contaminants infiltrate. As all groundwater is hydrologically connected to the land surface, it is the effectiveness of this connection that determines the relative vulnerability to contamination. Groundwater that readily and quickly receives water (and contaminants) from the land surface is considered to be more vulnerable than groundwater that receives water (and contaminants) more slowly and in lower quantities. The travel time, attenuation capacity and quantity of contaminants are a function of the following natural geological and hydrogeological attributes of any area:

iv) The sub-soils that overlie the groundwater;

v) The type of recharge - whether point or diffuse; and

vi) The thickness of the unsaturated zone through which the contaminant moves.

*In summary, the entire land surface is divided into four vulnerability categories (*Table 8.9*): extreme **(E)**, high **(H)**, moderate **(M)** and low **(L)** - based on the geological and hydrogeological factors described above. This subdivision is shown on a groundwater vulnerability map. The map shows the vulnerability of the first groundwater encountered (in either sand/gravel aquifers or in bedrock) to contaminants released at depths of 1-2 m below the ground surface. Where contaminants are released at significantly different depths, there will be a need to determine groundwater vulnerability using site-specific data. The characteristics of individual contaminants are not taken into account.' GSI 1999.*

Table 8.9: Extract from 'Groundwater Protection Schemes', Department of the Environment and Local Government, Environmental Protection Agency, Geological Survey of Ireland, 1999

Vulnerability Rating	Hydrogeological Conditions				
	Subsoil Permeability (Type) and Thickness			Unsaturated Zone	Karst Features
	High permeability (sand/gravel)	Moderate permeability (e.g. Sandy subsoil)	Low permeability (e.g. Clayey subsoil, clay, peat)	(Sand/gravel aquifers only)	(<30 m radius)
Extreme (E)	0 - 3.0m	0 - 3.0m	0 - 3.0m	0 - 3.0m	-
High (H)	> 3.0m	3.0 - 10.0m	3.0 - 5.0m	> 3.0m	N/A
Moderate (M)	N/A	> 10.0m	5.0 - 10.0m	N/A	N/A
Low (L)	N/A	N/A	> 10.0m	N/A	N/A

Notes: (1) N/A = not applicable.
(2) Precise permeability values cannot be given at present.
(3) Release point of contaminants is assumed to be 1-2 m below ground surface.

Although all levels of groundwater vulnerability status are observed in the area surrounding the Site, much of the mining area itself has low to moderate groundwater vulnerability because of the low permeability and hydraulically bounded nature of the Kingscourt Gypsum strata. In addition, areas of low subsoil permeability provide a protective layer to the groundwater and correspond to a "low" vulnerability designation. Much of the Kingscourt Sandstone Formation to the west of the site shows a "moderate" to "high" designation, with localised areas of "extreme" vulnerability associated with alluvial deposits, as shown in Figure 8.12. The karstified Milverton Group limestones are prevalent to the east of the Site and have mostly been assigned "moderate" to "extreme" vulnerability status, with large portions of the area comprising of "rock at or near surface or karst" making it highly vulnerable. Within these areas, the local-scale groundwater vulnerability bears a close relationship to the cover of sub-soils.

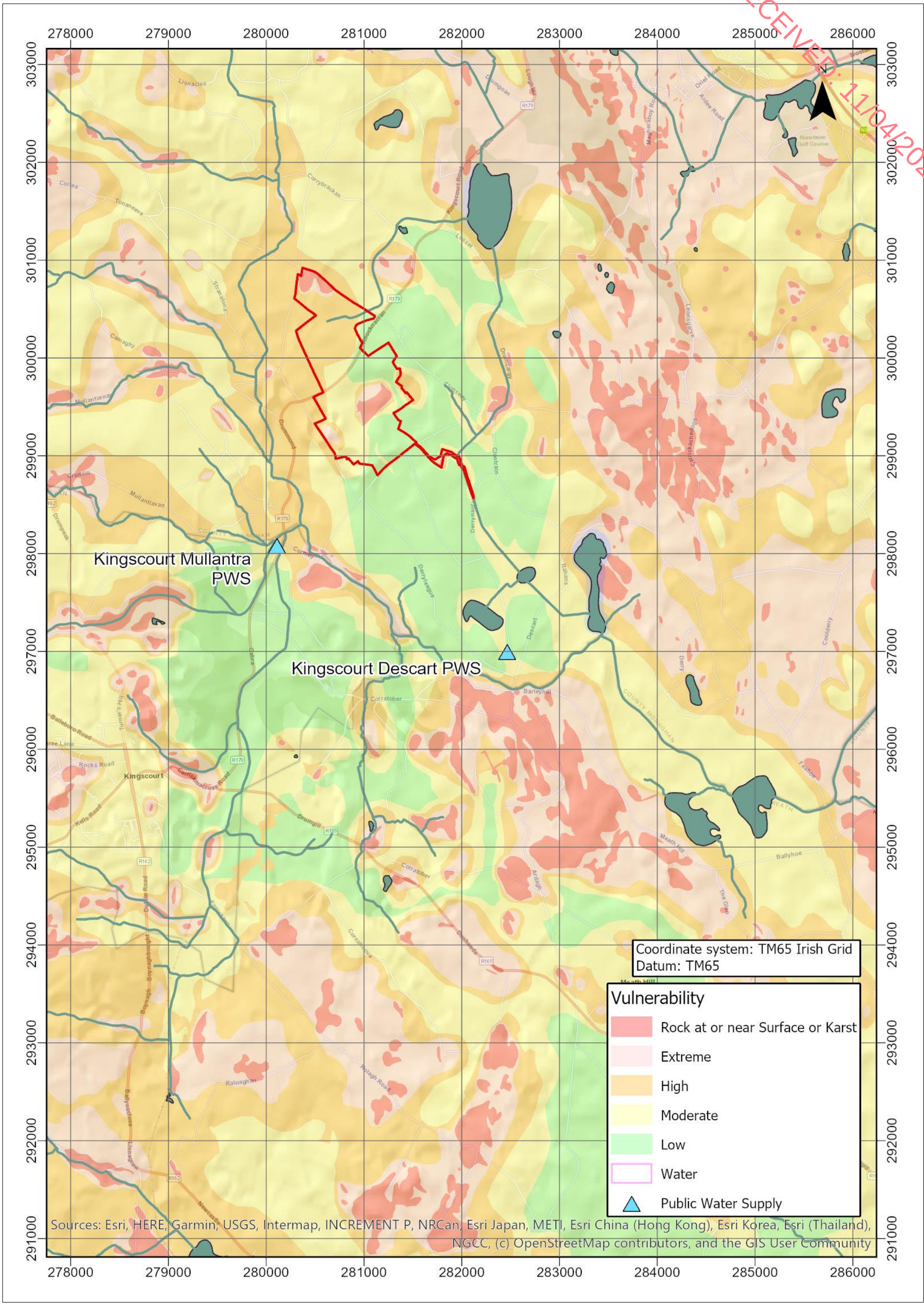

Figure 8.12: Groundwater Vulnerability Map (GSI)

8.4.5.6 Groundwater Recharge

Groundwater recharge in the area is mostly derived from infiltration of precipitation and local runoff. The national groundwater recharge map indicates that natural recharge may locally range between 1 and 800 mm per year (Figure 8.13). This is based on rainfall datasets held by the GSI that include annual rainfall, actual evapotranspiration, soil drainage, subsoil permeability, groundwater vulnerability and bedrock aquifer class.

According to the GSI maps, the recharge within the footprint of the mine area is typically 100 to 200 mm/yr, decreasing to less than 50 mm/yr above Drummond Underground Mine. The western margin of the Kingscourt Sandstone Formation is associated with higher recharge, between 350 to 550 mm per year, with small areas of higher (601 to 700 mm) recharge.

Recharge in Ireland primarily occurs between October and March when rainfall exceeds evapotranspiration (i.e. when the soil water is at field capacity). From March to October, the opposite is often true when the soil moisture is in deficit. A typical seasonal cycle of the soil moisture balance and recharge may be as follows:

- **Summer:** High rate of evapotranspiration and soil water removal; increasing soil moisture deficit; rainfall events cause near-surface infiltration, but the water is quickly removed from the soil profile by evapotranspiration. Little or no recharge;

- **Autumn:** High soil moisture deficit, which has been gradually built up over the summer months; infiltration from rainfall events is stored in the near-surface soils, even though evapotranspiration rates are low; little water percolates downward below the extinction depth to recharge;

- **Winter:** The soil moisture deficit that was built up during the summer months becomes progressively replenished by on-going infiltration due to precipitation events. At some point, the soil moisture deficit is used up, breakthrough occurs, and the percolating water moves downward below the capture zone of the root system. The water is able to move downward below the extinction depth and become recharge to the groundwater system; and

- **Spring:** The soils are fully saturated, and any rainfall is transmitted rapidly downward below the root zone to become recharge. This may also be the period of high water availability, so most or all of the annual recharge may occur during this period. As ambient air temperatures increase, so evapotranspiration rates also rise, and the soil moisture deficit starts to build up as summer approaches.

It should be appreciated that both the annual rainfall amounts, and the seasonal pattern of rainfall, are inherently variable, depending on seasonal precipitation events and longer term cycles. There have been a number of significant dry or wet periods over recent years. In any one year, the actual recharge is likely to be significantly different from the annual average. Low rainfall in winter and early spring may lead to lower-than-average recharge.

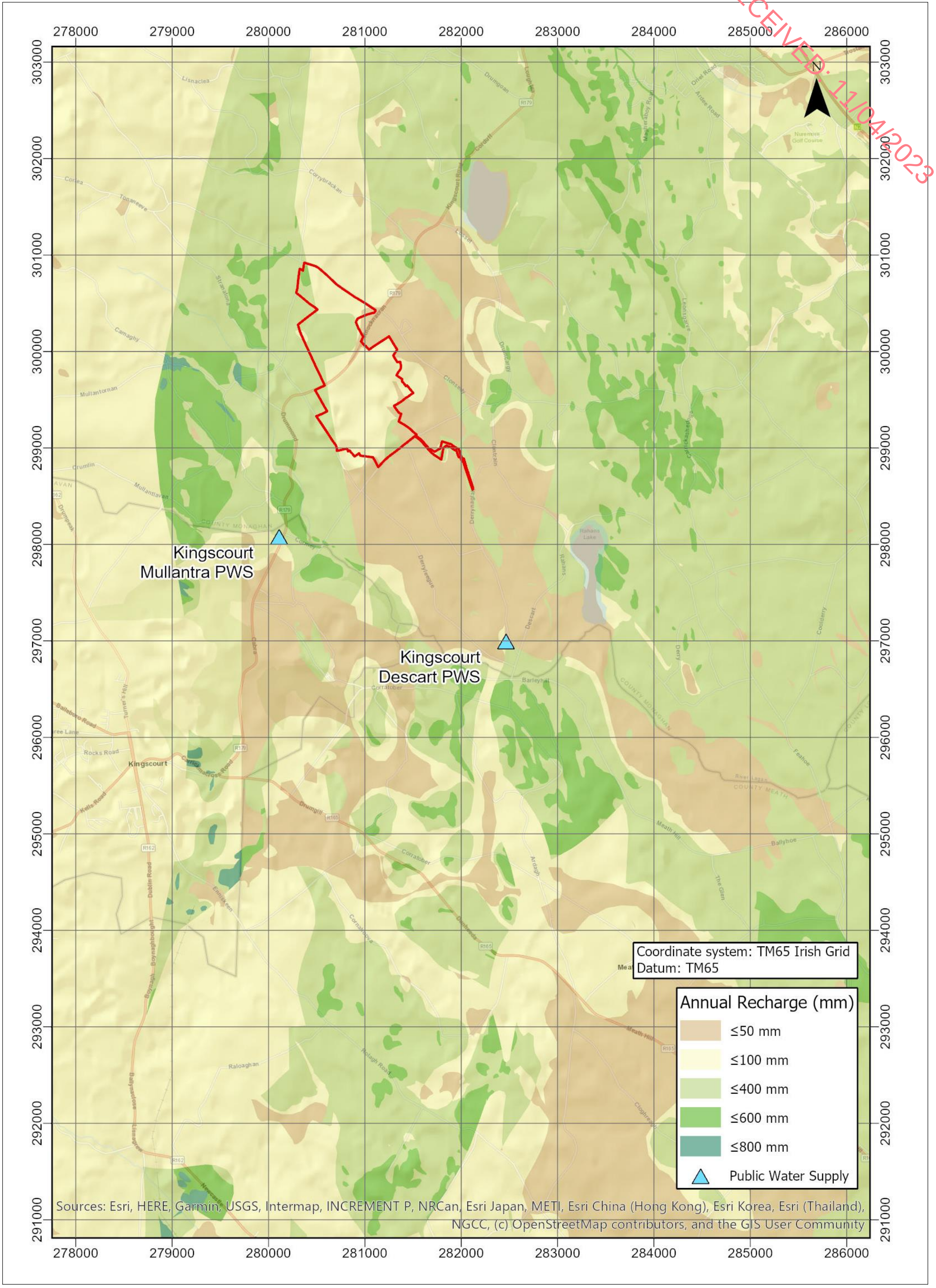

Figure 8.13: Aquifer Recharge Map (GSI)

8.4.5.7 Groundwater Inflows

Knocknacran Open-Cast Mine

The principal sources of inflow into the open-cast mine are from direct precipitation and runoff from the sloped earthworks. There is some minor groundwater seepage from the superficial deposits and dolerite intrusions. The dolerites may have enhanced localised permeability relative to mudstone and gypsum and may cause isolated seepages to the side slopes of the excavation. The presence of gypsum beds within the mudstones indicates that the volume of recharge to depth is not significant; otherwise the gypsum would have been gradually removed by dissolution over time. During times of excess rainfall or when the quality of the mine water discharge doesn't meet the IE Licence values for sulphate and/or electrical conductivity, excess water is stored in the mine sump prior to being discharged.

Drumgoosat Mine

The former Drumgoosat Underground Mine reaches a maximum depth of around 100 m below ground level to the north and northwest of the Knocknacran open-cast. Historically groundwater inflows to the mine were low. During operations, connate water was encountered in solution pipes ranging from ca. 0.012 m to 0.08 m in diameter in the gypsum. The inflow from these solution pipes was limited, suggesting that these conduits were hydraulically isolated. No water was encountered in the dolerite in the Middle Mudstone. Small amounts of water were encountered in some of the faults.

The Drumgoosat underground workings were historically used to store mine water as part of the water management plan for the Drummond Underground Mine. Water was stored during times of low flow in the River Bursk, and was discharged when the flow rate and assimilation capacity of the river were higher, in line with the conditions in the IE Licence for the mine site. Since the subsidence event in September 2018, a water management plan that reduces the rate of discharge from the old Drumgoosat workings when required, and a discharge licence revised by the EPA to allow additional discharge volumes, has reduced the need for any seasonal storage of water. Where needed on any exceptional short-term basis, the substantial sump of the Knocknacran open-cast pit is now used for temporary water storage prior to discharge to the River Bursk.

Drummond Mine

Inflows to the workings at the Drummond Mine have been recorded at various times since the mine went into full production in 2005. All inflows are derived from groundwater. Historical inflows were between ca. 1,400 and ca. 2,200 m^3/d. Current inflows have since reduced from ca, 4,100 m^3/d following the inflow of water derived from the intersection of the fracture/fissure associated with the Drummond Mine Fault in 2018, to a seasonal range between 2,500 and 4,000 m^3/d.

8.4.5.8 Groundwater Chemistry

The Applicant carries out groundwater monitoring at a number of locations (13) around the Site (Figure 8.14), both upgradient and downgradient of the mine, in accordance with the IE Licence P0519-04. Quarterly monitoring is specified for pH, electrical conductivity, COD, calcium, sulphate, ammonia, chloride, manganese, barium, and TPH. In addition, the licence requires biannual monitoring of pH, electrical conductivity, calcium, sulphate, ammonia, nitrate, chloride, sodium, potassium, magnesium, alkalinity, and total petroleum hydrocarbons. Biannual reports are submitted for groundwater monitoring. Groundwater reports for 2012 to 2016 note recurrent exceedances of the site-specific upper guideline values in relation to chloride and total alkalinity in MW2-P1, located in overburden. In addition, exceedances of IGVs for ammoniacal nitrogen are noted for numerous samples, mostly in wells that are located in mudstone, dolerite, and gypsum. Other parameters that show temporary exceedances of reference values include alkalinity, calcium, and pH; but they are not persistently elevated and can be attributed to the nature of the underlying geology.

The Minerex 2018 Annual Monitoring Report presents water quality plots for the monitoring wells. The plots are included in Appendix 8.4. The monitoring well locations and depths are presented in Figure 8.14 and Figure 8.15, respectively. In general terms, the groundwater of the area is near-neutral pH; with high chloride and sodium and moderate sulphate and calcium levels. However, each monitoring location tends to have at least one parameter which is an exception to these generalisations. There does not appear to be any correlation with regards to lithology, depth or location (except MW1 and MW3), suggesting that groundwater quality is localised and is primarily controlled by local flow conditions and the interaction of the specific combination of lithologies in that area.

Alkalinity is mostly high but is also variable between sampling locations. For samples that have high alkalinity, the sulphate and calcium are relatively low, suggesting that the water has not had significant residence time within any of the gypsum horizons. Samples that have high sulphate also tend to show high calcium (this is expected) and sodium which suggests the water has had contact with gypsum and other evaporite lithologies. The high pH values (> pH 8) indicate an external influence, possibly cement from the well construction.

Any groundwater that comes into contact with gypsum will, in principle, cause gypsum to dissolve, provided the water is unsaturated. The rate of dissolution is dependent on the extent of under-saturation and also the pH of the water (lower pH = faster dissolution). None of the groundwater samples obtained to date appear to be saturated with respect to gypsum. Therefore, there is the potential for dissolution of gypsum to occur, although the pH is typically neutral. Overburden groundwater levels tend to have the lowest pH, so the greatest potential for dissolution is where these waters have contact with gypsum such as in the wall of the open-cast excavation.

The ability for gypsum dissolution to cause mechanical changes to the formation is more likely to be a function of kinetics (physical movement) and not of thermodynamics (degree of under-saturation and pH). The kinematics of crystalline gypsum dissolution in Palaeozoic and Mesozoic rocks is typically slow and tends to be associated with water movement rather than thermodynamics. If flow through the wall rock is sufficiently slow, gypsum will dissolve, reach equilibrium and then begin to re-precipitate.

The data in Table 8.10 provides a summary of the groundwater quality for the monitoring boreholes located at 13 of the monitoring locations shown in Figure 8.14, between 2003 and 2022. MW1-P3 shows a significant change in groundwater quality as a result of intersecting the Drummond Mine Fault. The water goes from having relatively low concentrations of all parameters and elevated pH (unlike any other water type), to being similar to MW1-P1 and MW3-P2 (i.e. with relatively high sodium, calcium and sulphate).

Table 8.10: Summary of Groundwater Quality from 2003 to 2022

Lithology	Unit	Well	pH	Alkalinity	Chloride	Sodium	Calcium	Sulphate	Comment
Dolerite	Lr. Mudstone	MW4 P1	7 to 8	100 to 400	10 to 20	50 to 70	100 to 200	400 to 500	Comparable to M102-PA
Dolerite	Md. Mudstone	MW1 P1	7 to 8	100 to 400	40	50 to 100	500 to 600	1400 to 1900	Comparable to MW3-P2
Dolerite	Up. Mudstone	MW5 P1	7 to 8	400 to 1000	10 to 20	10 to 30	100	100 to 200	
Mudstone	Md. Mudstone	95 A 1 Deep	11 to 13	400 to 1000	10 to 40	10 to 30	Erratic	Erratic	
Mudstone	Md. Mudstone	MW3 P2	7 to 8	100 to 400	40 to 70	50 to 70	500 to 600	1400 to 1900	Comparable to MW1-P1
Mudstone	Up. Mudstone	MW1 P3	8 to 10	<50	10 to 20	10 to 30	100	100 to 1600	Pre-June 2018
			7 to 10	100 to 400	50	120	500 to 600	1400 to 1900	Post-June 2018
Till	OB	M102 PA	7 to 8	100 to 400	10 to 20	50 to 70	100 to 200	400 to 500	Comparable to MW4-P1
Till	OB	MW2 P1	6 to 7	500	60 to 80	10 to 30	200	100 to 600	
Till	OB	95 A 1 Shallow	11 to 13	100 to 400	10 to 20	10 to 30	100 to 300	10	
Till	OB	MW5 P2	7 to 8	100 to 400	10 to 20	10 to 30	100	10	Comparable to MW6-P1
Mudstone & Gypsum	Up. Mudstone	01JP S	10 to 13	400 to 1000	10 to 20	10 to 30	50 to 600	Erratic	
Sandstone	Namurian	MW6 P1	7 to 8	100 to 400	10 to 20	10 to 30	100	100 to 200	Comparable to MW5-P2
Sandstone	Namurian	MW3 P1	7 to 8	100 to 400	10 to 30	50 to 70	500 to 600	1400 to 1900	

Note: Higher than typical values are highlighted in orange and lower than typical in green.

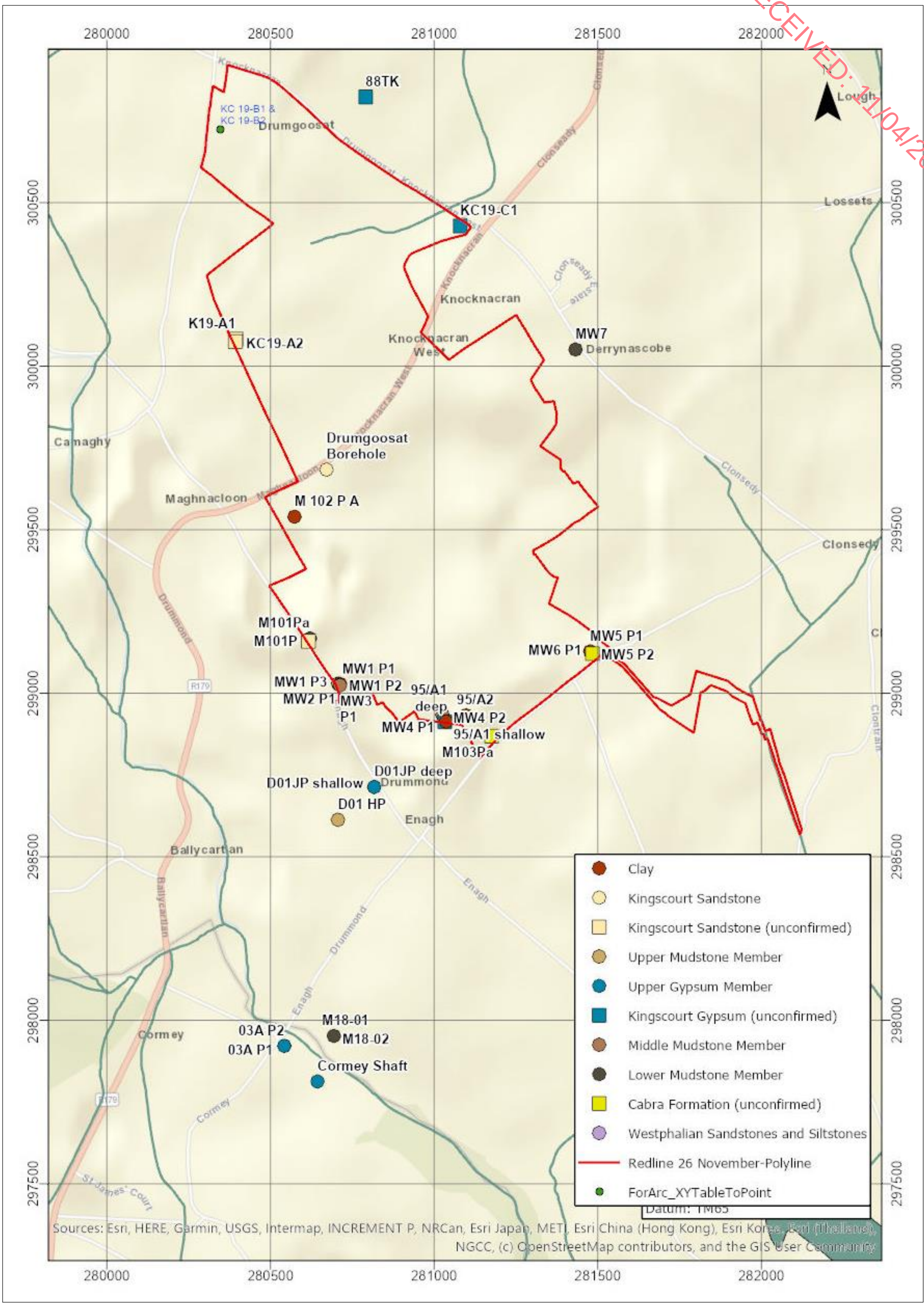

Figure 8.14: Groundwater well monitoring locations

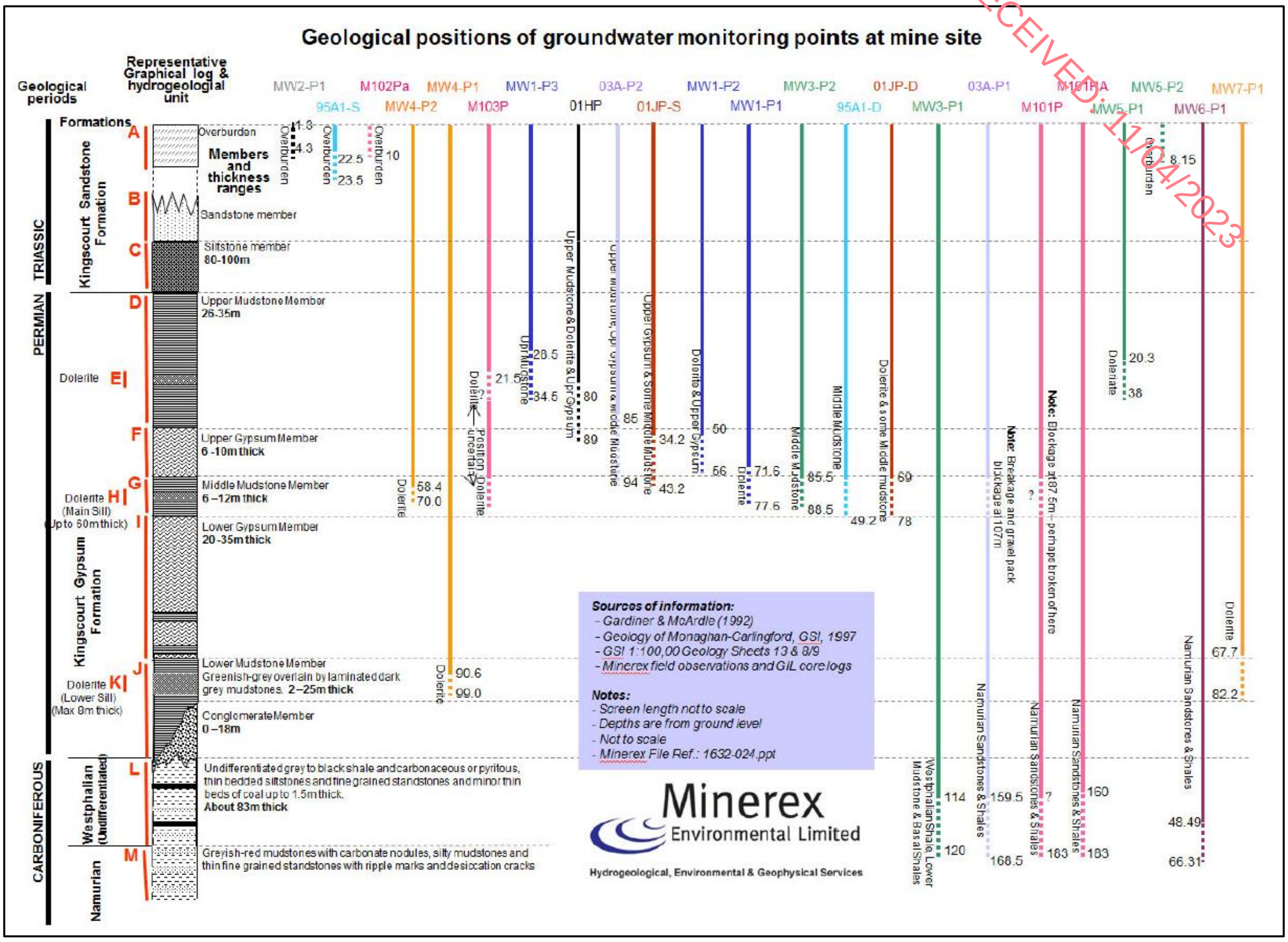

Figure 8.15: Groundwater monitoring well geological positions (Source: Minerex, 2019)

8.4.5.9 Groundwater Levels

General

Groundwater level monitoring data have been compiled by Minerex and are available for a 40 year period (1981 and 2022). Data for the wells with multiple years of data were analysed. The locations of the wells are shown in Figure 8.16. Of these:

- Six wells are in "clay" superficial deposits (till);
- Seventeen wells are in the Kingscourt Gypsum Formation (five in Upper Mudstone; four in Upper Gypsum; six in Middle Mudstone; two in Lower Gypsum; and none in Lower Mudstone); and
- Six wells are in the Namurian Sandstone Formation, including the well drilled into the Drumgoosat underground workings to control water levels in the interconnected mine area.

The wells are colour-coded by stratigraphic position by Minerex (Figure 8.15). Recent groundwater levels (July 2021) are shown on Figure 8.16 and in Table 8.11.

In addition, 5 wells were established on the Knocknacran West site in 2019 as monitoring wells in advance of the Proposed Development. The location of the onsite wells, KC19-A1, KC19-A2, KC19-B1, KC19-B2, and KC19-

C1 is shown on Figure 8.14. The groundwater monitoring elevations for these wells from June 2019 to July 2022 are presented on Figure 8.17.

Table 8.12 shows water levels for monitoring points in the South Drummond area only. Groundwater hydrographs between January 2013 and January 2023 are shown in Figure 8.18 to Figure 8.23. Drawdown levels described here are based on average groundwater levels reported over the past 10 years of monitoring (where available), this includes times when water was pumped both from and into the Drumgoosat workings. Water levels in the overlying superficial deposits are very localized and are not impacted by any of the mining operations. Water levels in the surrounding bedrock units are isolated from the Kingscourt sequence because of the bounding faults and lithological changes along the dip and strike of the Kingscourt strata. Consequently, changes in water level in the Drumgoosat mine due to pumping do not influence water levels in the adjacent groundwater units.

Knocknacran West Wells – Established in 2019

KC19-A1 was completed in sandy dolerite to a depth of about 74 m. KC19-A2 was completed in the Lower Seam Gypsum to a depth of about 120 m. The collar elevations are about 43 mODM and the depth to water is typically in the range of 8 to 12 m. Both completions show some degree of drawdown, but with no direct hydraulic connection to the Drumgoosat workings, illustrating the compartmentalized nature of the Kingscourt Gypsum sequence immediately to the west of the mining area, likely because of a north-south structural trend.

Similarly, KC-19B1 is completed in upper mudstone and dolerite to a depth of about 61 m. KC19-B2 is completed in the Lower Seam Gypsum to a depth of about 86 m. The collar elevations are about 55 mODM. The depth to water is typically in the range of 23 to 27 m. Again, both completions show the influence of some drawdown, but no direct connection to the Drumgoosat workings.

KC-19-C1 is located on the up-dip side of the proposed Knocknacran West open-cast. Its collar elevation is about 42.4 mODM. KC-19-C1 is completed in weathered dolerite to a depth of about 61 m. Over the monitoring period since mid-2019, the reported water level has fallen from about -6 m to about -9 mODM (Figure 8.17), which indicates a connection to the existing Drumgoosat workings and, in the future, to the proposed Knocknacran West open-cast. Observations elsewhere in the Kingscourt Gypsum sequence suggest there is less hydraulic compartmentalization in the gypsum sequence on the up-dip (east) side of the mining area.

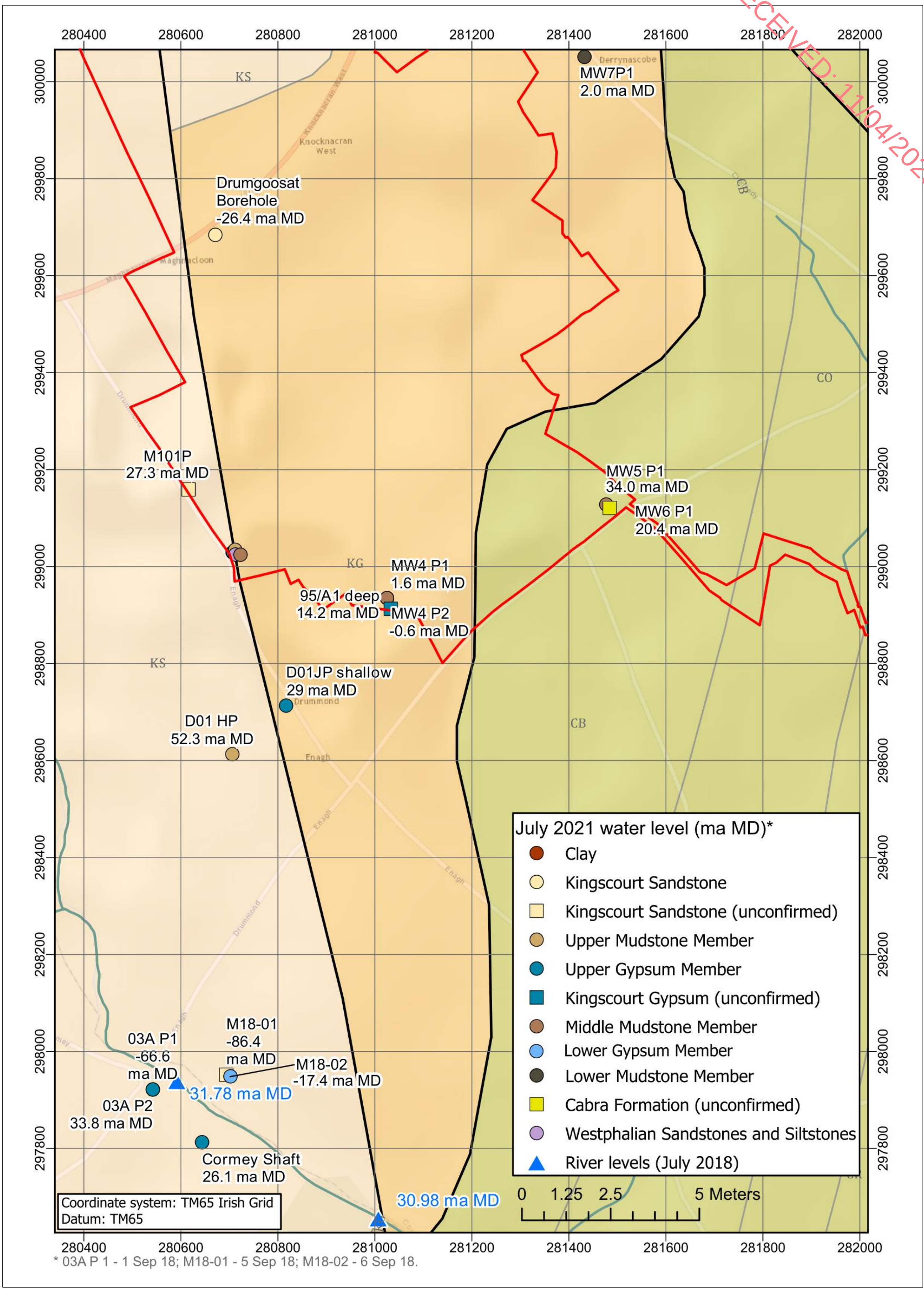

Figure 8.16: Currently recorded groundwater levels (July 2021)

Table 8.11: Recent groundwater levels in all available monitoring wells

Monitoring Point	Hydrogeological Unit	Date	Water level elevation (m OD Malin)	Inferred Drawdown from Baseline (m)
1 H P	Upper Mudstone Member	24 Mar 21	52.3	0
1 J P Shallow	Upper Gypsum Member	05 Aug 20	29.0	36.0
1998 - Cormey Shaft	Upper Gypsum Member	21 Jul 21	26.1	38.9
95 A 1 Deep	Middle Mudstone Member	01 Jul 21	14.2	21.8
95 A 1 Shallow	Clay	26 Mar 20	36.3	0.0
Drumgoosat Dewatering Well	Kingscourt Sandstone	09 Aug 21	-26.4	-12.6
M 101 P	Kingscourt Sandstone	21 Jul 21	27.3	19.7
M 102 P A	Clay	17 Jul 19	38.8	0.2
MW 1 P 1	Middle Mudstone Member	01 Jul 21	-23.4	70.4
MW 1 P 2	Upper Gypsum Member	01 Jul 21	-7.6	54.6
MW 1 P 3	Upper Mudstone Member	01 Jul 21	38.0	9.0
MW 2 P 1	Clay	01 Jul 21	45.2	1.8
MW 3 P 1	Westphalian Sandstones and Siltstones	01 Jul 21	-14.9	61.9
MW 3 P 2	Middle Mudstone Member	01 Jul 21	-23.9	70.9
MW 4 P 1	Lower Mudstone Member	01 Jul 21	1.6	63.4
MW 4 P 2	Middle Mudstone Member	01 Jul 21	-0.6	65.6
MW 5 P 1	Middle Mudstone Member	21 Jul 21	34.0	17.0
MW 5 P 2	Clay	21 Jul 21	49.6	1.4
MW 6 P 1	Cabra Formation	01 Jul 21	20.4	30.6
MW 7 P 1	Lower Mudstone Member	25 Mar 21	2.0	49.0
O3A P 2	Upper Gypsum Member	21 Jul 21	33.8	0.3
MW 18 2	Upper Gypsum Member	06 Sep 18	-17.4	79.8
MW 18 1	Lower Gypsum Member	01 Sep 18	-86.4	148.8
O3A P 1	Namurian Sandstone	01 Sep 18	-66.6	100.0
Drummond E 4	Lower Gypsum	01 Aug 18	-79.6	77.0
Drummond E 7	Lower Gypsum	01 Aug 18	-70.7	68.1
1 J P Deep	Middle Mudstone Member	01 Apr 14	43.8	18.6
M 101 P A	Lower Mudstone Member	01 May 10	49.1	-11.7
M 102 P	Clay	01 Apr 09	39.2	-2.8
95 A		01 Nov 05	64.9	-2.5
96 A		01 Nov 05	75.8	-3.4
95 A 2	Clay	01 Oct 05	38.5	-11.1
M 103 P	Upper Mudstone Member	01 Aug 05	29.8	4.6

Table 8.12: Water levels for South Drummond area monitoring points

Monitoring Point	Hydrogeological Unit	Date of Measurement	Water level elevation (m ODM)
River Lagan		Sep 2018	31.0
O3A P2	Upper Gypsum Member	01 Jul 2021	34.2
1998 - Cormey Shaft	Upper Gypsum Member	01 Jul 2021	26.6
MW 18 2	Upper Gypsum Member	06 Sep 2018	-17.4
O3A P 1	Namurian Sandstone	01 Sep 2018	-66.6
MW 18 1	Lower Gypsum Member	01 Sep 2018	-86.4

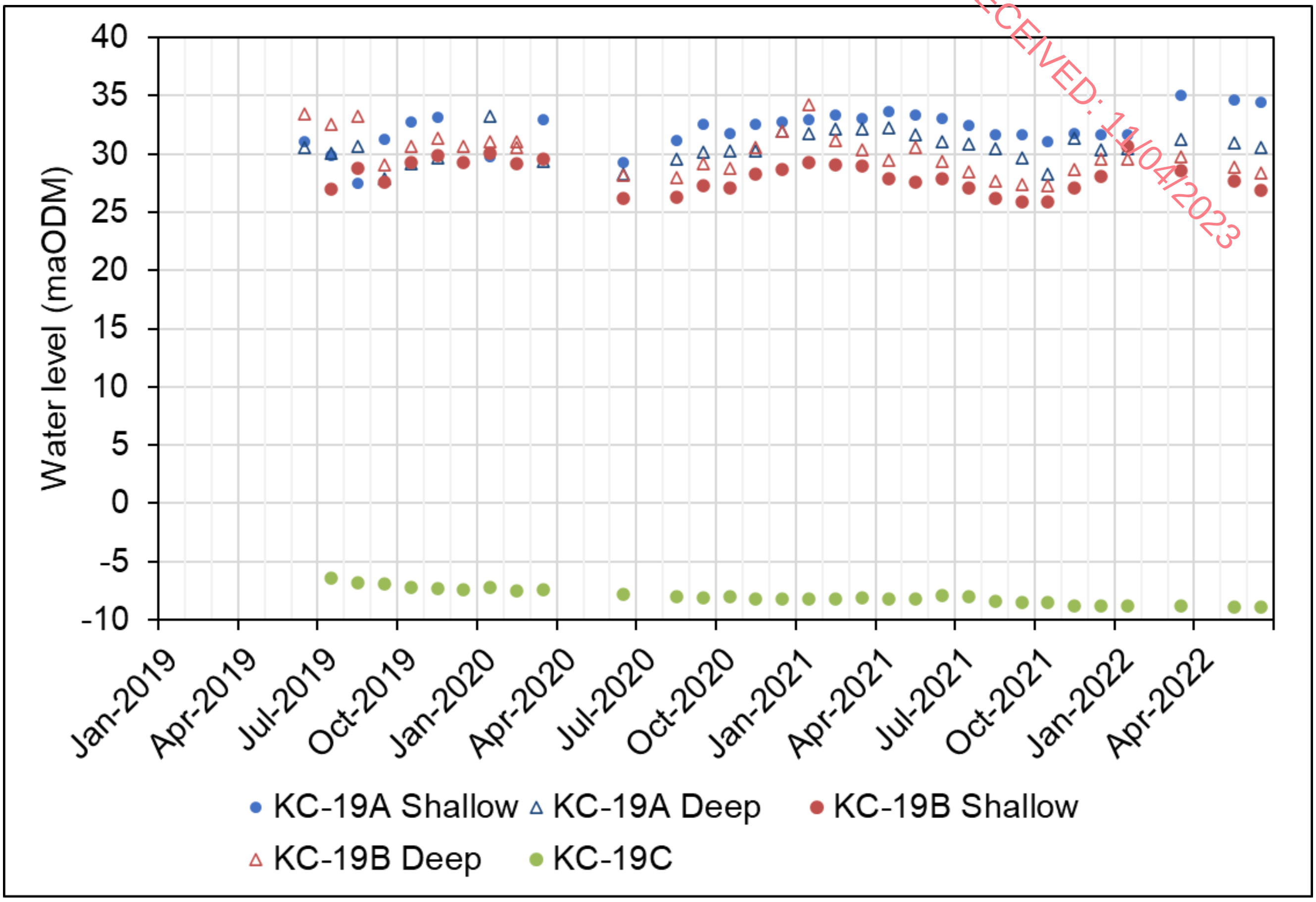

Figure 8.17: Groundwater monitoring elevations - Knocknacran West

Superficial Deposits

Figure 8.18 shows the hydrographs for the six wells representative of superficial deposits (mostly till) between January 2003 and January 2023. The observed water levels range between 28 m OD (95 A2) and 50 m OD (MW5 P2). The water elevation typically reflects the local topography and the elevation of the well collar. The depth to water in the wells is typically in the range of 0.5 to 2 m. All wells show a seasonal fluctuation, except for 95 A1.

The largest seasonal fluctuation is typically seen in MW2 P1, located close to the northern margin of the Drummond underground mining area. This showed a water level reduction of about 3 m during the dry summer of 2018; recovering during the recharge period towards the end of the year. It does not appear to show any correlation with the increased inflows to the Drummond workings in 2018. There are no trends that would indicate long-term drawdown.

As is seen in other mining districts in Ireland (and worldwide), the behaviour of water levels in superficial deposits tends to be mostly independent of conditions in the underlying bedrock formation. The data from these six superficial wells are consistent with this. The underlying mine workings do not significantly affect the near-surface water balance in the superficial deposits. The seasonal fluctuation in MW2 P1 appears to be related to natural climatic cycles.

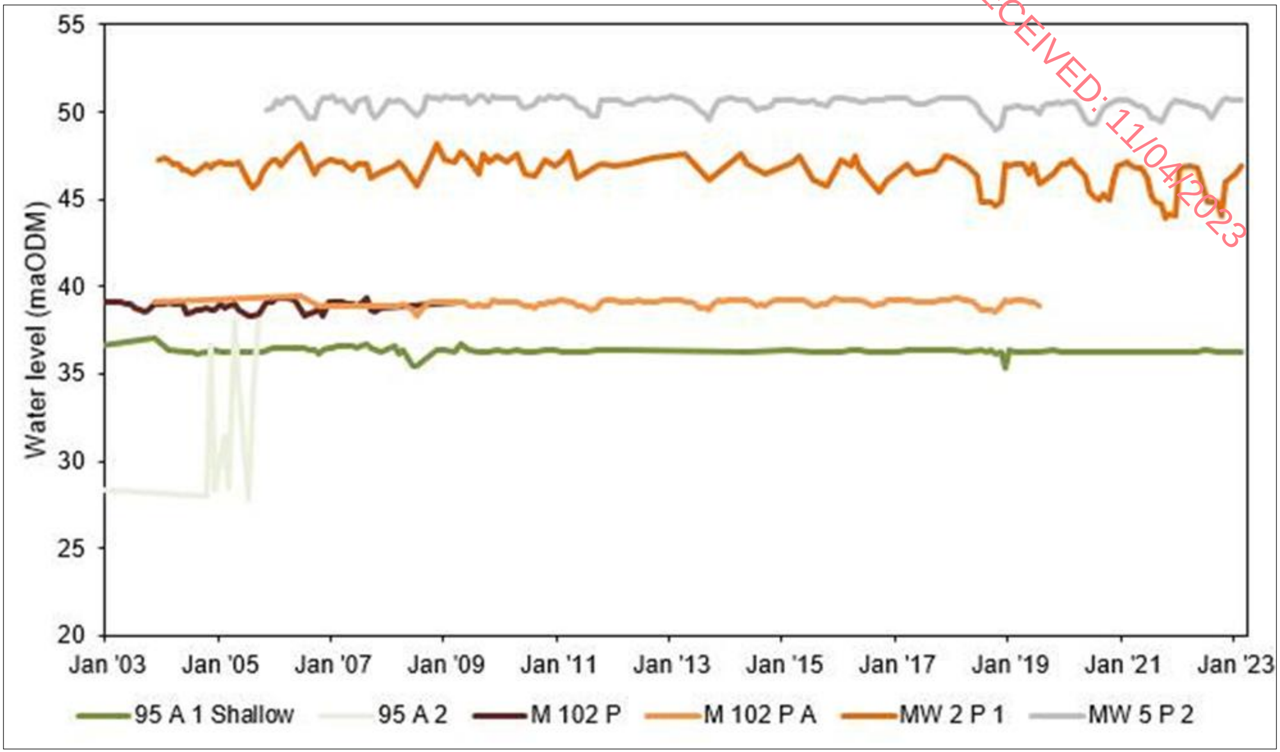

Figure 8.18: Hydrographs for wells screened in superficial deposits (till)

Kingscourt Gypsum Formation

Upper Mudstone Member

Monitoring data are available for three wells screened in the Upper Mudstone Member with records between January 2003 and January 2023 (Figure 8.19). Groundwater levels are above the inferred hydrogeological base level.

The record for M103 P ceased in mid-2005 but closely matched 1HP when concurrent data were available. Levels in 1HP have typically remained around 43 m OD since January 2005 and have shown a slight increase in the recent years. MW1 P3 shows a much broader range in level than 1HP, which is screened in the same unit. The reported groundwater elevation shows significant fluctuation between 15 m OD and 50 m OD since 2003, with greatest peaks correlating to wet winter periods. It is not apparent why the early water levels fluctuate.

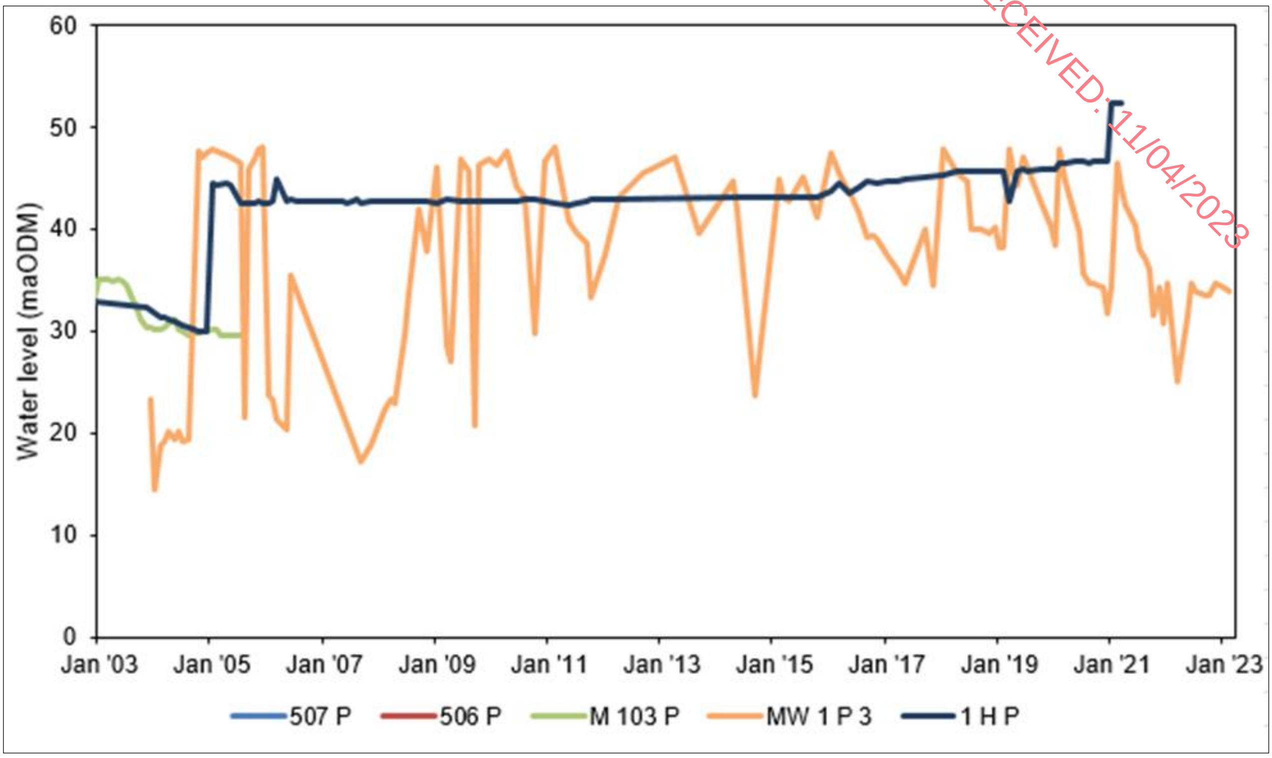

Figure 8.19: Hydrographs for wells screened in the Upper Mudstone Member

Upper Gypsum Member

There are four observation wells monitoring the Upper Gypsum Member (Figure 8.20). These typically have water levels around 10 m lower than the Upper Mudstone Member wells. This suggests a downward hydraulic gradient and indicates that significant downward groundwater flow does not occur.

Groundwater levels observed in MW1 P2 are about 35 m lower than in the other Upper Gypsum Member wells. The level was recorded at 18 m OD when monitoring began in February 2004 in this well. The drawdown may have been a response to early underground development in Drummond. Further drawdown occurred during 2006 and early 2007. The reason for the reported recovery in 2010 and the stable water level since June 2010 (- 8 m OD) is unclear, although it continues to be influenced by mining.

Monitoring data for the Cormey shaft have shown a slight downward trend since 2008. The reported water levels are representative of the Upper Gypsum Unit. A small amount of drawdown has progressively occurred as additional inflow zones were encountered in the Drummond Mine. There was a drop of about 1 m coincident with the increase in mine inflows in June 2018. The current water level is about 26.6 m OD (Figure 8.20).

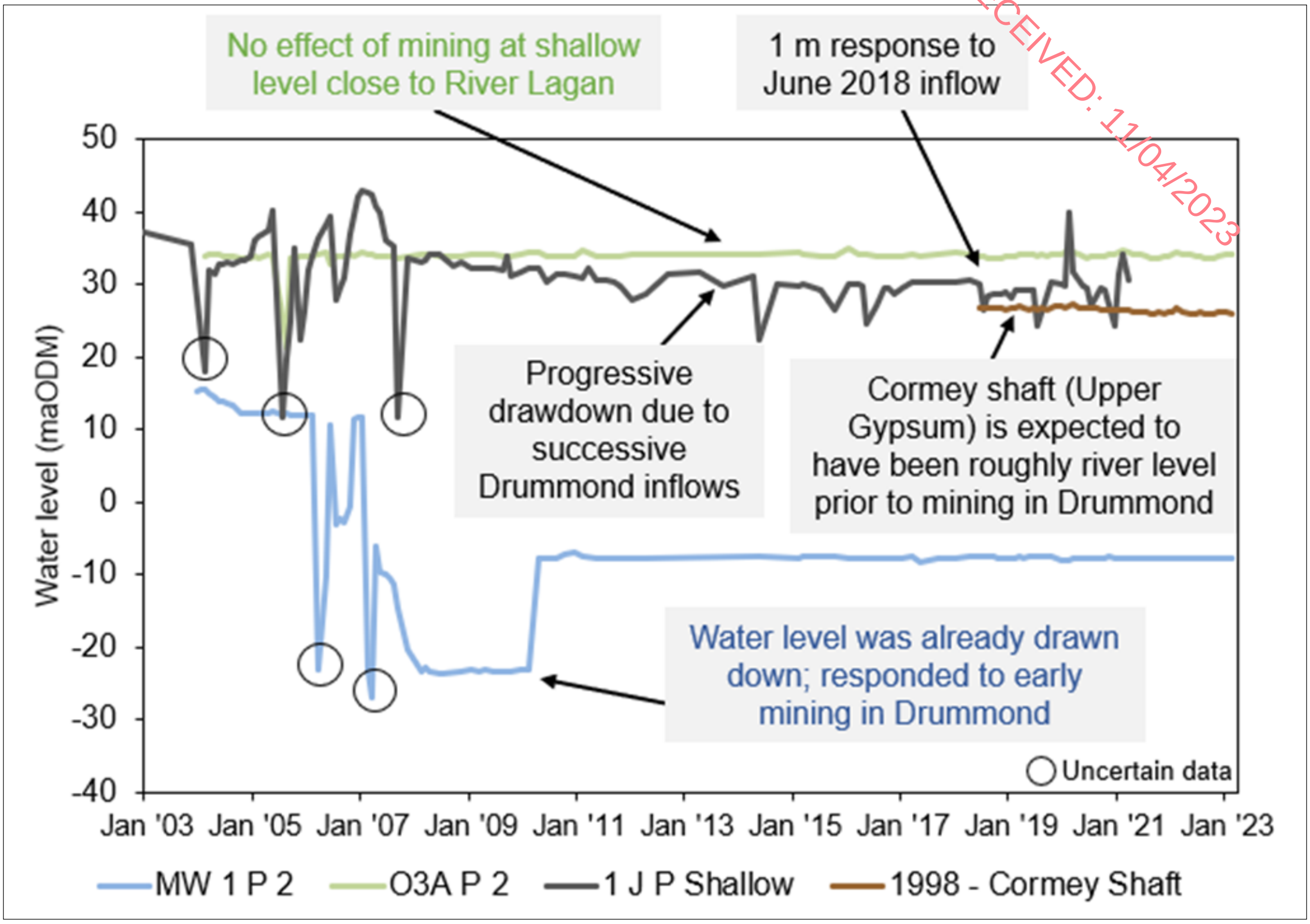

Figure 8.20: Hydrographs for wells screened in the Upper Gypsum Member

Middle Mudstone Member

Observation wells in the Middle Mudstone Member are shown in Figure 8.21. Overall, water levels show a much wider range than those seen in the upper units. This is due to proximity to mine workings and associated dewatering. All but two of the observation points (MW 5 P1 and 1 JP Deep) are below the hydrogeological base level. Key observations are as follows:

- Levels in MW5 P1 have remained stable at around 33 m OD since monitoring began in 2006 and do not appear to be impacted by mining;
- 1JP Deep increased from 22 m OD in November 2003 to 43 m OD in May 2005, where it has remained since;
- 95A1 Deep and MW4 P2 have shown similar trends, with levels declining gradually up until 2008 when they stabilised, and a slight rise in water level is seen in late 2018;
- M1 P1 and MW3 P2 have decreased in level by around 17 m and 35 m, respectively, with the main drop occurring in January 2007 (consistent with MW 1 P2 in the upper gypsum and M 101 P in the Namurian – albeit a more subdued response); and
- M1 P1 and MW3 P2 have had approximately the same reported groundwater level of around -23 m OD since January 2007.

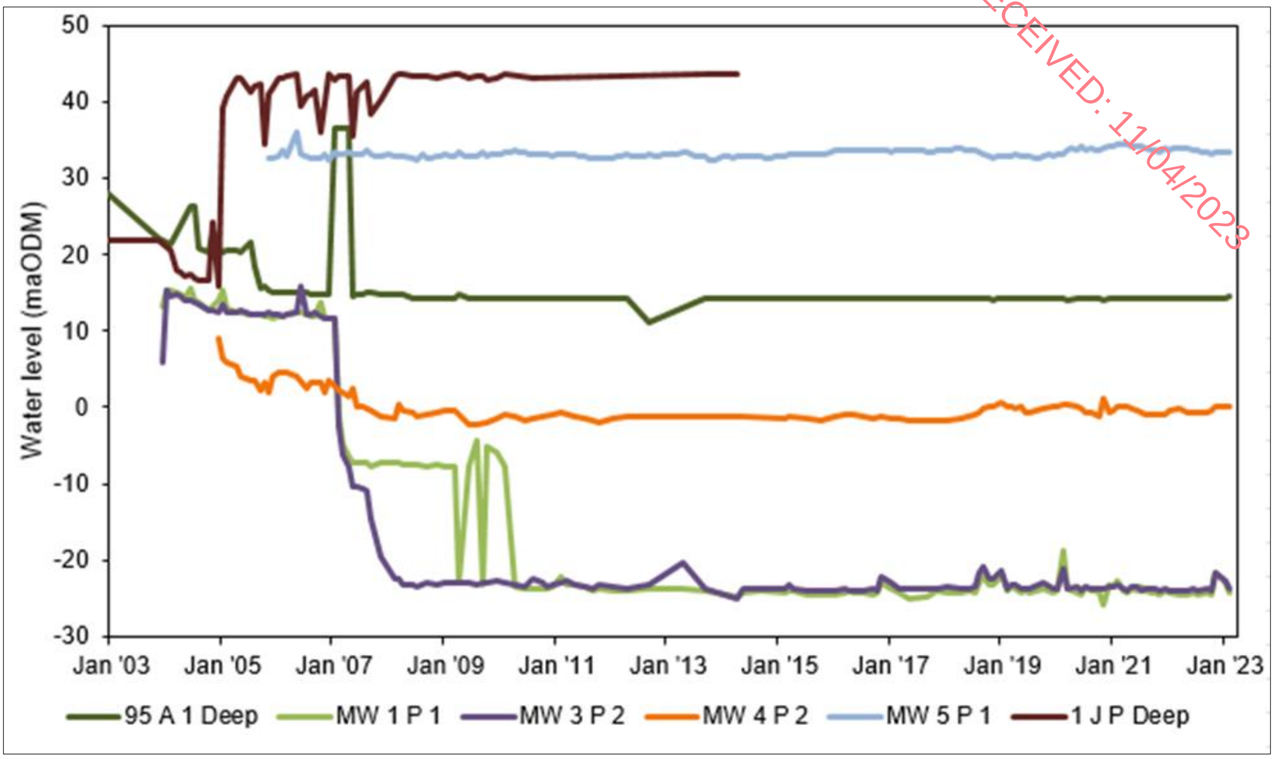

Figure 8.21: Hydrographs for wells screened in the Middle Mudstone Member (including dolerites)

Lower Gypsum Member

Observation wells in the Lower Gypsum Member (Figure 8.22) have shown little variation since monitoring started in about 2005. Reported water levels in MW4 P1 and MW7 P1 are very similar, but MW7 P1 fluctuates less than MW4 P1. Both wells have a reported water level of around 0 m OD which is significantly below the hydrogeological base level. However, neither well responds to the increase in Drummond Mine inflows in 2018.

Drummond E7 and MW18 2 are believed to be open in the Lower Gypsum Member. The level in Drummond E7 is approximately -65 m OD and the single water level measurement for MW 18 2 was 17 m ODM in September 2018. The borehole log for MW 18 1 shows it is open in a faulted interval of the Lower Gypsum Member. The water level had shown little variation until 2018 when a steep drop in water level was observed. This can be correlated with mining into a fracture zone associated with the Drummond Mine Fault in June 2018 (see Section 8.4.6). MW 18 1 and MW 18 2 are no longer monitored because of access constraints.

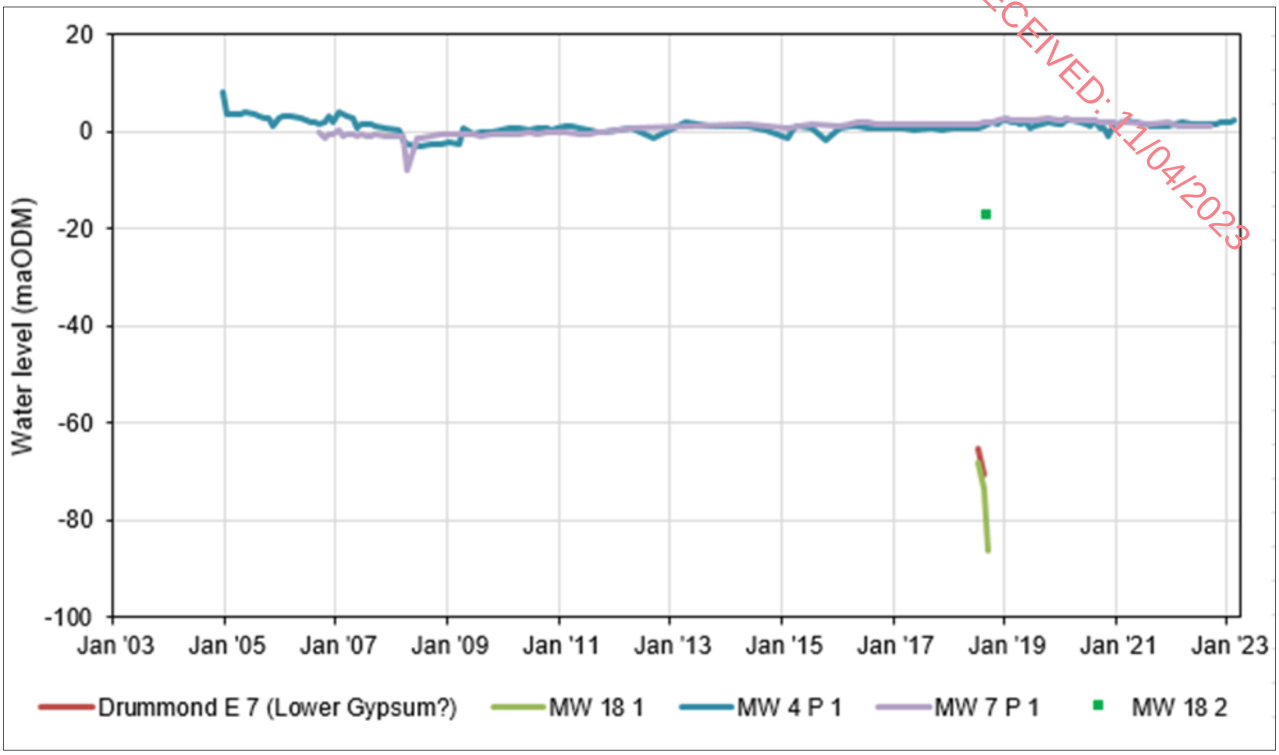

Figure 8.22: Hydrographs for wells screened in the Lower Gypsum and Lower Mudstone Member

Namurian Sandstone and Westphalian Shale

The Drumgoosat dewatering well is screened in Namurian sandstone. The monitoring data indicate that pumping maintained the water level at between -50 and -30 m OD until June 2018 (Figure 8.19), when water levels increased to around -5 m OD as a result of the increased inflow of water pumped from the Drummond Mine (see Section 8.4.6). The Drumgoosat dewatering well levels are approximately 80 m below the regional water levels reported for the Namurian sandstone, and the hydrograph shows a strong seasonal signature. Well levels have typically varied by around 10 m between seasons, but levels during the 2018 winter period exceeded those previously reported.

In addition to the Drumgoosat well/borehole, there are two observation wells screened in the Namurian sandstones (M101 P and MW6 P1). These are below their expected hydrogeological base level but show relatively little variation over the past 10 years (Figure 8.23). Between early January 2007 and January 2009, a decline in water level was observed in M101 P, from around 35 to 29 m OD. This response was not observed in MW6 P1, but was seen in MW 3 P 1 which is screened in the Westphalian Shales.

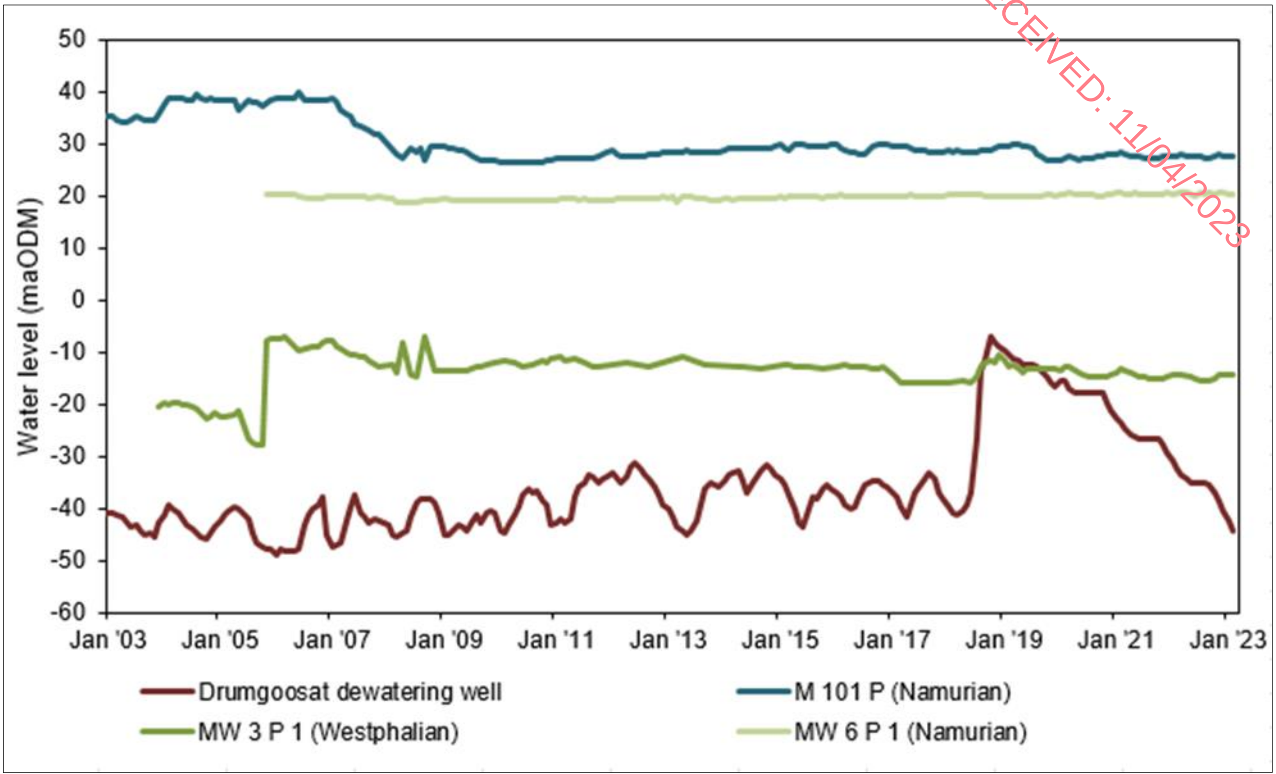

Figure 8.23: Hydrographs for wells screened in Namurian sandstone

Water levels in MW 3 P 1 (-10 to -20 m OD) are at least 30 m lower than the expected hydrogeological base level at that location, but remain relative stable from 2009 until early 2017, when a further reduction in level of around 3 m was observed. MW 3 P1 also shows a subdued response to the recent increase in water level in the Drumgoosat well.

There are no further apparent correlations between the water levels in the dewatering well and water levels in the observation wells. It is inferred that three of the observation wells have been influenced by historical mining to some degree, with only O3A P1 responding to recent mining activity.

Due to the hydraulic layering and poor connectivity of the geological units in the area, it is apparent that some lower units have become dewatered to variable degrees, while units above them remain unimpacted by mining. This is most notable with regards to the superficial deposits, but it also occurs in the bedrock due to the layering of the units with the Kingscourt Gypsum sequence and the presence of the dolerite sills.

Furthermore, below the Kingscourt Gypsum sequence, there are high groundwater levels in some of the underlying Namurian sandstone units compared to the overlying gypsum sequence.

8.4.5.10 Drawdown

Using the long-term water level records, the drawdown from original baseline for each monitoring well has been estimated as shown in Figure 8.24. Drawdown is greatest within the mudstone and gypsum members, as would be expected because these are the units where mine workings are present. There is some localised drawdown in the Kingscourt Sandstone and Namurian Sandstone units, some of which can be related to the penetration of the hydraulic barriers caused by the faults and lithological contacts (see Section 8.4.5.4).

Beneath the R179 and L4900 roads, about 70 m of drawdown has occurred within the Kingscourt Gypsum Formation as a result of historical mining and dewatering of the Drumgoosat Mine. The interpreted pre-mining groundwater level was likely around 38 to 39 m OD below the alignment of the road. Pumping from Drumgoosat underground has maintained dewatered conditions beneath the roads. It is expected that pumping from the Knocknacran West Open-Cast Mine will cause groundwater levels beneath the roads to remain low during the period of active operations. Any potential seasonal variation in groundwater level would be limited provided pumping from the workings is continuous.

All bedrock drawdown is relatively local to the mining areas. There is no indication of any regional-scale drawdown.

There is no apparent drawdown or influence of mining on the superficial deposits.

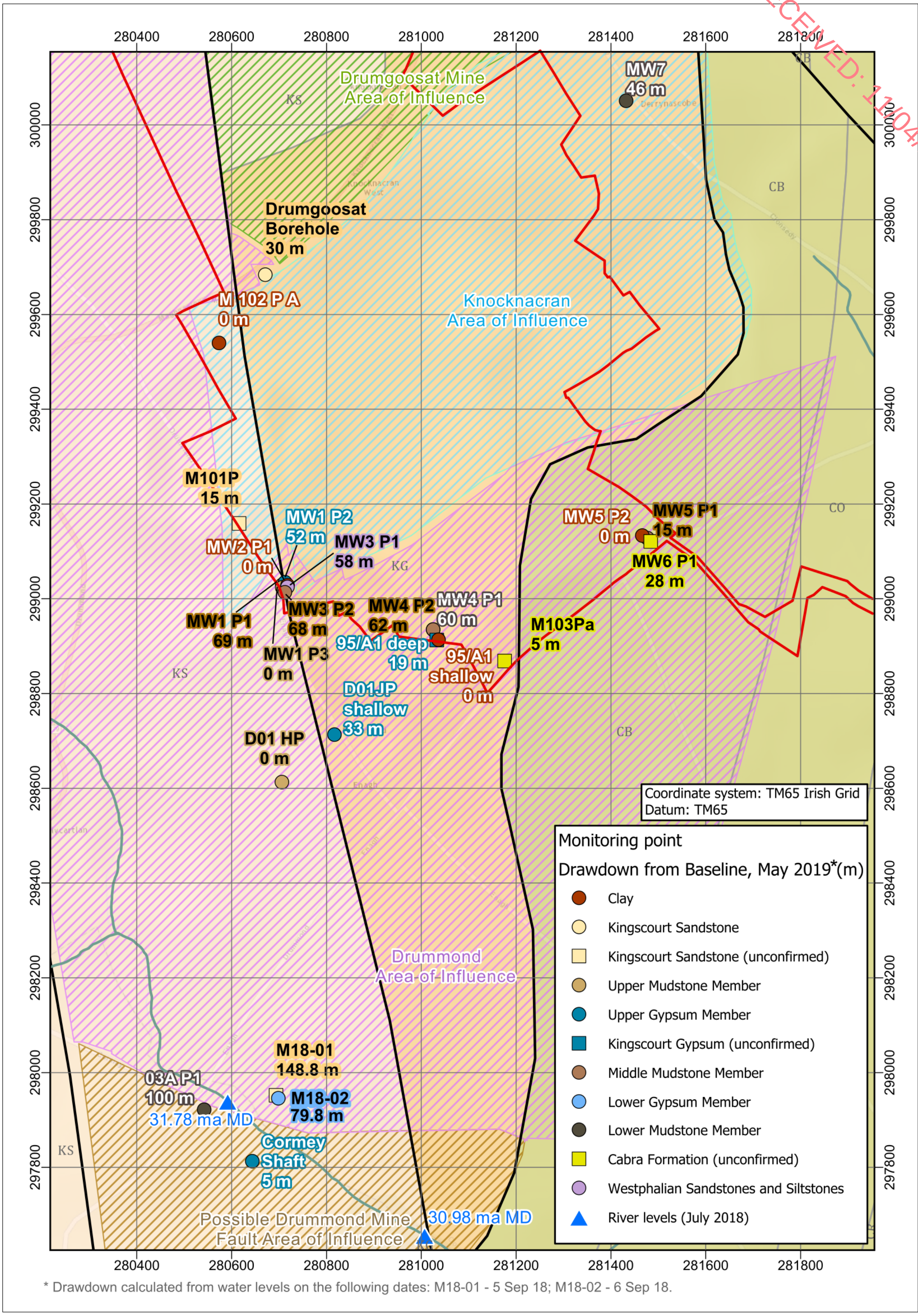

Figure 8.24: Interpreted monitoring well drawdown from baseline conditions

8.4.6 *Mine Water Volumes*

Drummond Underground Mine

All inflows to the active Drummond Mine are derived from groundwater. Historical inflows were between about 1,400 and 2,200 m³/d. Current inflows have since reduced from ca, 4,100 m³/d following the inflow of water derived from the intersection of a fracture/fissure associated with the Drummond Mine Fault in 2018, to a seasonal range of between 2,500 and 4,000 m³/d. About 50% of this water is estimated to be derived from the Drummond Mine Fault. The remainder of the inflows are derived from joints and fracture zones, as mapped on Figure 8.25, with much of the hydraulic connection thought to be from the Upper Gypsum Unit and/or a dolerite sill. There is a strong correlation between the mapped inflows and the position of inferred fault zones.

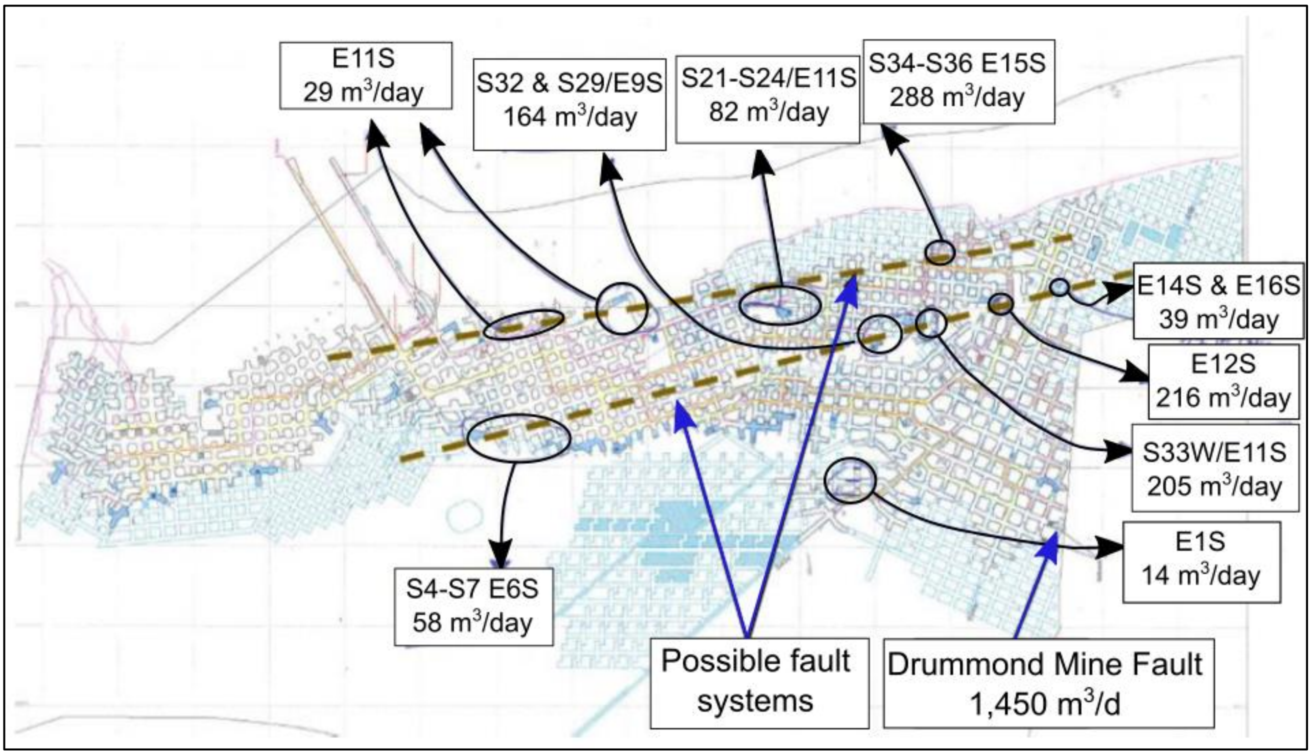

Figure 8.25: Sketch map showing inflows to the Drummond mine (October 2021; north is to the left)

Knocknacran Open-Cast Mine

Inflows to Knocknacran Open-Cast Mine are mostly derived from incident precipitation onto the pit walls and floor, with a minor amount of local groundwater inflow. The water in Knocknacran open-cast is collected in a sump on the pit floor and is pumped up to the settlement lagoons. Estimated sump pumping rates range between about 10 m³/d in September (groundwater flow only) and about 950 m³/d in April (mostly surface water runoff). A photo of the large existing sump on the Knocknacran site is provided in Figure 8.26. The sump has been variable in size throughout the life of the Knocknacran Mine, but is presently ca. 240 m long. Mining and water management has been well executed, with plating and draining of the bench faces to reduce erosion and piping (Figure 8.27).

Figure 8.26: Aerial photo showing the existing Knocknacran sump on the site, the size is variable, but it is currently ca. 240 m long

Figure 8.27: Good surface runoff management practices at the Knocknacran Open-Cast, including plating of the bench faces and drainage of the benches

Drumgoosat Underground Workings

Inflows to Drumgoosat workings are derived from groundwater. Historically, water was pumped into the workings as part of the site water management strategy prior to the subsidence event in 2018. Pumping records for the mine during active operations indicate groundwater inflows were low, but seasonally variable, between about 20 m^3/d in September to about 870 m^3/d in March.

The seasonal nature of the pumping records suggests that much of the water would likely have been derived from surface infiltration, potentially focused on natural or mining-induced surface depressions, and particularly in the central section of the mine where the Upper Gypsum and mine workings are within ca. 50 m of the ground surface.

Additional minor groundwater is likely to have entered the workings from the north, along the strike of the Kingscourt Gypsum Formation.

8.4.7 Water Management System

The water management system for the existing Knocknacran Open-Cast Mine and adjacent Plant Site and associated infrastructure is operated to comply with the conditions of IE Licence P0519-04 by controlling the quality and the quantity of water being discharged offsite.

Table 8.13 presents the annual volumes of mine water discharged (based on daily flow measurements) into the River Bursk from the Knocknacran site at the mine outfall (MSE-1) during the period 2012 to 2021.

Table 8.13: Annual volume of mine water discharged into the River Bursk (2012-2021) at MSE-1

Year	Annual Volume (m^3)
2021 (up to 3rd August)	927,136
2020	1,405,376
2019	1,629,093
2018	971,229
2017	613,338
2016	743,704
2015	824,560
2014	804,403
2013	857,972
2012	931,373

The volume of mine water discharged into the River Bursk decreased between 2012 and 2018, but increased again in 2018 due to the increase in water-make from the Drummond underground workings.

Groundwater inflow to Drummond Mine is routed to a central sump in the mine, from where it is pumped to the settlement lagoons. A bulkhead was installed following the inflow that occurred in June 2018 as a result of mining into the Drummond Mine Fault. Water from behind the bulkhead is also routed to the central sump and included in the overall water discharge from the mine to the Bursk. Water from Drumgoosat Mine is pumped from a borehole in the old mine workings up to the settlement lagoons. In summary, the existing water management system collects the water from the various sources, and routes it through the treatment facility to the discharge point on the River Bursk.

The quality of water in the existing Knocknacran sump is dependent on:

- Rainfall total and runoff intensity down the slopes of the open-cast (i.e., the amount of contact the water has with the materials in the slopes of the excavation).
- The amount of antecedent rainfall (which controls the extent to which solutes have been previously removed).
- The nature of the surface water flow paths (preferential flow channels tend to dissolve fewer constituents than diffuse flow paths).

A water chemistry sample from the existing Knocknacran sump was taken on 11th March 2020. The water has relatively high levels of calcium and sulphate indicating it has contacted gypsum material as it flowed down the open-cast slopes into the sump. Alkalinity is high (300 mg/l) as would be expected. The water contains dissolved iron which is likely to be in solid (colloidal) form. Low level detections of zinc and nickel are also reported. The reported value of nitrate is low. All waters from the Site are treated in the settlement ponds for the removal of suspended solids. The water from the various sources at the Site is relatively low in suspended solids so does not require significant settlement time (SLR, 2019). There is no process water used at the Site. There are four settlement ponds (lagoons) on the existing Knocknacran Open-Cast Mine site which will be continued to be used for the proposed development.

- Lagoon 1 has a volume of ca. 2,730 m^3;
- Lagoon 2 has a volume of ca. 3,000 m^3;
- Lagoon 3 has a volume of ca. 7,090 m^3; and
- Lagoon 4 has a volume of ca. 8,460 m^3.

Figure 8.28 presents details of the existing settlement lagoons on site. The settlement lagoons are designed to accept the entire yield for a 100-year return period flood of 24 hours duration, which would be pumped out over the following few days. From the lagoons, the water is pumped into a reservoir from where it is released under gravity flow to a discharge point (MSE-1) on the River Bursk (Figure 8.29).

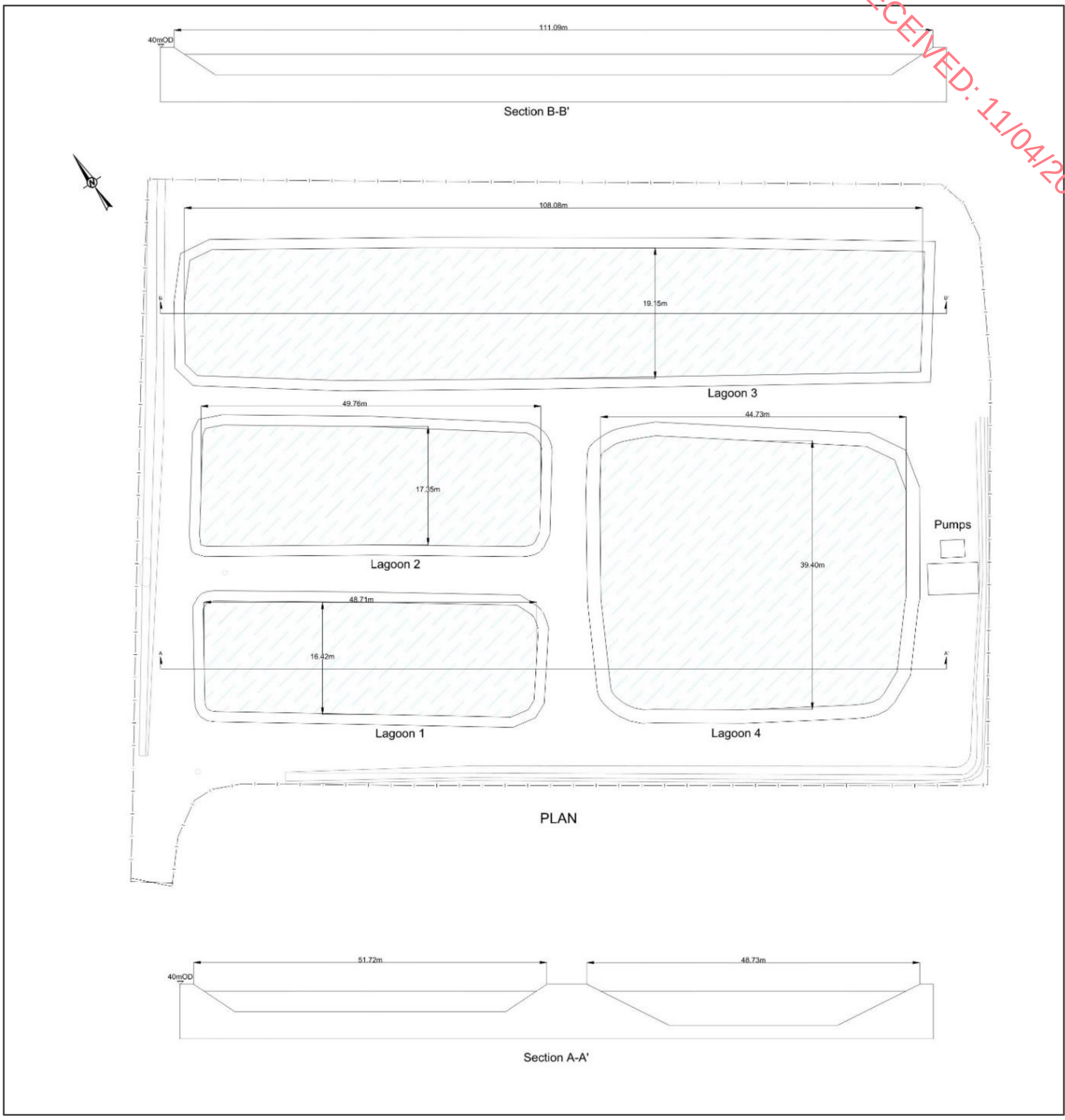

Figure 8.28: Details of the existing lagoons on the Knocknacran Open-Cast Mine site

The purpose of the surface water treatment facility is to control the discharge of suspended solids in line with the IE licence. The lagoons are settlement lagoons, there is no chemical treatment carried out.

The lagoons handle naturally occurring water from Drummond Mine, Knocknacran Open-Cast Mine and the former Drumgoosat Mine. No chemical processing occurs at any of these locations.

Water from the mine sites discharges to the lagoons. DMO-1 is the Drummond Mine outfall to the lagoons which is monitored before entering the lagoons. The lagoons discharge to MSE-1. MSE-1 is the discharge from the final holding tank prior to discharge to the River Bursk. CP1 is the sampling point 70 m downstream of the discharge to the River Bursk (Figure 8.29).

Efficiency of Water Treatment

A suspended solid limit of 25 mg/l is specified under the existing IE Licence (P0519-04) for the discharge from MSE-1.

Suspended solids measured at DMO-1, MSE-1 and CP1 between January 2012 and August 2022 are shown in Figure 8.30. Table 8.14 presents the minimum, maximum and average suspended solids measured at DMO-1, MSE-1 and CP1 over the same period. Based on the difference between the averages of 11.3 mg/l at MSE-1 and 24.5 mg/l at DMO-1, the lagoons are considered efficient at settling suspended solids from mine water. Additionally, the measured suspended solids at MSE-1 includes waters originitating from Knocknacran open-cast and Drumgoosat Undergound Mine (Drumgoosat dewatering borehole).

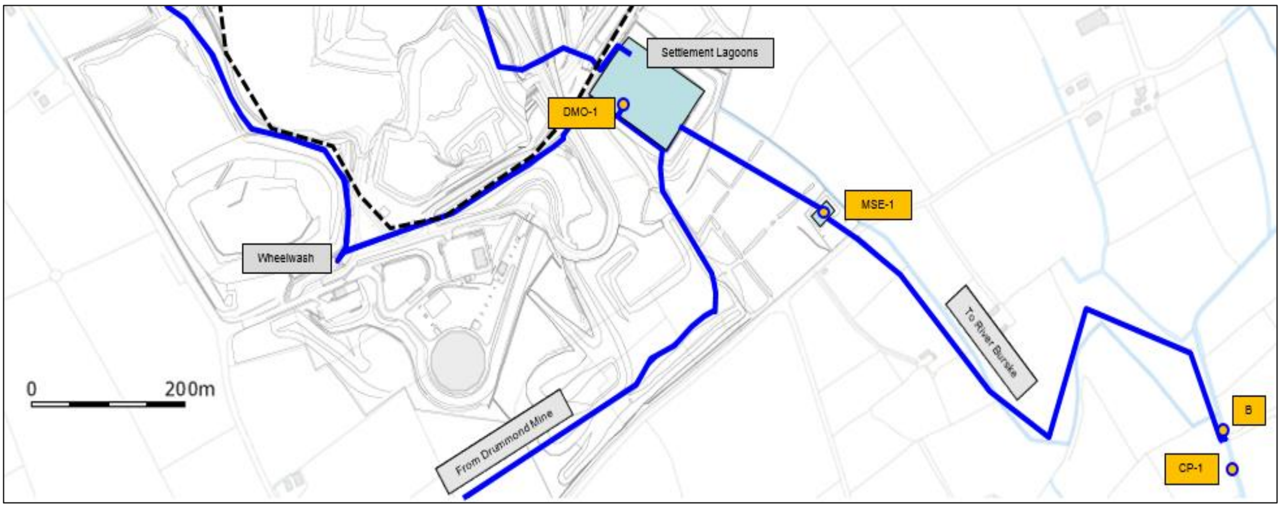

Figure 8.29: Location of DMO-1, MSE-1 and CP1 on the site

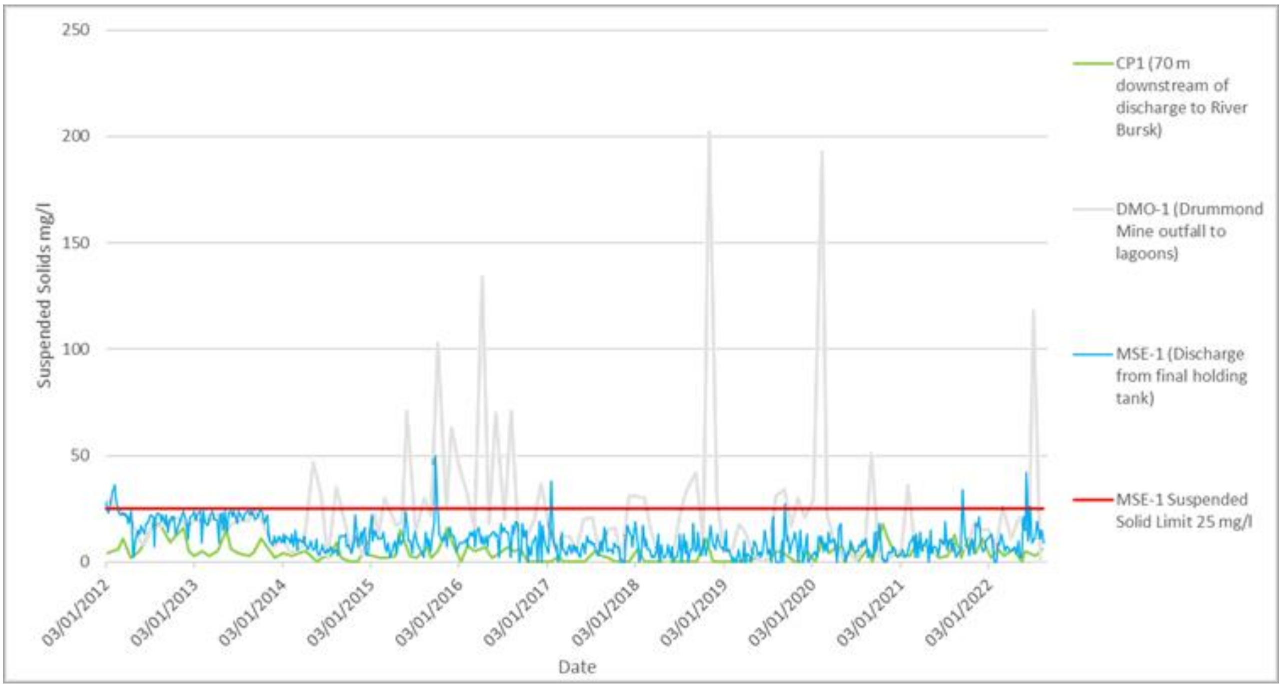

Figure 8.30: Suspended solids between January 2021 and August 2022 at DMO-1, MSE-1 and CP1

Table 8.14: Average, Minimum & Maximum suspended solids at MSE-1, CP1 & DMO-1 between 2012 & 2022

Station	MSE-1	CP1	DMO-1
Average January 2012 – August 2022	11.3	6.0	24.5
Minimum January 2012 – August 2022	2	2	2
Maximum January 2012 – August 2022	50	18	202

SGMI monitor the flow and electrical conductivity (to allow the estimation of sulphate) in the River Bursk in real time. The discharge of mine water is automatically adjusted depending on the available flow and assimilative capacity in the river. CP-1 is 70 m downstream of the discharge point (Figure 8.31). The volume of mine water discharging into the River Bursk is therefore managed by evaluating the mixing ratio of the Bursk as a product of the flow rate and the concentration of sulphate in the mine water on a real-time basis. The flow rate in the River Bursk is monitored continuously at the mine outfall.

Historically, SGMI stored the excess mine water in Drumgoosat Mine when discharge to the River Bursk would have exceeded the CP-1 compliance value in times of low flows in the river. The mine workings provided a buffer for water storage when there was insufficient assimilative capacity in the River Bursk. Water was released during higher river flows when there was adequate assimilative capacity.

Following the subsidence event at Drumgoosat in September 2018, SGMI commenced the discharge of mine water directly to the River Bursk via the existing settlement lagoons as part of emergency measures which went into force on 28th September 2018. Since the subsidence event in September 2018, in order to limit sulphate concentrations during low flow conditions in the River Bursk (when the mixing ratio is likely to be less than 10:1), a water management plan that reduces the rate of discharge from the old Drumgoosat workings when required, and a discharge licence revised by the EPA to allow additional discharge volumes, has reduced the need for any seasonal storage of water. Where needed on any exceptional short-term basis, the substantial sump of the Knocknacran open-cast pit is used for temporary water storage prior to discharge to the River Bursk (Figure 8.26). This arrangement will remain in place until such time as Knocknacran West Open-Cast Mine is developed and has the capacity to store water, thereby negating the need for water storage in Knocknacran Open-Cast Mine as it is remediated.

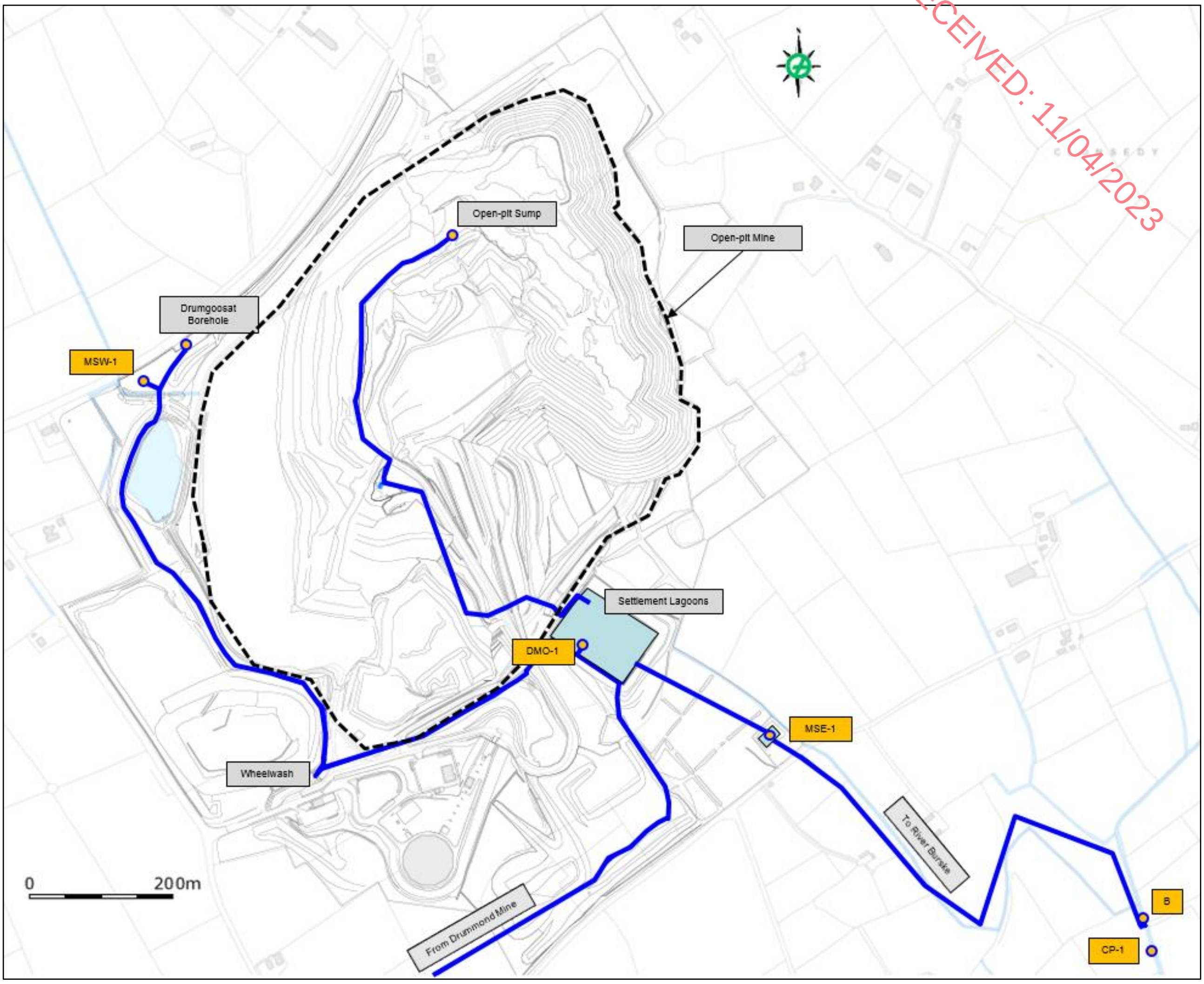

Figure 8.31: Plan showing existing water management infrastructure layout

8.4.8 Water Balance

Reported Flows

Within the current mine water management system, three flows are recorded on a regular basis:

- 'Effluent Monitoring' – daily monitoring of total mine site discharge from MSE-1 to the River Bursk (April 2004 to present);
- 'Drummond Pumping Log' – spot flow meter readings of water pumped from Drummond underground to the surface lagoon (January 2010 to present), including water from the June 2018 Drummond Mine Fault; and
- 'Drumgoosat Pump' – spot flow meter readings of the well abstracting water from the Drumgoosat workings to the surface lagoon.

In addition to these flows, paper records are available of pumping hours from Drumgoosat at various points in time between 1981 and 1992.

Estimated Flows

The available flow records were used to help support the development of a water balance model for estimating the following flows which are not recorded, including:

- June 2018 Drummond Mine Fault inflow;
- Drumgoosat (Knocknacran West) groundwater inflow;
- Knocknacran groundwater inflow; and
- Knocknacran and mine surface infrastructure area runoff.

The water balance model includes:

Drumgoosat Inflows

- Infiltration from above the level of the workings, through the superficial deposits; and
- Lateral groundwater flow within Kingscourt Gypsum from the north.

Outflows from Drumgoosat

- Water pumped out of the dewatering well.

Drummond Inflows

- Infiltration from above the level of the workings through Upper Gypsum and dolerite.
- Lateral groundwater flow within the Lower Gypsum from the south.
- Inflow from the 2018 Drummond Mine Fault.

Outflows from Drummond

- Water pumped out of the Central Sump.

Knocknacran Inflows

- In-pit runoff due to incident precipitation on the pit walls.
- Minor groundwater inflow from superficial deposits.
- Lateral groundwater flow within Kingscourt Gypsum (currently negligible because of the presence of the mines to the north and south).

Outflows from Knocknacran

- Water pumped from the sump.

The estimated site water balance for is provided in Appendix 8.5. A summary of the baseline water balance is provided in Table 8.15. The components of flow making up the MSE-1 discharge are shown in Figure 8.32.

The period shown is from 2017 to 2019 and is intended to cover the period following the intersection of increased inflows to the Drummond Mine. The following subsections describe the water balance for each of the mining areas.

Table 8.15: Baseline Water Balance

Year	Description	Phase	Total Average Discharge Volume (m^3/d)	Total Discharge to Water Management System (m^3/d)	Additional Flow to Water Management System (m^3/d)	Total Discharge to Corduff Stream** *(m^3/d)
Baseline	**Existing Knocknacran Open-Cast**	Operational	325	3,625	0	0
	Existing Drummond UG	Operational	3000			
	Knocknacran West Site (inc. Drumgoosat UG Well)	Pre-construction – continue to pump from UG Well	300			

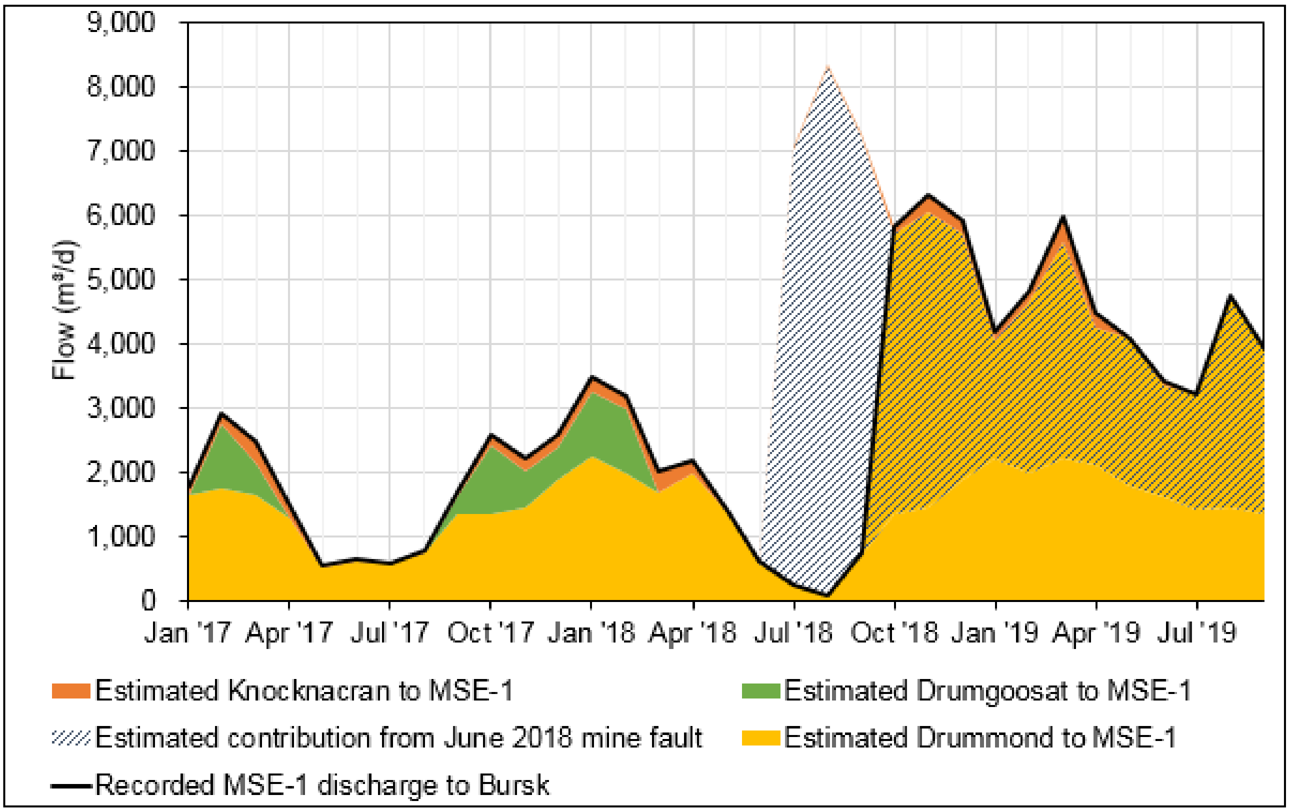

Figure 8.32: Example of the mine water balance covering the period when additional inflows were encountered in the Drummond mine (colour blocks show cumulative components of MSE-1 flow)

Drumgoosat Underground

Scanned copies of hand-written pumping records are available from the period when Drumgoosat was being mined. The records are not continuous but included dates between 1981 and 1992. 1991 provided the best record and had pump capacity estimates so flows could be derived from the pumping hours record. It showed that about 100,000 m³ was pumped from Drumgoosat between 9th January and 5th December 1991, giving an average flow of about 300 m³/d. However, flows were strongly seasonal ranging from 20 m³/d in September to 870 m³/d in March. This reflects the normal seasonal recharge pattern.

For the purposes of this study, and to take a conservative approach, it has been assumed that all water pumped was groundwater (i.e. no service water was pumped back underground for drill rigs or dust suppression). The monthly total flows for Drumgoosat were used directly in the water balance model, with two thirds of the flow being attributed to the current Drumgoosat underground and one third to the Knocknacran open-cast mine (which was mined into as the southeast portion of the Drumgoosat workings). These estimated flows are presented in Table 8.16.

Knocknacran Open-Cast Mine

Water pumped from the Knocknacran Open-Cast Mine is not currently metered. Surface runoff to the sump has been estimated to be about 20,000 m³/month (or ca, 650 m³/d) in the winter months. Based on the Drumgoosat groundwater inflow assessment shown in Table 8.16, the groundwater inflows to Knocknacran are estimated to be between ca. 200 m³/month in September and 9,000 m³/month in March. However, the actual groundwater inflows may be lower than these estimates because of the relatively small recharge area associated with Knocknacran Open-Cast Mine.

Table 8.16: Estimated groundwater inflows to the Drumgoosat Workings based on 1991 records and estimated groundwater inflows for Knocknacran Open-Cast

Month	1991 Drumgoosat pumping record (m³/month)	Estimated current Drumgoosat groundwater inflow (m³/month)	Estimated current Knocknacran groundwater inflow (m³/month)
January	11,351	7,567	3,784
February	10,885	7,257	3,628
March	26,786	17,857	8,929
April	17,037	11,358	5,679
May	1,437	958	479
June	1,879	1,253	626
July	1,426	950	475
August	1,511	1,007	504
September	672	448	224
October	8,240	5,494	2,747
November	14,101	9,401	4,700
December	12,726	8,484	4,242
Total (m³/yr)	**108,051**	**72,034**	**36,017**
Total (m³/day)	**296**	**197**	**99**

Drummond Underground

Table 8.17 shows that the dewatering rate from Drummond underground is seasonally variable between (ca. 2,500 and ca. 4,000 m³/d). These flows are consistent with the groundwater point-source inflow mapping (Figure 8.25). The point source inflows appear to occur along linear features as indicated in Figure 8.25. This would be expected in this environment where faults typically act as barriers to groundwater flow (and in some cases flow may also be slightly enhanced parallel to their strike).

A significant groundwater ingress to the Drummond Mine occurred on 21st June 2018 after the advancing development encountered a fracture zone in the rock (Minerex[2]). Initially, the ingress was not apparent, however, the inflow increased substantially during the night and the mine area was found to be partially flooded the next morning.

The inflow to Drummond mine on 21st June 2018 caused drawdown in several observation wells near the south end of the mine, particularly those installed at deeper levels. The inflow had a notable impact on monitoring well O3A P 1 (in the Lower Mudstone member). The rapid change in water level suggests a limited source of groundwater storage in the locally interconnected fracture network. The reduced inflow rate is likely because much of the groundwater storage has been removed from the localized area of drawdown (including the fault zone).

Table 8.17: Estimated current groundwater inflows to the Drummond Mine

Locations	Summer Months May-Sept (m^3/d)	Winter Months Oct-Apr (m^3/d)
E11S	25	50
S21-24 E11S	80	288
S34-S36 E15S	300	720
E14/E16S	130	360
E12S	125	144
S33W E11S	205	480
S32-S29 E9S	145	360
E1S	15	30
S4-S7 E6S	60	120
Drummond Mine Fault	1450	1488
Total	**2,535**	**4,040**

8.4.9 Conceptual Groundwater Model

8.4.9.1 Summary of Mine Inflows

Groundwater inflows to the existing mining areas is typically low. Inflows to the Drumgoosat Mine are estimated to be seasonally between about 20 and 870 m^3/d. Inflows into the Knocknacran Open-Cast Mine are mostly derived from incident precipitation onto the pit walls and floor, with a minor amount of local groundwater inflow. In the Drummond Mine, inflows are between about 2,500 and 4,000 m^3/d, including about 1,450 to 1,490 m^3/d derived from the Drummond Mine Fault.

8.4.9.2 Recharge

Precipitation records from 1990 to 2020 show that the Site rain gauge has an annual average precipitation of 988 mm. Dunsany synoptic station (45 km south of the site) has an annual average potential evapotranspiration of 515 mm (2016 to 2019). Assuming actual evapotranspiration is 95% of potential, the effective rainfall for the area is around 466 mm/yr.

[2] Minerex, 2019a. Drummond Mine Water Ingress: Assessment of Impact on Groundwater Resources -Rev 1, June 2019. Doc. Ref.: 1632-2093 (Rev 3).

The GSI national groundwater recharge map indicates that recharge within the footprint study area is typically 100 to 200 mm/yr. This represents 10 to 20% of mean annual precipitation and 22 to 42% of the effective rainfall, which is considered to be slightly high given the local topography, but is reasonable for planning purposes. It represents a conservative estimate for predicting on-going recharge to the mining areas.

Under natural (pre-mining) conditions, and assuming a recharge rate of 100-200 mm/yr over a footprint area of about 2 km^2 for the combined mining areas (Drumgoosat, Knocknacran, Drummond), the flux entering the gypsum strata within the mining area can be estimated to be within the rate 500-1,000 m^3/day. Given the observed low groundwater inflow rates during operation of Drumgoosat and Knocknacran (ca. 296 m^3/day) and the relatively limited lateral extent of Drummond, the natural recharge rate to the combined mining areas would likely have been at the low end of the range (ca. 500 m^3/day).

Most of the observed groundwater inflow to the Drummond Mine is thought to originate from the saturated alluvial deposits below the River Lagan. Under operational (dewatered conditions), the Upper Gypsum Unit above the mine remains saturated and in hydraulic communication with the river. All mining occurs in the Lower Gypsum. The hydraulic connection between the Upper Gypsum and the Lower Gypsum appears to occur through discrete pathways that are observed to be principally controlled by fault zones (Figure 8.25).

8.4.9.3 Near-surface Water Table

Groundwater levels in the superficial deposits typically show a seasonal variation of less than 2 m. The seasonal variation is due to recharge from October to March (increasing levels) and limited recharge between April and September as groundwater is removed from the system through evapotranspiration and discharge to local diches or small streams.

There are no declining trends in any of the superficial groundwater monitoring points, which suggests that any leakage from the alluvium to the dewatered underground mining areas would represent only a small part of the near-surface water balance. Other underground mines in Ireland have not seen any noticeable change in the near-surface water balance of the superficial deposits caused by mining.

8.4.9.4 Groundwater Flow

Based on the available monitoring results, it can be inferred that the north-south strike of the stratigraphical contacts exerts a significant influence on groundwater flow. Most of the groundwater movement within the strata of the Kingscourt Gypsum Formation occurs under fracture flow conditions through structures (faults/fractures, or occasionally karst within the gypsum units) or within the dolerite sills where locally altered and more potentially permeable than the surrounding gypsum and mudstone units.

The observed geological discontinuities within the strata means there is limited lateral or vertical groundwater flow within the Kingsland Gypsum Formation on a site scale. The layered nature of the strata impedes the downward flow of groundwater to the mine voids and creates strong vertical hydraulic gradients.

The north-south strike of many of the major faults helps to reinforce the groundwater compartmentalisation. The Kingscourt Gypsum Formation is located within the Kingscourt Outlier, which is a half-graben feature, approximately 1.2 km wide (east-west) and 12 km long (north-south). During mine dewatering, the boundaries of the half-graben have helped to localise the area of drawdown. The western limit of drawdown is a fault within the Kingscourt Sandstone Formation.

The geological information and available water level data suggest that the area of drawdown influence from the mining is anisotropic in a north-south direction. This is illustrated in Figure 8.24, where the relatively low groundwater inflow rates to Drumgoosat and Knocknacran produce highly localised areas of drawdown, primarily defined by north-south trending faults. Penetration of the Drummond (June 2018) Mine Fault by mining extended the area of influence by a small amount to the south and west.

The groundwater inflows to the Drummond Mine are around an order of magnitude larger than Drumgoosat and Knocknacran combined due to the proximity of saturated alluvial deposits below the River Lagan. The saturated alluvium crosses the north-south trending sub-crop areas of the Kingscourt Gypsum units. The saturated alluvial deposits that underlie the river cause on-going recharge to the Upper Gypsum Unit while the underlying mine is being dewatered.

8.4.9.5 Hydrogeological Boundaries

The total area of drawdown for Drumgoosat, Knocknacran and Drummond is estimated to be less than 4.5 km². The inferred hydrogeological boundaries are illustrated in Figure 8.20 and can be described as follows:

- **Western Boundary:** A fault within the Kingscourt Sandstone Formation. Mine workings have not penetrated this fault. The area of drawdown is unlikely to extend beyond it;
- **Northern Boundary:** The inferred geological interpretation shows the gypsum pinching out, which would support the relatively localised northward extent of the drawdown, potentially further constrained by a northwest-southeast trending fault mapped by the GSI. Current indications are that drawdown extends no more than about 0.5 km from the northern part of the workings;
- **Eastern Boundary:** Where mining into the Namurian Sandstone has occurred (Drummond and the southeast portion of Drumgoosat/Knocknacran), the area of drawdown may locally extend outside of the Kingscourt Gypsum Formation; and
- **Southern Boundary:** Drawdown to the south appears to have been limited, potentially by offsets in the Kingscourt Gypsum strata. Recharge from the saturated alluvial deposits below the River Lagan also creates a recharge boundary between the Drummond Mine and the old Cormey workings.

In summary, the layered nature of the strata impedes the downward flow of groundwater to the mine voids and creates local (discontinuous) perched groundwater layers and strong vertical (downward) hydraulic gradients.

8.4.10 Selection of Sensitive Receptors

Taking into account the conceptual model and the methodology for assessment presented in Section 8.3.4, the receptors and their assigned importance are presented in Table 8.18.

Table 8.18: Water Receptors

Receptor	Reasoning	Sensitivity
Groundwater (including water users and schemes) – quality and availability due to use as a resource and wider regulatory	Bedrock under the Site is classified as a mixture of a poorly productive aquifer and locally important aquifers. Local supplies are generally low yield, supporting single household domestic properties in the immediate site area. In the	**Negligible**

requirement to maintain good quality status	wider area (7 km of the Site) there are 3 public groundwater supply schemes, however, these are considered to be hydraulically disconnected from the mining area. Abstraction is shown to cause bedrock drawdown relatively local to mining areas and there is no indication of regional-scale drawdown. The proposed Knocknacran West development is within an area where drawdown has already occurred. No significant additional drawdown is expected as a result of the proposed development.	
Surface Water – quality and availability due to use as a resource and wider regulatory requirement to maintain good quality status.	Downgradient river (River Bursk) is classified as Good by WFD and in hydraulic connectivity with the Site via discharge to the river from the mining operations which would continue for the Proposed Development. The local surface water system has already been affected by the historical mining (in that the surface water is receiving discharge from the mine as is) and minimal additional disturbance is expected as a result of the proposed development. The proposed development seeks to maintain and continue the current permitted discharge, it is not proposed to increase or deviate from what is currently permitted by the EPA.	**Medium**
Flooding – changes in presence and water flows on infrastructure onsite and in the locality.	Site and wider area is not at risk of flooding under pumped conditions. The mine area has a large sump area for water storage within the open-cast. Sufficient attenuation capacity is noted for the Site when pumping at the Site ceases.	**Low**

8.5 Key Characteristics of the Proposed Development

8.5.1 Construction Phase: Community Sports Complex

During this phase, the existing Community Sports Complex will be further developed. The initial phase of this development has been constructed (Reg. Ref.: 20/365), and the next phase will involve extending the Community Sports Complex by the construction of two further playing pitches, one with a perimeter running track, an all-weather pitch, a new club building, including a sports hall, a handball alley, changing rooms & toilets, a viewing gallery, a part-covered grandstand, additional parking and associated siteworks.

The existing Drumgoosat dewatering pump will also be relocated to an existing borehole on the Knocknacran West site to continue to provide dewatering.

8.5.2 Construction Phase: Mine Development

During this phase:

- A temporary diversion of the R179 is proposed and a Cut-and-Cover Tunnel will also be constructed;
- One residential and three unoccupied houses and sheds will be demolished;

- The existing processing plant on the existing Knocknacran Open-Cast Mine site will be refurbished; and
- A new vehicular entrance will be constructed to the existing mine site from the L4816.

8.5.3 Operational Phase: Community Sports Complex

During this phase, the Community Sports Complex will be in operation.

8.5.4 Operational Phase: Mine Development

During this phase:

- Overburden and Interburden will be stripped to expose the Gypsum Mineral;
- The gypsum remaining in the former Drumgoosat Underground Mine will be extracted by open-cast mining methods;
- The existing Knocknacran Mine will be restored to near original ground level;
- The proposed Mine Development amounts to the replacement of the loss of mining at the Knocknacran Open-Cast Mine with the mining at Knocknacran West Open-Cast Mine;
- The existing plant site will process and despatch the extracted gypsum; and
- The existing Drumgoosat dewatering pump, will be relocated to an existing borehole on the Knocknacran West site to continue to provide dewatering.

8.5.5 Restoration/Closure Phase: Community Sports Complex

There is no proposal to close the Community Sports Complex development and this phase is non applicable.

8.5.6 Restoration/Closure Phase: Mine Development

During this phase:

- The Knocknacran site will be returned to near original ground levels;
- The Knocknacran West site will be returned to grassland and a waterbody;
- The Knocknacran Plant site will be partially dismantled whereby mine plant is removed; and
- In line with the current CRAMP it is presented that here that a suitable developer would be sought to utilise the general buildings existing on site for a light industrial usage into the future. This would be subject to a future developer seeking the necessary permits for continuation of use and change of use from mining to a non-mining use.

8.6 Potential Effects

8.6.1 Potential Effects: Construction Phase: Community Sports Complex

Fuel and other substance leaks or spills from stored substances or from machinery/equipment used during the construction of the Community Sports Complex could affect the chemistry of the soil during construction activities or could infiltrate to the groundwater through the bedrock or enter the surface water network indirectly. Material underlying the site is a mixture of natural and backfilled soils, subsoils and bedrock including tills, red clays of the Middle and Upper Mudstone Members and doleritic sands. Proposed construction activities would be undertaken by licenced contractors and regular maintenance of machinery/equipment would take place. Any leaks or spills would be small in scale and the underlying clays would hinder flow to bedrock. Therefore, the predicted potential impact on the groundwater resource from potential fuel or other substance leaks is considered to be Negligible (Adverse) while the sensitivity of the receptor (groundwater) is considered to be Negligible and Medium for surface water. The significance of effect is therefore considered to be Imperceptible for groundwater and Slight for surface water.

The existing wastewater treatment system (Oakstown Super BAF 50 PE Wastewater Treatment System with a design capacity of 46 PE) is permitted for the Community Sports Complex (Reg. Ref. 20/365) and will be available for use during the construction of the proposed further development of the Community Sports Complex.

Given that the proposed Community Sports Complex will have an independent wastewater infrastructure, no impact is envisaged on the groundwater resource in the area. The sensitivity of the groundwater is considered to be Negligible, the magnitude of impact due to the presence of an existing water treatment system on the site is considered to be Negligible (adverse). The effect of this is considered to be Imperceptible.

A surface water management system was designed for the construction of the first phase of the Community Sports Complex development. The first phase of the development was granted planning permission under Reg. Ref.: 20/365. The surface water management system was designed/sized so that construction related water was routed through a temporary management system into the existing mine water management system.

For the further development of the Community Sports Complex development, presented here, it is proposed that surface water management during the construction will again be routed through the existing mine water management system (due to suspended solids being allowed to settle out through the mine's water management system).

The existing site for the proposed Community Sports Complex receives runoff waters from a relatively small catchment south of the R179 road. This catchment will drain through an attenuation tank before passing through a Class 1 By-Pass Petrol Interceptor prior to discharging to a culvert under the R179, where it will intersect with an existing stream which flows to the west (refer to Reg. Ref.: 20/365).

The sensitivity of the surface water is considered to be Medium, the magnitude of impact to be Negligible (adverse) and the effect of this during construction works is considered to be Imperceptible as the existing surface water system on Knocknacran will capture the surface water drainage and route it through the system prior to discharge to the River Bursk.

An existing dewatering borehole is located within the proposed Community Sports Complex site. This will be relocated to the existing monitoring well at Knocknacran West. Its relocation enables development of the running track.

The borehole is considered here in the context that it is abstracting groundwater from the existing Drumgoosat workings, which means it is abstracting from the groundwater (resource) in the locality at present and will continue to do so into the future. This assessment is not considering the borehole itself for its significance in the context of the mine as an asset, this is referred to in Material Assets (Chapter 16.0, Section 16.6). The sensitivity of the groundwater is considered to be Negligible. The magnitude of impact is considered to be Negligible (beneficial) as its relocation enables development of the running track while continuing to dewater the workings and the effect of this is considered to be Imperceptible.

8.6.2 Potential Effects: Construction Phase: Mine Development

Consideration relates to the construction of a new mine entrance on the existing Knocknacran Mine site, the temporary diversion of the R179, the construction of the screening berms and construction of the Cut-and-Cover tunnel connecting the Knocknacran West Mine site and the Knocknacran Mine site. The mining activities will also require the demolition of four houses, one of which is currently occupied (owned by SGMI and will be vacant prior to demolition works) and three unoccupied houses.

To enable the development of the proposed mine entrance off the L4816, earthworks will occur and involve the removal of a shallow soil layer over an area of ca. 865 m^2 so that the road paving can be laid. Soil removed in the earthworks process will include at a minimum the topsoil and organic layers. Removed soil will be reused in landscaping around the new entrance and the former entrance. No soils will be exported offsite. Material brought to site for paving of the road will be sourced from an approved supplier to ensure the material is of suitable quality and free of potential contamination sources. An access point will be maintained to existing monitoring wells by the proposed entrance and routine monitoring of these wells will not be impacted by the proposed works, a layby has been accounted for in the design so access is maintained.

To enable the development of the temporary diversion of the R179, earthworks will also occur in a similar way as the construction of the new entrance to the mine site. Shallow soil will be removed to allow for the paving of the diversion road along an area of ca. 8,500 m^2. Soil removed will remain onsite to be used in screening berms or landscaping within the Site. Material brought to site for paving will be sourced from an approved supplier.

The construction of the Cut-and-Cover tunnel beneath the R179 will occur once the diversion has been constructed and cumulative impacts are not anticipated during the construction phase of these developments. The tunnel will require earthworks to remove the soil, subsoil and bedrock down to the depth of the tunnel which is ca. 38 m OD. The bedrock unit the tunnel will be located in is the Upper Mudstone Member of the Kingscourt Gypsum Formation which is a soft clay onsite. The tunnel construction area will be ca. 940 m^2. Material excavated will be reused onsite to either cover the tunnel once emplaced or material will be stored in screening berms on the mine sites. No material will be brought offsite and the tunnel will be sourced from a suitable supplier and will arrive onsite as a precast structure.

Approximately 200,000 t of the stripped material (and any excess material from the other mine construction works) will be used to construct the perimeter screening berms around the Knocknacran West Mine. No soils will be exported offsite. The magnitude of the impact superficial deposits is considered to be Negligible (Adverse). The potential impact magnitude on soils and subsoils is considered in the context that these materials will not be removed from the site and they will be stored within screening berms and therefore they will not be lost or removed permanently from site.

Potential fuel and or leaks from machinery or items stored on site have the potential to impact the underlying soils, subsoils and bedrock during the construction activities detailed above. In the area of the diversion and tunnel, recent works have been undertaken to characterise the soil for the purposes of an effluent treatment system for the future site office and welfare facility on the Knocknacran West site. As part of the work, trial holes were dug to test the nature of the shallow soils. The soils were confirmed to be poorly draining given the nature of the soil in the area (including the Mine Development construction site areas) (Appendix 3.2). Any spills or leaks would be contained and removed quickly onsite and the natural subsurface material would inhibit rapid percolation at this location. Construction works for the proposed new mine entrance would be of a temporary duration and with limited plant and machinery needed. Plant and machinery will be regularly maintained and inspected for leaks or spills and bunds will be placed onsite around items required a bund for both the tunnel, diversion and new entrance works. The magnitude of the impact on groundwater or surface from potential leaks and spills is considered to be Negligible (Adverse). The sensitivity of the groundwater is considered to be Negligible while the sensitivity of the surface water is Medium. The significance of effect for surface water is considered to be Imperceptible while the significance of effect to groundwater is considered to be Imperceptible.

8.6.2.1 Potential Impacts to the Water Balance and Water Management System

A water balance has been developed for the Mine Development during its construction phase. For the purposes of a robust assessment, the water balance (Table 8.19) has assumed that Drummond Mine would remain operational post 2032 and will close in conjunction with Knocknacran West Open-Cast Mine, however, this is subject to a planning permission being sought, and granted, for development to continue past 2033 at Drummond.

The nature and volumes of the waste waters from mining activities during construction are as follows:

- Construction – sediment only. Approximately 3,625 m^3/d of water will be generated during this phase of the development.

The baseline discharge to the settlement lagoons is currently ca. 3,625 m^3/d. As can be seen from the water balance, the construction phase will not cause an increase in flow to the lagoons. Rather, the flow from the Site will remain similar to the baseline of ca. 3,625 m^3/d during the construction period for the proposed development. The existing settlement lagoons will therefore have sufficient capacity to treat the volume of water during the construction phase of the development compared to the baseline conditions.

The magnitude of the impact on groundwater or surface from water management onsite is considered to be Negligible. The sensitivity of the groundwater is considered to be Negligible while the sensitivity of the surface water is Medium. The significance of effect for surface water is considered to be Imperceptible while the significance of effect to groundwater is considered to be Imperceptible.

Table 8.19: Water balance summary during the construction phase of the Mine Development

Year	Description	Phase	Total Average Discharge Volume (m^3/d)	Total Discharge to Water Management System (m^3/d)	Additional Flow to Water Management System (m^3/d)	Total Discharge to Corduff Stream*** (m^3/d)

Baseline	**Existing Knocknacran Open-Cast**	Operational	325	3,625	0	0
	Existing Drummond UG	Operational	3,000			
	Knocknacran West Site (inc. Drumgoosat UG Well)	Pre-construction - continue to pump from UG Well	300			
During Knocknacran West Construction	**Existing Knocknacran Open-Cast**	Operational	325	3,625	0	0
	Existing Drummond UG	Operational	3,000			
	Knocknacran West Site (inc. Drumgoosat UG Well)	Construction	300			
		Continue to pump from UG Well				

8.6.3 Potential Effects: Operational Phase: Community Sports Complex

The main predicted impacts likely to be associated with the Community Sports Complex will be the management of surface runoff from the site and the maintenance of the waste water treatment system which are currently permitted under Reg. Ref. 20/365. The existing (Reg. Ref. 20/365) wastewater treatment system was sized to accommodate a further development of the Community Sports Complex. The sensitivity of the groundwater receptor is considered to be Negligible, the sensitivity of the surface water in the area is considered the be Medium. The magnitude of impact from the further development is considered to be Negligible (adverse) and there will be no direct impact. The effect of this on the groundwater and surface water site is considered to be Imperceptible.

There will no longer be a dewatering borehole on this site during the operational phase as it will have been decommissioned and moved to the Mine Development. Therefore, there will be no impact or effect and it is scoped out in this phase for consideration.

8.6.4 Potential Effects: Operational Phase: Mine Development

8.6.4.1 Potential Effects: Operational Phase: Mine Development: Potential Effects: Groundwater

During the later stages of excavation, once the open-cast has been excavated through the gypsum sequence, pumping from the open-cast floor sump may supersede pumping from the dewatering well.

Based on the understanding of the water environment underlying and surrounding the Proposed Development, no new groundwater impacts are anticipated in the excavation of the proposed Knocknacran West Open-Cast Mine. There may be minor localized seepage from the dolerite, glacial till and overburden materials exposed in the side slopes of the proposed new excavation, but it is expected that flow rates will be minor and localized because of the low permeability nature of the deposits, as is currently observed to be the case in the existing Knocknacran open-cast.

The overall area of exposed side slopes in the combined Knocknacran West and Knocknacran mines will increase for a limited time period due to the excavation and backfilling sequence. However, as long as the exposed gypsum faces are concurrently restored on an on-going basis, as currently planned, it is considered unlikely that the levels of sulphate recorded in the combined water pumped from the open-cast will be higher than those currently pumped from the existing Drumgoosat and Knocknacran pumping systems. Also, as long as mobile plant is properly maintained, it is considered very unlikely that hydrocarbon pollution will become an issue at the Site.

While the existing Knocknacran open-cast continues to be backfilled, pumping from the sump will be continued (as at present) until final restoration is compete. Throughout the phased restoration process on Knocknacran (and Knocknacran West), the sump will be maintained on the surface of the backfill to allow on-going management of any residual contact water.

While mining and backfilling in the proposed Knocknacran West open-cast is carried out, pumping will be from a new sump in the Knocknacran West open-cast and from the dewatering well pumping system, as described above. Thus, sumps in Knocknacran and the proposed Knocknacran West will be operated simultaneously for a period of time. All hydraulic gradients will be inward to the mining areas, so there can be no release of any groundwater or contaminants. The potential polluting impacts associated with the proposed activities is the introduction of sulphate and hydrocarbons to the groundwater system, but these will be contained while pumping is continued.

At present, any emergency water storage is routed to the sump at the base of the existing Knocknacran open-cast. The maximum capacity of the sump is over 450,000 m^3 which is adequate to hold all conceivable rainfall and runoff events, and also for emergency storage of water from the Drummond mine, if required. The sump size is variable and can be temporarily increased if necessary (Figure 8.26).

The planning application provides additional flexibility and storage as it includes the development of active sumps in both the existing Knocknacran and the planned Knocknacran West open-cast. Both sumps will have a large capacity (each over 450,000 m^3) which can be increased during a period of extreme wet weather, if required.

The sump in Knocknacran will be maintained throughout the phased restoration period (which occurs within the operational phase) until all water from the restored inert backfill surface is considered to be non-contact water suitable for release to the local ditches. As the existing Knocknacran open-cast mine ceases operations and is restored, the quantity of water to be managed on the Mine Development will be reduced. Similarly, as Drummond operations are currently only permitted until 2033, operations here would cease on or before then and during the first half of the operational life of the Mine Development. This again will also reduce the amount of water to be managed.

Potential pollutants from the waste water treatment system associated with the office and welfare facilities located adjacent to the Cut-and-Cover Tunnel may also be an impact, however, this system is designed to meet the required guidelines (refer to Chapter 3.0, Appendix 3.2).

Therefore, the magnitude of impact is considered to be Negligible (adverse) on groundwater during the operational phase, the sensitivity of the groundwater is Negligible and the significance of effect is considered to be Imperceptible.

8.6.4.1.1 Potential Effects: Operational Phase: Mine Development: Groundwater: Kingscourt Sandstone

Since the strata to be mined by the proposed Knocknacran West open-cast have already been dewatered by the Drumgoosat underground mine, the proposed Mine Development will not create any additional bedrock drawdown, so no impacts to the Kingscourt Sandstone are expected. This is consistent with current observations.

Furthermore, information contained in the source protection zone report for water supply well BW01 (drilled into the Kingscourt Sandstone about 2 km to the southwest of the planning application area) indicates that the majority of the sandstone aquifer footprint is confined by the overlying low and moderate permeability subsoil deposits. It is mainly recharged at areas of bedrock outcrop and extreme vulnerability along the

Kingscourt Fault scarp, to the west of the borehole. This indicates that the borehole is not abstracting water from the area of the mine and the mine dewatering does not affect water levels within the borehole. The isolation from the mining areas is further supported by a Cavan County Council (2011) report which states that the sandstone aquifer appears to be "*hydraulically isolated from the gypsum aquifer by the low permeability basal layer of the sandstone and upper strata of the gypsum. Where the two aquifers are juxtaposed by faulting, the gypsum appears to be sealed off by a low permeability "gouge" of marl.*"

Therefore, the magnitude of impact is considered to be Negligible (adverse) on groundwater during the operational phase, the sensitivity of the groundwater is Negligible and the significance of effect is considered to be Imperceptible.

8.6.4.1.2 Potential Effects: Operational Phase: Mine Development: Groundwater: Doleritic Sands

Expected groundwater inflows to the planned Knocknacran West will vary seasonally between 10 and 300 m^3/d, with an average inflow rate of about 100 m^3/d. Most of this water will enter the workings from the gypsum strata from the east (up-dip) side of the excavation.

The predicted rate of groundwater inflow is less than the reported groundwater inflow during the previous operation of the Drumgoosat underground mine (which was reported to vary seasonally between 20 m^3/d in September to 870 m^3/d in March). The reasons for this are: (i) any groundwater inflow from the south is already cut off by the low permeability backfill placed in the existing Knocknacran open-cast, (ii) any groundwater inflow from the north will be cut off by the placement of low permeability backfill within the north side of the planned Knocknacran West open-cast, (iii) there will be limited on-going groundwater recharge because the recharge area will largely have been removed by the open-cast, and (iv) there will be limited groundwater inflow from the east or west because of the presence of faulting and stratigraphical offsets to the gypsum strata in those directions.

Along the eastern portion of the existing and planned future mining area, the stratigraphic units of the Kingscourt sequence are up-dip, so any strata-controlled groundwater movement in the doleritic sands and gravels will be towards the mining area and is already mostly captured by the underground workings (Figure 8.11). The proposed Knocknacran West open-cast development will continue to capture this seepage.

Monitoring borehole KC-19C1 on the up-dip side of the proposed open-cast shows a water level of about -9 mAODM which indicates a hydrogeological connection to the existing Drumgoosat workings and to the proposed Knocknacran West open-cast. It suggests there is less hydrogeological compartmentalization on the east (up-dip) side of the mining area. However, as for the current Knocknacran open-cast, the seepage rates are small. Little seepage from the doleritic sands and gravels is observed in the current Knocknacran open-cast excavation.

To the west of the planned open-cast, the dip of the strata is locally reversed, so the groundwater is disconnected from the current or proposed future open-cast workings, as evidenced by the relatively low drawdown in KC-19B and KC-19B. KC-19A1 (completed in sandy dolerite) shows a depth to water in the range of 8 to 12 m. The shallow completion in KC-19B1 (in upper mudstone and dolerite) shows a depth to water of about 23 m. Both completions show some degree of drawdown, but with no direct hydraulic connection to the Drumgoosat workings, even though they are relatively close. This illustrates the compartmentalized nature and lack of drawdown in the Kingscourt Gypsum sequence immediately to the west of the mining area. The hydrogeological compartments are thought to be caused by the prevalent north-south structural trend.

The sensitivity of the groundwater is considered to be Negligible, the magnitude of impact due to the proposed Mine Development is considered to be Low (adverse). The significance of the effect is considered to be Slight.

8.6.4.1.3 Potential Effects: Operational Phase: Mine Development: Shallow Domestic Wells

A key issue for the proposed new excavation is to ensure there is proper protection of any local or community water supply sources.

Nature of the superficial deposits

Superficial deposits within and surrounding the proposed Knocknacran West excavation consist mostly of low permeability glacial till. The till is of variable thickness but is reported to average 13 m. Isolated sand and gravel lenses have not been mapped, but some isolated sands within the till may be tapped by some local shallow wells.

Given that the till is low permeability, no significant drawdown away from the immediate area of excavation would be expected. No drawdown is observed from the current monitoring results. If there are sand and gravel lenses isolated within the till, they would be unlikely to be affected by the excavation.

Shallow wells regularly monitored on the mine sites

There are six superficial wells included in the regular site monitoring program (Figure 8.14 and Figure 8.18). The reported water elevations typically reflect the local topography and the elevation of the well collar. There are no trends that would indicate long term drawdown or changes due to the mining operations. The behaviour of water levels continues to remain independent of conditions in the underlying bedrock formations.

All superficial wells show a seasonal fluctuation (except for 95 A 1). The largest seasonal drawdown typically occurs during dry summer periods. MW2P1 shows low summer water levels in 2020 and 2021 which are likely due to the low recharge during those years. MW2P1 is located close to the northern margin of the Drummond underground mining area. The well shows a water level reduction of about 3 m during dry summers, recovering during the recharge period towards the end of the year. The seasonal variation is due to recharge from October to March (increasing levels) and evapotranspiration between April and September and discharge to local diches (falling levels). The seasonal fluctuation in MW2 P1 is related to natural climatic cycles and the observed trends are consistent with many wells in the east of Ireland.

MW-102PA is a superficial well located to the south of the Drumgoosat workings. Reported water levels are consistent at about 39 mODM with little seasonal variation. The reported water elevations are typical of the superficial deposits and also appear to be unaffected by mining.

KC series wells – Monitoring Wells on the Knocknacran West site established in 2019

Figure 8.14 shows the location of three multi-level monitoring wells installed by Gyproc in 2019 (KC-19A, KC-19B and KC-19C). The mining license area is shown in red. The groundwater monitoring elevations for these wells from June 2019 to July 2022 are shown on Figure 8.17.

KC-19A1 is completed in sandy dolerite to a depth of about 74 m. KC19-A2 is completed in the Lower Gypsum seam to a depth of about 120 m. The collar elevation is about 43 mODM and the depth to water is typically in the range of 8 to 12 m. Both completions show some degree of drawdown, but with no direct hydraulic connection to the Drumgoosat workings, even though they are relatively close. This illustrates the compartmentalized nature of the Kingscourt Gypsum sequence immediately to the west of the mining area. The hydrogeological compartments are thought to be caused by the prevalent north-south structural trend.

Similarly, KC-19B1 is completed in upper mudstone and dolerite to a depth of about 61 m. KC19-B2 is completed in the Lower Gypsum seam to a depth of about 86 m. The collar elevation is about 55 mODM. The depth to water is typically in the range of 23 to 27 m. Again, both completions show the influence of some drawdown, but no direct connection to the Drumgoosat workings.

KC-19C1 is located on the up-dip side of the proposed Knocknacran West open-cast. Its collar elevation is about 45 mODM. It is completed in weathered dolerite to a depth of about 61 m. Over the monitoring period since mid-2019, the reported water level has fallen from about -6 m to about -9 mAODM. The low water level indicates there is a hydrogeological connection to the existing Drumgoosat workings. It suggests there is less hydrogeological compartmentalization on the east (up-dip) side of the mining area.

Observations elsewhere in the Kingscourt Gypsum sequence also indicate there is less hydraulic compartmentalization in the gypsum sequence on the up-dip (east) side of the mining area. Monitoring well MW7, also on the up-dip side, shows a similar low water elevation to KC-19C1, which also indicates a hydraulic connection to the Drumgoosat workings.

Domestic wells

There are six domestic wells in proximity to the planned Knocknacran West open-cast, as follows:

- To the west of the proposed Knocknacran West excavation: Well 5 (not in use), 6, 7, 8, 10 (not in use).

- To the north of the proposed Knocknacran West excavation: Well 9 (not in use)

Table 8.8 shows that the three wells which are in use are shallow, with a depth range 3.3-5.4 m. They have reported water depths of between 1.9 and 3.37 m below ground. They are located at a distance of between 370 and 500 m from the license boundary. They do not show any drawdown resulting from the Knocknacran open-cast or the Drumgoosat underground.

Because of the low permeability nature of the glacial till, and the fact that superficial water levels have become decoupled from drawdown in the underlying Kingscourt Gypsum sequence, the propagation of drawdown towards these wells as a result of the planned Knocknacran West open-cast excavation would not be expected.

All six wells will be added to the monitoring plan for Knocknacran West (as possible, based on access). Should there be any reduction in drawdown due to mining, they would be connected to the nearby group water scheme, which runs very close to the wells.

Summary of Potential Impact and Significance of Effect to Domestic Wells

Because of the low permeability nature of the glacial till, and the fact that superficial water levels have become decoupled from drawdown in the underlying Kingscourt Gypsum sequence, the propagation of drawdown towards these wells as a result of the planned Knocknacran West open-cast excavation would not be expected.

The footprint area of the proposed new open-cast will be largely within the footprint area of existing Drumgoosat Underground Mine and the existing Knocknacran Open-Cast Mine. The existing mines operate within a well-established drawdown zone of contribution which has been in existence since the mid-1960s since the time of development of the Drumgoosat Mine (a period of nearly 60 years). The mines are not located within a Source Protection Area of a public water supply scheme. The level of activity proposed for the Knocknacran West Open-Cast Mine will be in keeping with the level of activity previously taking place at the Knocknacran Open-Cast Mine.

The sensitivity of the groundwater resource (which the domestic wells are abstracting from) is considered to be Negligible, the magnitude of impact due to the proposed Mine Development is considered to be Negligible (adverse). The significance of the effect is considered to be Imperceptible.

8.6.4.2 Potential Effects: Operational Phase: Mine Development: Surface Water

There is no proposed change to the permitted discharge rates and limits with the addition of Knocknacran West Open-Cast Mine to the River Bursk.

An EPA licence review process was completed in 2021 for the existing EPA IE Licence (P0519-04). The licence review was initiated to seek an increase in the emission limit value for sulphate and conductivity in discharges to water from mining operations and the review was subsequently granted by the EPA after consideration of the application. The proposed development presented here in this EIAR will not seek a deviation to the limits on the discharge, continuation of the same discharge limits in a future EPA licence will be sought.

The EPA Inspector's report noted the following:

"Taken together along with the EPA biologists assessment, the above indicates that the current discharge is not impacting on the biological quality or on the drinking water quality of the River Bursk or the River Glyde into which it flows."

There is no specific standard for drinking water for mammals (not humans) and birds, although surface water provides a drinking water source for them. As part of the review process for the existing licence, ecological impact assessments were carried out and the EPA inspector separately produced a report on the review. The EPA Inspector's Report for the review noted the following:

"Based on monitoring data provided in the licence review application and by OEE, the receiving waters are currently compliant with all relevant quality standards as set in the European Communities Environmental Objectives (Surface Waters) Regulations 2009 as amended.

The key parameters for this assessment are sulphate and conductivity for which there are no environmental quality standards (EQSs) set in the Surface Water Regulations 2009 as amended. There were recommended limits for these parameters in the EPA's 2003 interim groundwater guidelines for surface waters of 200mg/l and 1000µS/cm respectively.

There are, however, EQSs for sulphate and conductivity in the Drinking Water Regulations 2014 which are 250mg/l and 2500µS/cm respectively.

The licensee has assessed the ecological impact of the discharges on the River Bursk involving the following:

1. An assessment of available peer-reviewed scientific research into the effects of sulphate, calcium and conductivity on aquatic habitats and organisms.

2. Biological assessments at locations on the River Bursk and on the River Glyde in 2020. This has determined that it is moderately polluted (Q3) upstream of the mine discharge, no change immediately downstream of it (Q3) and relatively unpolluted (Q4-5) further downstream.

3. Fish survey assessment (by electrofishing) in 2019 on locations upstream and downstream of the discharge including in the main channel of the Glyde. The conclusion was that there was no evidence that the mine discharge was influencing the fish community or the habitat quality that is available to the fish population and the data was broadly similar to the data already held by IFI from their survey in 2010. In particular, it was noted that there was no salmonid spawning or nursery habitat detected in the lower reaches of the River Bursk downstream of the discharge.

4. An assessment of the effects of the parameters of concern in the raw mine water, which is not treated before discharge, indicated an absence of significant acute toxicity to freshwater fish or crustaceans and minor impact on freshwater algae and marine bacterium.

Taken together along with the EPA biologists assessment, the above indicates that the current discharge is not impacting on the biological quality or on the drinking water quality of the River Bursk or the River Glyde into which it flows."

The Inspector's Report notes the following in relation to the limit values which were subsequently granted and have become licenced in P0519-04:

"Nonetheless, the RD proposes not to grant the requested increase from a daily limit of 200mg/l to 1,250mg/l at the compliance point CP-1 but instead to set a daily average limit of 625mg/l, a monthly average limit of 500mg/l and an annual average limit of 400mg/l. This is based on current data and scientific knowledge which points to the importance of longer-term exposure to elevated sulphate in terms of impact. The proposed daily limit of 625mg/l is set at well below the lowest observed short term or acute sensitivity for most of the relevant species in recent literature. Regard has been had to nearby jurisdictions' (Environment Agency and SEPA) EQS of 400mg/l annual average value for the protection of freshwaters."

And:

"Furthermore, the EPA interim results from 2020 indicate that ecological status of the Glyde catchment has not deteriorated since the current mine discharge regime was established following the subsidence incident in late 2018."

In addition, there is limited surface water in the proposed area of the Knocknacran West open-cast. At present, some of the surface water ditches flow towards the R179 and L4900 roads, with runoff water managed along with the drainage systems for the roads. The proposed excavation will reduce the number and size of the catchment areas that drain towards the roads.

Some surface water at the current site is locally captured by the topographic depressions that are either natural or have been caused by historical mining activities. All this water will be captured by the proposed new open-cast excavation.

The Corduff Stream rises in an area above the Drumgoosat Mine and flows northeast to meet the River Bursk (WFD reach "GLYDE_030"). A drainage area of about 0.45 km^2 that currently contributes to the stream will be captured by the proposed open-cast. The catchment area of the River Bursk to its inflow point to Rahan's Lough is approximately 30 km^2, with the catchment captured by the open-cast representing about 1.5% of the total drainage area. The proportion of catchment is small so the impact on streamflow in the Corduff Stream and River Bursk will be negligible, particularly given the existing disturbance in the upper part of the catchment area. The Corduff Stream is currently ephemeral at the location where is leaves the mining area. The Kingscourt Descart PWS is within the GLYDE_030 reach but is downstream of the planned mine, approximately 1 km west of Raffan's Lough, so is unlikely to be affected. Overall, the magnitude of impact to the Bursk catchment is considered to be Low (adverse) and the effect significance is considered to be Slight to Moderate during the operational life of the mine development.

Where there is potential for minor surface water locally flowing towards the proposed excavation, a protective screening berm constructed around the proposed Knocknacran West open-cast will exclude surface water runoff. As for the current Knocknacran excavation, the existing berm will be contoured to minimize the risk of ponding water and localized flooding around the periphery of the excavation.

8.6.4.2.1 Potential Effects: Operational Phase: Mine Development Corduff and Magheracloone streams

A detailed report on the potential impact and effects on the Corduff and Magheracloone streams is provided in Appendix 8.1. This section presents a summary of the findings of the report.

The Corduff Stream rises from the north/central part of the Drumgoosat mine footprint area and flows northeast into Lough Fea, about 2.2 km downstream of the proposed Knocknacran West footprint area. The total catchment area of the Corduff Stream down to Lough Fea is about 6.1 km^2.

About 7% of the headwaters drainage area (about 0.45 km^2) is included within the footprint area of the proposed Knocknacran West Open-Cast Mine. However, within this area, some surface water is already locally captured by the topographic depressions that are either natural or have been caused by historical mining activities, so the current effective drainage area is less than 0.45 km^2.

Monitoring and sampling carried out in 2019 and 2022 confirms that streamflow is ephemeral. There are no springs in the proposed area the excavation and there is no summer streamflow. In the summer, all flow in the Corduff Stream occurs downstream of the planned Knocknacran West footprint area.

Consequently, the planned development will have little effect on summer flows. Flow entering Lough Fea in June and July 2022 was estimated between 2.5 and 5 L/s.

The stripping (and phased restoration) of the site will be undertaken at specific times and last for defined periods of time (typically < 6 months) over the life of the proposed Mine Development. The stripping and phased restoration earthworks will be undertaken by a specialist Contractor following a tender process. Section 8.7.2 provides details on the embedded mitigation measures which will be in place during earthworks (including stripping campaigns) to mitigate potential effects within the design.

For the Magheracloone/Lagan stream, Appendix 8.1 shows that the impact of the application on the Magheracloone catchment is minimal. The effected catchment area is minimal and the monitored flows were low. The EPA notes the greatest threat to the Magheracloone Stream relates to potential impacts from agriculture.

Sediment control will be put in place for the stripping activities when there is the potential for surface water runoff to discharge from the site to local watercourses. Following the initial stripping, all water generated within the site boundary will be contained, routed to sumps and pumped to the existing sedimentation ponds to the south.

The designed interceptor drainage system(s) and settling pond/filter system, for each stripping campaign, will be installed prior to stripping of material. The design will be updated throughout the stripping campaigns as the works progress. The design will be agreed with the relevant authorities prior to stripping.

During mine operations, no water will be discharged directly from the Knocknacran West site to local watercourses. The results of the 2019 and 2022 sampling indicate the proposed development will have little impact on either of the two streams during the period of active excavation.

The sensitivity of the both the Magheracloone and Corduff streams is considered to be Medium (as they are both surface water features) and the impact magnitude due to the proposed Mine Development on the streams is considered to be Negligible. The significance of effect is considered to be Imperceptible.

8.6.4.3 Potential Effects: Operational Phase: Mine Development: Water Balance and Water Management System

The proposed new excavation will change the overall water balance of the Site in three ways:

- There will be additional rainfall captured by the sump in the new excavation;
- Towards the latter stages of the new excavation, some of the groundwater currently pumped by the existing Drumgoosat well will enter the future open-cast sump; and
- As backfill material is progressively placed around the outer margins of the existing Knocknacran open-cast and these areas become restored, and subject to satisfactory water quality monitoring results, some areas of surface water that currently drain to the mine sump will be routed towards the surrounding natural drainage and ditch system, as part of the overall site restoration programme.

The water balance model has been updated to simulate the inflows of the proposed Knocknacran West excavation and the implications for the existing surface water management system. For the purposes of a robust assessment, the water balance (Table 8.20) has assumed that Drummond Mine would be operational post 2032 and closes in conjunction with Knocknacran West Open-Cast Mine, however, this is subject to a planning permission being sought, and granted, for continued operation at Drummond.

The water balance for the proposed Mine Development is made on the following basis:

- Rainfall on the slopes of the excavation which will run off to the sump during operations;
- Incident rainfall on the sump which will be small during operations;
- Groundwater from the Kingscourt Gypsum sequence which will continue to be captured by the existing Drumgoosat dewatering well until the latter states of operations;
- Groundwater from the superficial deposits in the upper part of the excavation which is seen to be negligible in the existing Knocknacran excavation and is expected also to be small or negligible for Knocknacran West because of the similar low permeability nature of the glacial till surrounding both excavations; and
- Runoff from the slopes of the existing Knocknacran open-cast excavation currently enters the sump (during operations). The runoff will continue to run off to the sump during the initial years of restoration, but will be increasingly diverted to external ditches as non-contact water as backfill material is progressively placed around the outer margins of the restored area.

The nature and volumes of the water to be managed is as follows:

- Operations – analogous to the current Knocknacran open-cast regarding chemical constituents (sulphate) and sediment load. Approximately 3,000 – 3,500 m³/d mine water will be generated, this is a decrease of 625 - 125 m³/d from current operations.

Table 8.20: Water Balance during the operational phase of the Mine Development

Year	Description	Phase	Total Average Discharge Volume (m³/d)	Total Discharge to Water Management System (m³/d)	Additional Flow to Water Management System (m³/d) v's baseline	Total Discharge to Corduff Stream** *(m³/d)
Baseline	**Existing Knocknacran Open-Cast**	Operational	325	3,625	0	0
	Existing Drummond UG	Operational	3,000			
	Knocknacran West Site (inc. Drumgoosat UG Well)	Pre-construction - continue to pump from UG Well	300			
ca. 2 - 15	**Existing Knocknacran Open-Cast**	Restoration Reduction in water inflow to sump	150	3,500	-125	0
	Existing Drummond UG	Operational – assumed to continue*	3,000			
	Knocknacran West Site (Drumgoosat UG Well - only)	Continue to pump from UG Well	150			
	Knocknacran West Open-Cast Mine Area	Operational - Water capture in new sump	200			
ca. 15	**Existing Knocknacran Open-Cast**	Restored	0	3,350	-275	0
	Existing Drummond UG	Operational – assumed to continue*	3,000			
	Knocknacran West Site (Drumgoosat UG Well - only)	Continue to pump from UG Well	150			
	Knocknacran West Open-Cast Mine Area	Operational – northern area extracted	200			
ca. 16 - 30	**Existing Knocknacran Open-Cast**	Restored	0	3,425	-200	0
	Existing Drummond UG	Operational – assumed to continue*	3,000			
	Knocknacran West Site (Drumgoosat UG Well - only)	Continue to pump from UG Well	100			
	Knocknacran West Open-Cast Mine Area	Operational – southern area extracted. Materials stored in northern extraction area.	350			
End Year ca. 30	**Existing Knocknacran Open-Cast**	Restored	0	3,325	-300	0

	Existing Drummond UG	Operational – assumed to continue*	3,000			
	Knocknacran West Site (Drumgoosat UG Well - only)	Pumping ceases from UG Well	0			
	Knocknacran West Open-Cast Mine Area	Cessation of Mining	350			

*Notes: * Drummond Mine is assumed to be active – however, this is dependent on a future planning application being sought and granted post 2032. ** No discharge to Corduff Stream during operational phase of the mine. Discharge will only take place once a waterbody is formed and its water level reaches the Corduff Stream invert level.*

The water balance indicates there will be an ca. 350 - 450 m^3/day water pumped from the Knocknacran West excavation as the open-cast progresses from ca. year 2 to year 30 (the operational period of the mine). However, when the loss of inflows from the restored Knocknacran Open-Cast Mine and the Drumgoosat borehole are accounted for over time, the overall change to the water balance would be a decrease of ca. 125 - 275 m^3/day from existing conditions. This scenario considers that Drummond Mine would still be operational (with 3,000 m^3/day contribution) for the purposes of a robust assessment, however, this would be subject to planning permission being sought, and granted, for continued operation at Drummond.

The greatest incremental inflows (at the high end of the range) will occur during the winter when the River Bursk has adequate assimilative capacity to accommodate the discharge. Incremental inflows during the summer will be minor (at the low end of the range). Furthermore, the new excavation provides an opportunity to store additional water seasonally (as required) in the new pit floor sump and will therefore provide additional flexibility to the site-wide water management system.

If some of the groundwater pumped by the dewatering well enters the proposed new sump in Knocknacran West instead of the well during the latter stages of the excavation, there would be no net effect on the water balance. The groundwater impact of the proposed new excavation would not be increased relative to the existing Drumgoosat Underground Mine, so the overall volume of groundwater inflow requiring management would not increase. It is considered that the impact magnitude would be Negligible (adverse) and the significance of effect would be Imperceptible.

The restoration of peripheral areas of the existing Knocknacran open-cast as part of the progressive backfilling process during the life of the mine, will marginally reduce the amount of water that requires pumping and management.

As the existing Drumgoosat and Knocknacran mining areas and the proposed new Knocknacran West open-cast are all contained within a well-established drawdown zone of contribution, there will be no incremental groundwater flows entering the mining areas requiring management as a result of the proposed new Knocknacran West Open-Cast Mine development.

All of the water would enter the existing site water management system for retention and treatment, prior to any release to the existing discharge point in the River Bursk. The significance of effect is considered to be Imperceptible.

Table 8.21 shows the predicted sump water quality at the maximum extent of the proposed Knocknacran West excavation. For comparison, the table also references the local groundwater chemistry from monitoring borehole M102PA. The quality of the runoff water pumped from the proposed Knocknacran West sump is expected to be similar in nature to the water currently pumped from the existing Knocknacran sump and the prediction below accounts for this (refer to Section 8.4.7 for further quality details for the Knocknacran sump).

The magnitude of the impact on groundwater or surface from the water management onsite is considered to be Negligible (Adverse). The sensitivity of the groundwater is considered to be Negligible while the sensitivity of the surface water is Medium. The significance of effect for surface water is considered to be Imperceptible while the significance of effect to groundwater is considered to be Imperceptible.

Table 8.21: Predicted quality of water pumped from the proposed Knocknacran West Open-Cast sump

	Groundwater	Pit Wall Runoff
Parameter	**M102 PA**	**Knocknacran West Sump**
	mg/L	**mg/L**
Sodium	65	65
Potassium	8	5
Calcium	175	368
Magnesium	75	45
Chloride	16	16
Sulphate	500	973
Nitrate	0.5	0.7
Phosphate	0.12	0.12
Alkalinity	300	300
Aluminium	0.24	0.24
Zinc	0.04	0.04
Iron	0.29	0.29
Lead	0.0005	0.0005
Manganese	0.099	0.099
Nickel	0.028	0.028
Tin	0.0005	0.0005
Copper	0.001	0.001

8.6.4.5 Potential Effects: Operational Phase: Mine Development: R179 and L4900 Roads

Prior to June 1998, the groundwater level in the Kingscourt Gypsum beneath the R179 was about -37 m OD, which represents over 70 m of drawdown from its original pre-mining groundwater level. Pumping water into the Drumgoosat underground workings through the Drumgoosat Well following the June 2018 Drummond inflow event caused the water level beneath the road to rise to a maximum of about -7.6 m OD (1002.6 m mine level) (Figure 8.33). Figure 8.34 shows the extent of inundation of the Lower Gypsum for water levels of about -37 m OD mine level (May 2018) and -6 m OD mine level (December 2018). The current groundwater level beneath the road is about -28 m OD mine level (November 2021).

While mining is on-going in Knocknacran open-cast and pumping from the dewatering well is being continued, it can be expected that groundwater levels will remain at or below their current level beneath the R179 and L4900. The backfilled material acts to minimize the likelihood of groundwater outflow in the gypsum or dolerite at the southern end of the existing Drumgoosat Underground Mine.

Once mining ceases in Knocknacran open-cast, backfill (material stripped from Knocknacran West) will be placed in the existing Knocknacran open-cast void space as the planned mining of Knocknacran West commences, leading to the hydraulic connection between Knocknacran open-cast and Drummond Mine being gradually cut off. The hydrogeology of the Drummond Mine will therefore become independent of the hydrogeology of the existing Knocknacran Open-Cast Mine and the proposed Knocknacran West Open-Cast Mine.

Hydraulic isolation is also an inherent by-product of the proposed Mine Development. However, while it is inherently useful by further reducing the potential for groundwater movement, it is not a target of the development. In overall terms of design, it is of low importance.

The proposed excavation of the Knocknacran West open-cast will not cause any water level rise. In fact, because the proposed Knocknacran West open-cast development will eventually be excavated below the current water level, the risk of a rise in the water level below the roads will be reduced. The impact magnitude of dewatering is considered to be Low (beneficial) during the operational life and the significance of the effect is considered to be Imperceptible.

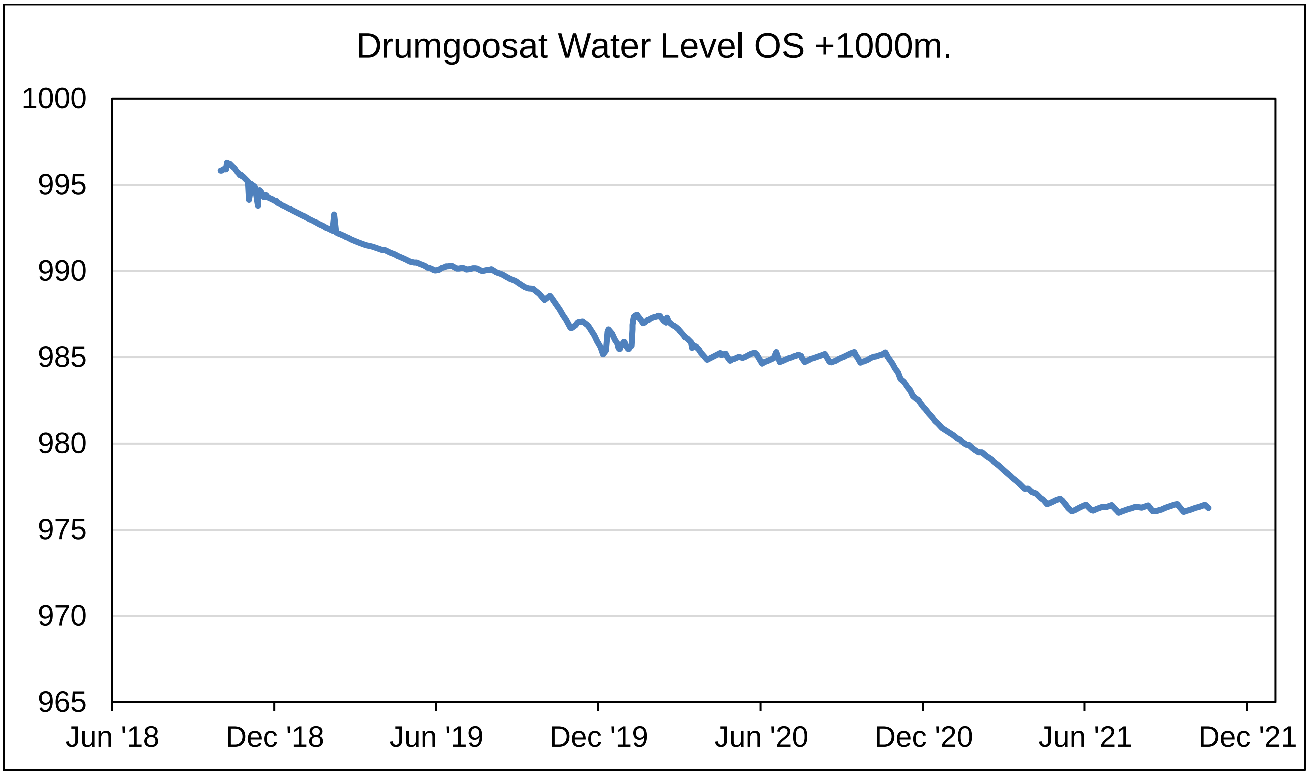

Figure 8.33: Water levels in the Drumgoosat workings from January 2018 to October 2021 (note that water levels on the y-axis are mine level (m OD plus 1,000 m)

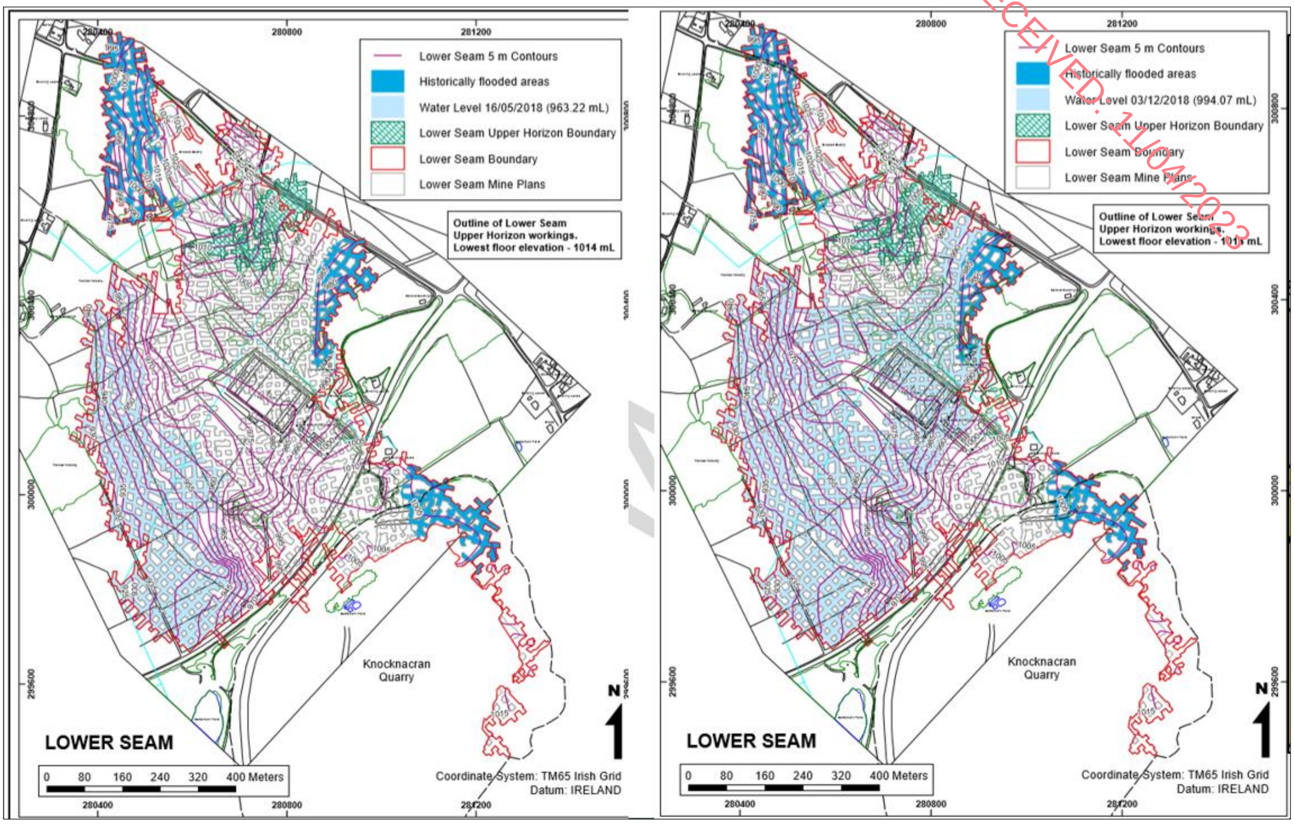

Figure 8.34: Extent of inundation in the Lower Gypsum close to the R179 with a water level of -37 m OD mine level (left) and -6 m OD mine level (right)

The proposed temporary diversion of the R179 road is described in Chapter 3.0, Section 3.4 and Appendix 3.5. The temporary road is adjacent to the existing road so underlying groundwater levels are similar. The gypsum that remains in place in the Upper and Lower Units beneath the temporary road will also become hydraulically isolated from any active groundwater flow pathways.

8.6.4.6 Potential Effects: Operational Phase: Mine Development: Flooding

The potential risk of flooding from rainfall events has been addressed for the proposed Knocknacran West development and for the backfilled existing Knocknacran open-cast.

By its nature, open-cast mining creates a large pit in the ground which acts to provide an alleviation to any potential flooding. Surface water will be captured within the open-cast area and will then enter the mine's water management system which will see it stored in lagoons on the Knocknacran site before a controlled release to the River Bursk. The presence of the open-cast will not create a flooding problem, rather it would help to attenuate surface water release in the event of an extreme rainfall event.

Berms placed around the crest of the proposed Knocknacran West open-cast will be designed such to minimize any potential for localised flooding of fields. Any potential for accumulating water at the pit crest may represent a hazard to the geotechnical stability of the walls of the pit so, if any minor areas are identified during development, additional field drains will be installed to minimise the potential for accumulating water.

Progressive reclamation of the Knocknacran open-cast will gradually increase the amount of non-contact runoff that reports to the surrounding area. Surface drainage will be to the southwest towards the Corlea Stream, which is the closest EPA recorded waterbody and occurs about 650 m to the west of the pit area. An

OPW-maintained ditch (numbered Channel C43(3a) occurs between the pit and the Corlea Stream. Local runoff from the restoration surface will eventually flow towards this channel, in the same direction that runoff currently flows (prior to any mining at Knocknacran West). The channel is not mapped on the EPA Envision map but is known to carry flow from a small catchment north of the R179 road which is culverted across the road. The ditch is then culverted in a 600 mm diameter pipe under a filling station forecourt to the west, and then into a 900 mm diameter pipe, before discharging to the Corlea Stream at the crossroads to the west of the Site. The Corlea Stream runs from the north to the south, to the west of the Knocknacran area and joins into the Magheracloone Stream to the southwest of the pit area. Both the Corlea Stream and Magheracloone Stream will be located at a sufficient distance from the restored open-cast mining voids that the risk of flooding due to the incremental runoff from the restoration surface(s) is considered to be extremely unlikely.

In addition, consideration has been given to the potential impact and effect of an unexcepted inflow event. The most important factors when dealing with an unexpected inflow event is the ability to store water in the immediate aftermath of the event and the ability to discharge the stored water to the River Bursk in due course.

The old Drumgoosat Underground Mine is currently not used as an emergency storage for water, and neither will it be into the future.

The licence review issued in December 2021 provides an increased ability to release water to the River Bursk which reduces the need for water storage.

The sump in the existing Knocknacran Open-Cast Mine provides emergency storage capacity should the need arise currently.

As discussed in Section 8.4.7, emergency storage of water will be facilitated by storing it in the existing Knocknacran Open-Cast Mine as is currently the case. As the proposed Knocknacran West Open-Cast Mine is developed, it will provide capacity for emergency water storage replacing the capacity of the existing Knocknacran Open-Cast Mine as it is remediated.

In addition, a safe working procedure is in place to deal with potential water flow inrush into Drummond Underground Mine workings (Appendix 8.6). This procedure is based on historical mine design records, water intersections, survey data and geological reports generated since the mine opened in 2006.

The magnitude of impact due to the open-cast on flooding is considered to be a Negligible (beneficial) impact and the effect is considered to be Imperceptible effect as the flooding sensitivity is Low.

8.6.4.7 Potential Effects: Operational Phase: Mine Development: Climate Change

EPA guidance documentation "*Integrating Climatic Factors into the Strategic Environmental Assessment Process in Ireland*", 2019 indicates that climate change will cause additional winter rainfall and drier weather in the summer. Although there is a "*high level of disagreement*" on spatial distribution of the change, the document indicates that the frequency of heavy precipitation events during the winter may increase by up to 20%. There is no specific guidance value for precipitation to use within assessments for Ireland, but current planning in the UK indicates 5-10% more winter rainfall and 0-10% lower summer rainfall, on average (Environment Agency, 2022). The implications of climate change for the Mine Development are:

- Receiving waters (primarily the River Bursk) will have higher flows in winter and lower flows in summer;

- There will be higher winter sump flows in both the existing Knocknacran and the proposed Knocknacran West excavations. The higher discharges would occur when flows in the receiving waters are higher. The additional flexibility to store water in the sumps will allow discharge flows from the site to be matched with receiving stream flows;

- The excess assimilative capacity in the River Bursk would remain the same and would not be effected by climate change. There would be less requirement for any discharge during the summer months when flows in the receiving stream are low; and

- The natural seasonal water level cycle in the superficial groundwater system will be greater. Many areas in the east and northeast of Ireland are already experiencing lower natural groundwater levels in the summer months. Since superficial groundwater inflows to the pit will be small, and the extent of drawdown around the planned excavation will be limited, there is no requirement to consider this aspect of climate change for the development of the project.

The sensitivity of groundwater is considered to be Negligible, while surface water's sensitivity is considered to be Medium. The impact magnitude from the Mine Development, accounting for climate change, is considered to be Negligible (adverse) and the effect for groundwater is considered to be Imperceptible and Imperceptible for surface water.

8.6.5 Potential Effects: Restoration/Closure Phase: Community Sports Complex

No closure phase is proposed for the Community Sports Complex, therefore the potential impact and effect from this phase is not considered further.

8.6.6 Potential Effects: Restoration/Closure Phase: Mine Development

8.6.6.1 Potential Effects: Restoration/Closure Phase: Mine Development: Groundwater

Upon eventual completion of mining and placement of backfill, the dewatering pumps in Knocknacran West open-cast and the dewatering well will be permanently shut down and the water levels within the open-cast void will start to rise. The proposed placement of low permeability backfill (mudstone) within the existing Knocknacran open-cast will have the positive benefit of reducing any hydraulic connection in the gypsum strata and effectively isolating the Drumgoosat / Knocknacran West mining areas from the Drummond Mine to the south. Modelling of the final open-cast void indicates the water level will eventually rise to the level of the lowest points on the northeastern rim of the excavation. The final water level will be about 38-39 m OD. The final waterbody will be about 55 m deep, 500 m in width, and 760 m in length. The final waterbody is described in the report Knocknacran West pit lake model and restoration plan (Piteau Associates, 2022) (Appendix 8.7).

While the existing Knocknacran open-cast continues to be backfilled, pumping from the sump will be continued (as at present) until final restoration is compete. At that time, any surface water runoff from the reclaimed and restored backfill surface will be considered as non-contact water and will be directed to the natural surface water collection ditches, similar to conditions prior to mining. Throughout the backfill process, the sump will be maintained on the surface of the backfill to allow on-going management of any residual contact water. The sump will be retained and restored to natural grassland as part of the permanent site restoration programme.

Groundwater levels in the Kingscourt Gypsum strata that surround the open-cast will rise at approximately the same rate as the waterbody within the final void. The amount of groundwater storage is small and will not materially affect the rate of rise in the water level in the open-cast. The presence of low permeability backfill material immediately to the north and south of the Knocknacran West workings will isolate the open waterbody from much of the surrounding groundwater system. As a result, it is considered likely that much of the replenishment of local groundwater storage will already have occurred by the time restoration commences in the Knocknacran West Open-Cast Mine. Water levels in the interconnected groundwater units surrounding the open-cast are expected to be similar to the water level in the open-cast.

The monitoring data show that groundwater levels in the superficial deposits are localized. There are no known continuous sand and gravel lenses within the superficial deposits. Conditions in the groundwater levels upgradient of the mine are expected to remain the same as present. Therefore, the magnitude of impact is considered to be Negligible (adverse) on groundwater, the sensitivity of groundwater is considered to be Negligible and the significance of effect is considered to be Imperceptible.

8.6.6.1.1 Potential Effects: Restoration/Closure Phase: *Domestic Wells*

Upon completion of the mining excavation, the water level in the restored excavation will eventually rise to 38-39 mODM which is consistent with (marginally higher than) the natural groundwater table in the footprint area of the planned excavation, so the permanent excavation is not expected to affect these wells.

Because of the low permeability nature of the glacial till, and the fact that superficial water levels have become decoupled from drawdown in the underlying Kingscourt Gypsum sequence, the propagation of drawdown towards these wells as a result of the planned Knocknacran West open-cast excavation would not be expected.

The sensitivity of the groundwater resource (which the domestic wells are abstracting from) is considered to be Negligible, the magnitude of impact due to the proposed Mine Development is considered to be Negligible (adverse). The significance of the effect is considered to be Imperceptible.

8.6.6.1.2 Potential Effects: Restoration/Closure Phase: Hydraulic Isolation

The current plan for the proposed Knocknacran West Open-Cast Mine is to continue to place backfill material (stripped mudstone) against the walls of the open-cast where gypsum is exposed. This will mean that the gypsum that remains in place in the Upper and Lower Units surrounding the open-cast (including beneath the roads) will become hydraulically isolated from any active groundwater flow pathways, which will greatly reduce the potential for any on-going kinetic reactions and possible gypsum dissolution which, in turn, will help minimize the potential for any future settlement.

Hydraulic isolation is an inherent by-product of the proposed Mine Development. However, while it is inherently useful by further reducing the potential for groundwater movement, it is not a target of the development. In overall terms of design, it is of low importance.

A separate report by Piteau Associates (*Hydrogeology Study of Drumgoosat Underground Workings, May 2021*) considers that the actual saturation state of the water entering the mine workings would not cause dissolution of the gypsum in the mine workings (Appendix 8.8).

Nevertheless, the act of hydraulic isolation is considered to be positive benefit of the proposed Knocknacran West development and the magnitude of the impact for the restoration phase is considered to be Low (beneficial) and the significance of effect is Slight.

8.6.6.2 Potential Effects: Restoration/Closure Phase: Mine Development: Surface Water

Upon cessation of mining and final restoration of the landform, the pump in the Knocknacran West open-cast will be shut down and the water levels within the final void will start to rise. The physical nature and water quality in the pit lake has been predicted and is presented in Table 8.22 (Appendix 8.7).

The sources of water that will inflow into the final void will be as follows:

- Rainfall onto the walls of the open-cast which runs off into the developing waterbody. Runoff from the sides of the open-cast will be the main source of water initially; but will reduce with time as the sides slopes gradually become submerged.

- Direct incident rainfall onto the open waterbody, which will gradually increase with time as the area of open water increases.

- Surface water runoff that enters the open-cast from the marginal area. This is assumed to be minor since a berm will be placed around the crest of the open-cast.

- Minor bedrock groundwater from the gypsum strata and dolerite that surround the pit area. Groundwater inflows to the Drumgoosat underground workings were low. Groundwater inflow to the open-cast is expected to be even lower than the water pumped from the Drumgoosat underground workings.

- Minor groundwater from the superficial deposits exposed within the upper side slopes of the open-cast which is also expected to be very low because the superficial deposits consist mostly of low permeability boulder clay and there are no known sand and gravels lenses in the local area.

The water chemistry of the impounded waterbody has been predicted using an industry-standard pit lake model (Appendix 8.7). The model has been run for 100 years following shut down of the pumps. In the model, the waterbody is assumed to fully mix seasonally (laterally and vertically), which is a reasonable assumption given the ambient weather conditions at the Site. At the point where outflow occurs from the pit rim, the total dissolved solids (TDS) concentration is predicted to be 400-550 mg/l. Sulphate values are predicted to be about 149 mg/l, with calcium about 73 mg/l. The water is predicted to have a near-neutral to slightly alkaline pH. Outflow from the waterbody will mostly occur during the months of October to March when flows in surrounding ditches and streams are also high.

The level of the waterbody in the open-cast is expected to rise slowly with time to a final level of 38-39 m OD, when the lake will overflow into the original Corduff Stream on the northeast side. The final waterbody will be about 36 m deep, 500 m in width, and 760 m in length. The predicted area of the waterbody is approximately 26 ha, or about 15% of the current Corduff Stream catchment upstream of monitoring point "SW Flow F". The presence of the waterbody will increase the effective catchment of the Corduff Stream by about 11 ha, extending the Corduff catchment area to Lough Fea from about 169 hectares to about 180 hectares. The estimated average annual outflow from the waterbody is within the range 500-700 m^3/d (5.8–8.1 L/s), varying seasonally from zero in the summer up to over 1,000 m^3/d (11.6 L/s) in the winter months.

In the summer, the waterbody will have little impact on the Corduff Stream because there is already no flow in the upper headwaters. In the winter, the waterbody will provide a sustained and steady outflow. The presence of the waterbody will provide a damping effect which will marginally reduce the magnitude of high winter flood flows in the stream. In the spring, the presence of the waterbody will cause flows in the headwaters to be sustained for a slightly longer period of time than at present before the stream dries up.

Monitoring locations "SW Flow C" and "SW Flow F" will be maintained throughout the operational and restoration phase of Knocknacran West.

Table 8.22 provides a comparison between the existing water chemistry in the Corduff Stream and the predicted water chemistry of the final Knocknacran West waterbody. An assimilative capacity study has been carried out for the Corduff Stream and is provided in Appendix 8.1.

Table 8.22: Comparison of current and predicted post-closure water quality of the Corduff Stream at SW_F

Parameter	*Unit*	*EQS AA**	*Corduff D/s SW_F 13/06/2022*	*Predicted Pit Lake Discharge Post-Closure*
Ammonia	*mg/L as N*	*0.065*	***0.24***	
BOD	*mg/L*	*1.5*	*1.2*	
Chloride	*mg/L*	*-*	*29*	*7*
Chromium	*mg/L*	*-*	*<0.001*	
COD	*mg/L*	*-*	*26*	
Copper	*mg/L*	*0.03*	*0.002*	*0.0006*
Manganese	*mg/L*	*-*	*0.702*	*0.06*
Nickel	*mg/L*	*0.02*	*0.002*	*0.016*
Phosphate	*mg/L as P*	*0.035*	***0.09***	*0.03*
Phosphorus	*mg/L as P*	*-*	*0.2*	
Solids (Settleable)	*mg/L*	*-*	*<1*	
Solids (TSS)	*mg/L*	*-*	*8*	
Sulphate	*mg/L as SO4*	*-*	*65*	*150*
pH	*Units*	*-*	*6.96*	
Conductivity	*µS/cm*	*-*	*548*	
DO	*mg/L*	*-*	*10.37*	
Temperature	*Deg C*	*-*	*13.3*	
TSS	*ppm*	*-*	*277*	

The study found the following:

"The Knocknacran West open-cast is located at the head of the Corduff catchment so discharge from the waterbody will be the primary water source in the upper catchment. For this reason, a 'standard' assimilative capacity for a receiving waterbody is not appropriate. For the purposes of this report, a comparison has been made between the 2022 water quality results, the proposed pit lake discharge quality (Piteau, 2021) and the EQS (refer to Table 8.23 below).

This shows that the Corduff is currently elevated (no assimilative capacity) for ammonia and phosphate. Both are related to agricultural practices. The post-closure pit lake is predicted to have phosphate concentrations of 0.03 mg/L, less than the EQS of 0.035 mg/L. Ammonia has not been predicted but without the agricultural influence, it is also likely to meet EQS after closure.

All other parameters where comparisons are available, but no EQS show that the water quality will be broadly similar to current conditions. The exception is sulphate which will increase in post-closure to around

150 mg/L. AECOM (2022) completed a Natural Impact Statement (NIS) for the project which concluded that a discharge (from the sedimentation ponds) of between 200 and 250 mg/L would have "no significant effect on QI habitats or SCI species, that conservation objectives will not be compromised, and therefore that there will be No Adverse Effect on the integrity of Dundalk Bay SPA, Dundalk Bay SAC or Stabannan-Braganstown SPA from the Proposed Development either alone or in-combination with other projects or plans."

Table 8.23: Predicted quality of the impounded water in the Knocknacran West Open-Cast during Year 1, Year 10 and the time that the water seasonally overflows the final pit rim

Parameter	WQ Standard (mg/L)	Concentration at 10 years post-closure (mg/L)	Concentration at the time of overflow (mg/L)
Potassium	-	3.2	2.4
Sodium	-	30.4	19.5
Calcium	-	132.1	73.0
Magnesium	-	26.6	18.3
Chloride	-	9.0	7.0
Sulphate	-	321.0	148.9
Nitrate	25	0.52	0.50
Phosphate	0.065	0.05	0.03
Alkalinity	-	185.7	154.7
Aluminium	-	0.1	0.05
Zinc	-	0.027	0.023
Iron	-	0.12	0.06
Lead	0.008	0.0003	0.0003
Manganese	-	0.07	0.06
Nickel	0.0047	0.019	0.016
Tin	-	0.00033	0.00029
Copper	0.02	0.0007	0.0006

It is noted that the existing restoration plan in place for Knocknacran Mine (Reg. Ref. 17/217) includes the creation of an additional waterbody in the area once restored. The waterbody proposed in this EIAR is an amendment to the existing restoration plan and will allow the waterbody to be located on the proposed Knocknacran West Open-Cast Mine site rather than the existing Knocknacran Open-Cast Mine site.

Therefore, the impact magnitude of a surface waterbody on the Knocknacran West site (including chemistry considerations) rather than the Knocknacran site in the restoration phase is considered to be Negligible. The significance of the effect is considered to be Slight.

8.6.6.3 Restoration/Closure Phase: Mine Development Potential Effects: Climate Change

EPA guidance documentation "*Integrating Climatic Factors into the Strategic Environmental Assessment Process in Ireland*", 2019 indicates that climate change will cause additional winter rainfall and drier weather in the summer. Although there is a "*high level of disagreement*" on spatial distribution of the change, the document indicates that the frequency of heavy precipitation events during the winter may increase by up to 20%. There is no specific guidance value for precipitation to use within assessments for Ireland, but current planning in the UK indicates 5-10% more winter rainfall and 0-10% lower summer rainfall, on average (Environment Agency, 2022). The implications of climate change for the Mine Development are:

- The proposed Knocknacran West pit lake would recover and stabilize slightly quicker because there would be more winter runoff. Runoff coefficients during the summer are already low so any influence of drier summers would be limited. If there is more summer evaporation, the seasonal change in lake level may be marginally greater; and

- Discharge flows to the Corduff Stream following restoration would be marginally higher if there is more winter rainfall, but flows will be less peaky than for the natural condition because outflows will be damped by the lake storage.

The sensitivity of groundwater is considered to be Negligible, while surface water's sensitivity is considered to be Medium. The impact magnitude from the Mine Development, accounting for climate change, is considered to be Negligible (adverse) and the effect for groundwater is considered to be Imperceptible and Imperceptible for surface water.

8.6.6.4 Potential Effects: Restoration Phase: Mine Development: Water Balance and Water Management System

The water balance for the proposed Knocknacran West excavation includes the following components:

- Rainfall on the slopes of the excavation which will run off to the lake (during restoration);

- Incident rainfall on the sump which will be small during operations but which will become an increasing part of the water balance to the lake during restoration;

- Groundwater from the Kingscourt Gypsum sequence will be allowed to flow into the sump during the final years of the excavation and during the restoration stage;

- Groundwater from the superficial deposits in the upper part of the excavation which is seen to be negligible in the existing Knocknacran excavation and is expected also to be negligible for Knocknacran West because of the similar low permeability nature of the glacial till surrounding both excavations;

- Open water evaporation which will become an increasing part of the water balance of the lake during the restoration phase stage; and

- Runoff from the slopes of the existing Knocknacran open-cast excavation currently enters the sump (during operations). The runoff will continue to run off to the sump during the initial years of restoration, but will increasingly be diverted to external ditches as non-contact water as backfill material is progressively placed around the outer margins of the restored area.

The updated water balance model (Table 8.4) for the restoration phase of the development indicates that, during restoration of the proposed Knocknacran West excavation, runoff from the side slopes from the excavation will be higher than during operations for three reasons. First, preferential flow channels will develop which will increase the runoff coefficient. Second, there will be no in-pit stockpiles so water will flow directly to the developing lake. Third, the length of the flow paths for the runoff water will decrease as the lake level rises. Runoff from the side slopes is predicted to occur at an annual average of about 350 m^3/d upon shut down of the pumps (in the early stages of restoration) but will decrease to an annual average of about 150 m^3/d when the level of the open waterbody has reached its final (stable) elevation. Seasonally, the runoff will vary from zero during dry summer months to an average of about 230 m^3/d in the autumn and winter months.

Pumping from the existing Drumgoosat well will continue to occur at a rate of about 150 m^3/day throughout much of the planned operating period of Knocknacran. In the final years of the excavation, the well will be shut down and the groundwater that was captured by the well will flow into the sump in the bottom of the excavation. During the restoration stage, the water will flow into the developing lake at an average inflow rate of about 100 m^3/d.

The Corduff Stream will be reinstated during the restoration phase, and the flow will be improved from baseline conditions. It has been noted in the aquatic survey report (Appendix 8.7) that the existing baseline for the Corduff Stream has issues with low flow and high sedimentation. It is considered that an increased flow will help alleviate this issue in the long-term for the stream and will likely improve the quality.

The sensitivity of the groundwater is considered to be Negligible while the sensitivity of the surface water is Medium. The magnitude of the impact on groundwater or surface from the water management onsite is considered to be Negligible (positive). The significance of effect for surface water is considered to be Slight (positive) while the significance of effect to groundwater is considered to be Imperceptible.

Table 8.24: Water Balance during the restoration phase of the Mine Development

Year	Description	Phase	Total Average Discharge Volume (m^3/d)	Total Discharge to Water Management System (m^3/d)	Additional Flow to Water Management System (m^3/d)	Total Discharge to Corduff Stream* (m^3/d)
Baseline	**Existing Knocknacran Open-Cast**	Operational	325	3,625	0	0
	Existing Drummond UG	Operational	3000			
	Knocknacran West Site (inc. Drumgoosat UG Well)	Pre-construction - continue to pump from UG Well	300			
ca. 30 - 60 pit lake development	**Existing Knocknacran Open-Cast**	Restored	0	3,000	-1,350	0
	Existing Drummond UG	Operational – assumed to continue*	3,000			
	Knocknacran West Site (Drumgoosat UG Well - only)	Pumping ceased from UG Well	0			
	Knocknacran West Open-Cast Mine Area	Restored**	0 (pit lake development)			

ca. 60+	**Existing Knocknacran Open-Cast**	Restored	0	0	0	580
	Existing Drummond UG	Cessation of Mining	0			
	Knocknacran West Site (Drumgoosat UG Well - only)	Pumping ceased from UG Well	0			
	Knocknacran West Open-Cast Mine Area	Restored**	580			

*Notes: * No discharge to Corduff Stream during operational phase of the mine. Discharge will only take place once a waterbody is formed and its water level reaches the Corduff Stream invert level.*

8.7 Mitigation and Management

This section presents mitigation measures that will be incorporated into the Proposed Development to ensure that no adverse environmental impacts will occur to the surface and groundwater environments as a result of the Proposed Development.

8.7.1 Mitigation and Management: Construction Phase: Community Sports Complex

- Works will be undertaken in line with any conditions set by MCC;
- All works will be undertaken in accordance with best practice and adhere to the following guidelines:
    - Inland Fisheries Ireland (2016). Guidelines on Protection of Fisheries During Construction Works in and Adjacent to Waters;
    - CIRIA (2009). Control of Water Pollution from Construction Sites – Guidance for Consultants and Contactors (C532);
    - NRA Guidelines (2006). NRA Guidelines for the Crossing of Watercourses during the Construction of National Road Scheme; and
    - Defra (Department for Environment, Food and Rural Affairs) (2009). Construction Code of Practice for the Sustainable Use of Soils on Construction Sites.
- Any plant will be regularly maintained and kept in good order on the proposed Community Sports Complex site;
- Refuelling of mobile plant will take place from bunded fuel tanks;

- Surface runoff will be managed by attenuation measures as granted under Reg. Ref.: 20/365; and
- Waste water will be managed by a fully designed and engineered waste water management system as granted under Reg. Ref.: 20/365.

8.7.2 Mitigation and Management: Construction Phase: Mine Development

8.7.2.1 Embedded Mitigation: Construction Phase: Mine Development

The initial assessment of the significance of potential effects resulting from the Mine Development takes into consideration any embedded design and commonly undertaken good practice mitigation. The elements of the Mine Development design and good working practices that reduce the potential for impacts to soils and geology include the following:

- Fencing will be maintained at the Site to ensure that the risk of injury to the public and livestock is minimised;
- Re-handling of the topsoil will be kept to a minimum to preserve the integrity of the material;
- All plant on the Site be regularly maintained, and where plant is damaged or leaking, it will be fixed or replaced immediately, as part of ongoing operational management of the site;
- Refuelling and the addition of hydraulic oils or lubricants to vehicles or generators will take place on-site only in designated areas; and
- Stockpiles will be evaluated and monitored and kept stable for safety and to minimise erosion.

8.7.2.2 Additional Mitigation: Construction Phase: Mine Development

The following additional mitigation will be implemented onsite:

- Works will be undertaken in line with any conditions set by MCC;
- Earthworks will follow the embedded mitigation measures outlined above. All works will be undertaken in accordance with best practice and adhere to the following guidelines:
    - Inland Fisheries Ireland (2016). Guidelines on Protection of Fisheries During Construction Works in and Adjacent to Waters;
    - CIRIA (2009). Control of Water Pollution from Construction Sites – Guidance for Consultants and Contactors (C532);
    - NRA Guidelines (2006). NRA Guidelines for the Crossing of Watercourses during the Construction of National Road Scheme; and
    - Defra (Department for Environment, Food and Rural Affairs) (2009). Construction Code of Practice for the Sustainable Use of Soils on Construction Sites.
- On-going geotechnical monitoring by means of extensometers will continue along the R179 and L4900;
- Any processing plant and / or mobile plant on the mine sites will be regularly maintained and kept in good working order; and
- Refuelling of mobile plant will take place from bunded fuel tanks as required.

8.7.3 Mitigation and Management: Operational Phase: Community Sports Complex

- Works will be undertaken in line with any conditions set by MCC;

- Any plant will be regularly maintained and kept in good order on the proposed Community Sports Complex site; and
- Refuelling of mobile plant will take place from bunded fuel thanks.

8.7.4 Mitigation and Management: Operational Phase: Mine Development

8.7.4.1 Embedded Mitigation: Operational Phase: Mine Development

The initial assessment of the significance of potential effects resulting from the Mine Development takes into consideration any embedded design and commonly undertaken good practice mitigation. The elements of the Mine Development design and good working practices that reduce the potential for include the following:

- In the Plant Site area, local runoff is prevented from discharging to surface water by a series of gullies and drains prior to passing through a hydrocarbon interceptor;
- Maintenance of vehicles being confined to the workshop area where practical;
- Hydraulic oils and engine oils being adequately bunded;
- Fuel tanks having bunded or have double skins;
- Waste oils being collected and stored prior to collection by a hazardous waste contractor.
- Groundwater levels within the gypsum strata will be managed by pumping from an existing monitoring well to the north of the existing Drumgoosat Well. The well will continue to dewater the full area of the proposed Knocknacran West open-cast, so the future area of mining influence will not increase. The well will continue to be pumped as necessary, with the existing Drumgoosat Well being subsequently plugged and abandoned, i.e. dewatered conditions will remain but pumping infrastructure will be relocated to an existing monitoring well on the Knocknacran West site for use as a dewatering well;
- As the new Knocknacran West open-cast is progressively excavated, a sump on the floor of the excavation will be used to manage surface water and any minor residual groundwater inflow to the workings, in much the same way as the sump in the current Knocknacran open-cast excavation does;
- A protective berm will be placed around the perimeter of the proposed Knocknacran West excavation to exclude surface water runoff. Again, this is much the same as the current Knocknacran excavation; Site operations will be managed in accordance with relevant health and Safety legislation (Safety, Health & Welfare at Work Act (2005, as amended); and the Mines and Quarries Act (1965, as amended));
- Fencing will be maintained at the Site to ensure that the risk of injury to the public and livestock is minimised. The entrance gate is locked and controlled by the Site's management;
- The extraction of gypsum will take place using the mining industry standard method of cyclical drilling, blasting, loading, hauling and supporting;
- The removal of soils will be conducted in a phased basis to reduce the overall potential impact on the land use and underlying groundwater;

- Re-handling of the topsoil will be kept to a minimum to preserve the integrity of the material;
- All plant on the Site be regularly maintained, and where plant is damaged or leaking, it will be fixed or replaced immediately, as part of ongoing operational management of the site;
- Refuelling and the addition of hydraulic oils or lubricants to vehicles or generators will take place on-site only in designated areas.
- Existing groundwater wells will be continuously monitored on site during mining operations and for a period following cessation of mining (to be agreed with the relevant authorities);
- Blasting will take place at the Site using licenced and experienced operators. Site management give advance notification of blast events to nearby residents as is standard procedure for the existing mine;
- Geotechnical assessments will be conducted on a regular basis by an experienced and suitably qualified geotechnical engineer;
- The mine manager will ensure compliance with relevant safety and statutory legislation and best practices recommended by national legislation (and guidelines);
- Backfill material (in the form of stripped mudstone) will be placed against the pit slopes of the Knocknacran West open-cast to help provide further hydraulic isolation of the gypsum strata that remain below the R179 and L4900 roads. The north and west slopes of Knocknacran have already been backfilled in this manner to minimize circulation of groundwater beneath the R179 road;
- Areas identified with current or potential future surface settlement above the historic Drumgoosat workings will be stripped and an incorporated into the Knocknacran West open-cast;
- All topsoil, overburden and interburden (mudstone) from within the proposed Knocknacran West not used in ongoing restoration open will stored in temporary stockpiles and vegetated to minimise the risk of rain/wind erosion. It will also reduce the potential for potential long-term groundwater contamination. All temporary stockpiled material will be used in the final restoration of the Knocknacran West Site;
- The current mine water management system will be maintained throughout the entire period of mining and until such time as full restoration of the entire Site has been completed:
    - The water balance model confirms that existing infrastructure will be sufficient for the purposes of managing all water from the proposed future extraction and restoration;
    - Future gypsum mining will be from an area that has previously been mined; and
    - The ability to temporarily store water in the base of Knocknacran and subsequently Knocknacran West open-cast will be retained until the flows and assimilative capacity in the receiving River Bursk are sufficient to allow discharge. This mitigates against the impact of releasing high sulphate water into the River Bursk, thereby preventing degradation of the river environment.
- An on-going programme of regular cleaning and maintenance will be carried out for the sump(s), attenuation ponds and other on-site water management facilities;

Maintenance works for the existing settlement lagoons on the Knocknacran Mine site are carried out periodically by a subcontractor and the programme of works is as follows:

- A CAT scanner is used to scan the ground for underground services in conjunction and any underground services identified are marked up on the ground and recorded on permit issued to excavator drivers;
- Activities require two excavators at the excavation area and an excavator at the deposition area. Two dump trucks are used for the haulage of material removed from the lagoons to the open-cast area;
- All handrails (and pumps where required) are removed prior to the works;
- The lagoons are dewatered individually prior to cleaning;
- Mine water is diverted to other lagoons which are not yet cleaned (or to the open-cast) and therefore have not yet been drained;
- An excavator is positioned on the roads between ponds. A linear strip is excavated along the length of the lagoon and material is loaded onto a dump truck for removal to the open-cast;
- An excavator enters the lagoons when the linear strip is cleaned back to allow safe entry to the pond to clean the interior;
- The excavator will side cast the remaining material for removal from the lagoons;
- As lagoon 3 is dewatered, the top half of the water column is diverted to lagoons 1 and 2 while the bottom half is diverted to the open-cast. The location of the lagoon is shown on Figure 8.28. This is carried out to minimise suspended solid concentrations in the newly cleaned lagoons, and while they are still refilling;
- After each lagoon is cleaned, mine water is gradually allowed to refill the lagoon, so as to minimise turbulence and suspended solid generation from the lagoon floor;
- Should there be a period of heavy rainfall during the lagoon cleaning, or refilling period, the pump at the open-cast sump is turned off so mine water is no longer diverted to the lagoons and water is left to settle in the open-cast sump first;
- Monitoring of the clearness of the water in both the lagoons and sump is carried out continuously. A monitoring sample is taken from MSE-1 to confirm suspended solid content and the water management system is then allowed to resume as normal after cleaning; and
- Table 8.25, below, provides the details of the maintenance plan for wastewater treatment systems on the mine site.

Table 8.25: Mine site maintenance plan

Wastewater treatment (Foul system)			
Item	**Inspections**	**Frequency of Inspection**	**Who**
Shredding pumps/ sump	As per OEM instruction	6 monthly	Waste Water Solutions Direct Ltd, Co Cork
Cycle/ storage tank/ sump	As per OEM instruction	6 monthly	Waste Water Solutions Direct Ltd, Co Cork
Percolation pump	As per OEM instruction	6 monthly	Waste Water Solutions Direct Ltd, Co Cork

Percolation area	As per OEM instruction	6 monthly	Waste Water Solutions Direct Ltd, Co Cork
Electrical Panel	As per OEM instruction	6 monthly	Waste Water Solutions Direct Ltd, Co Cork
Note: Service level Agreement reviewed every 12 months			
Mine Water Management Maintenance Plan			
Items	**Inspections**	**Frequency of Inspection**	**Who**
Drumgoosat Pump/ pipe system	Pump operational/ flow/ Power to electrical panel	4 per week as per pump check	SGMI
Open-Cast Pump/ pipe system	Pump operational/ flow/ Power to electrical panel	4 per week as per pump check	SGMI
Drummond Mine Pumps/ pipe system	Pump operational/ flow/ Power to electrical panel	4 per week as per pump check	SGMI
Lagoon Pumps/ Pipe system (x3)	Pump operational/ Power to electrical panel	Operation alarm system/ Automatic rotation/ visual 2 per week	SGMI
Lagoon Sumps (x4)	Check water/silt level	4 per week (visual) - water level on Scada system	SGMI
Holding Tanks/ MSE-1	Check water level/ silt level/ flow	1 per week min. (visual) - monitored continuously Scada system	SGMI
Outfall to Bursk	Check water level/ flow	1 per week min. (visual) - monitored continuously Scada system	SGMI
Mine Site drainage/ pipe reticulation	Integrity of pipes	Every 3 years	Subcontracted - SGMI

8.7.4.2 Additional Mitigation: Operational Phase: Mine Development

The following additional mitigation will be implemented onsite in addition to the embedded mitigation presented above:

- Works will be undertaken in line with any conditions set by the IE licence;
- Earthworks will be undertaken in accordance with best practice and adhere to the following guidelines:
    - Inland Fisheries Ireland (2016). Guidelines on Protection of Fisheries During Construction Works in and Adjacent to Waters;
    - CIRIA (2009). Control of Water Pollution from Construction Sites – Guidance for Consultants and Contactors (C532);
    - NRA Guidelines (2006). NRA Guidelines for the Crossing of Watercourses during the Construction of National Road Scheme; and
    - Defra (Department for Environment, Food and Rural Affairs) (2009). Construction Code of Practice for the Sustainable Use of Soils on Construction Sites.
- Restoration of any remaining gypsum that may be exposed in the sides of the open-cast will be covered with low permeability material (i.e. previously stripped mudstone) to help optimize pumped water quality from the open-cast during operations and the final water quality post-restoration of the Site;
- Control of suspended solids will be carried out using settlement on the pit floor and in a sump(s);
- Whenever possible, water from the pit sump(s) will be preferentially used for dust suppression;
- The pit sump(s) will be regularly cleaned to remove fine grained material, with the material being used in rehabilitation and restoration work;
- Mobile plant will use the existing refuelling facilities at the Plant Site garage for refuelling. Static plant and tracked excavators will refuel over a drip tray with an absorbent mat;
- All mobile plant shall be regularly maintained, and where plant is damaged or leaking it will be fixed or replaced immediately, as part of the ongoing operational management of the mine to reduce the risk of leaks;
- No storage of hydrocarbons will take place in the open-cast area;
- Emergency spill kits (including absorbers) will be available for use in the event of an accidental spill in the open-cast area;
- Ongoing (real-time) monitoring of surface (mine) water discharge to the River Bursk will continue to take place in compliance with IE Licence P0519-04;
- The provision of adequate drainage along the upper benches of the proposed Knocknacran West Mine in the overburden will be employed as is the current arrangement in the existing Knocknacran Mine; and
- The qualified mine manager will ensure compliance with relevant safety and statutory legislation and best practices as set out in the HSA's 'Guidelines to the Safety, Health and Welfare at Work (Quarries)

Regulations 2008', and other relevant statutory and industry guidelines from Government Departments and the EPA for the mine sites;

- The designed intercept drainage system(s) and settling pond/filter system, for each stripping campaign, will be installed prior to stripping of material. The design will be updated throughout the stripping campaigns as the works progress. The design will be agreed with the relevant authorities prior to stripping;

- The contractor will organize the earthworks operations, whether in excavation or in restoration, so that all water shed onto the earthworks, or which enters the earthworks from any source is rapidly led away into a specifically designed intercept drainage system(s) and settling pond / filter system prior to discharge into the underlying mine workings, where it will enter the existing mine water management and treatment system;

- As the earthworks progress, the contractor will construct, maintain and revise, as necessary, all temporary ditches, sumps, pump lines and pumping units required for the effective disposal of all such water flows;

- The contractor will not commence main earthworks operations or continue with a section of main earthworks operations until a plan and programme of ditches, sumps, pump lines and pumping units has been agreed with SGMI's project manager;

- Depending on the area(s) to be stripped and restored, the contractor will construct a temporary de-silting settling pond / system at approximate location(s) to be agreed with SGMI's project manager prior to any stripping taking place;

- The contractor will construct surface water cut-off drains, ditches, swales and sumps, as required to ensure that the works are maintained free from standing water and to divert surface water and groundwater gathered to the drainage system via gravity and/or pumping. The cut-off drains will be a minimum of 600 mm deep and 400 mm wide at the base, and will have side slopes of no steeper than 1(V):2(H);

- The contractor's working surfaces in excavation and in filling will be sufficiently regular and will have such cross falls or longitudinal falls or both as are necessary to prevent standing water and to rapidly dispose of water run-off. The contractor's earthworks slopes, whether in cutting or in filling, will be trimmed to regular profile and compacted so as to prevent ponding water and to rapidly dispose of water run-off without scour;

- The contractor's temporary ditches and sumps will be located such that when backfilled they shall not have any adverse effects on the strengths or stability of the completed works. When temporary ditches and sumps are no longer required in a particular area of the site by reason of progress of the work, the contractor will promptly remove all temporary pump pipelines and pumping units. All softened deposits will be removed from the ditches and these areas backfilled with suitable material. Filling, compaction and field quality control will be as specified for the adjacent earthworks operations;

- The contractor's temporary sumps, pumping units and fuel or power supply will have adequate capacities for the pumping loads and will be maintained regularly to ensure efficient and reliable operation. The contractor will provide adequate supervision to ensure continuous operation whenever this is required to ensure rapid disposal of water run-off and will have adequate standby arrangements available to cope with pump or power failures;

- To avoid siltation of watercourses from crossing point locations, silt traps will be placed beside temporary crossing points with an associated buffer strip. The silt-traps will be maintained and cleaned regularly during the course of the works;
- A maintenance schedule and operational procedure will be established by the contractor for silt and pollution control measures during the stripping period. This will be undertaken in consultation with the relevant statutory authorities; and

8.7.5 Mitigation and Management: Restoration/Closure Phase: Community Sports Complex

There is no proposed decommissioning of the Community Sports Complex and so this is not considered further here.

8.7.6 Mitigation and Management: Restoration/Closure Phase: Mine Development

8.7.6.1 Embedded Mitigation: Restoration/Closure Phase: Mine Development

The initial assessment of the significance of potential effects resulting from the Mine Development takes into consideration any embedded design and commonly undertaken good practice mitigation. The elements of the Mine Development design and good working practices that reduce the potential for impacts to soils and geology include the following:

- SGMI will carry out hydrogeological assessments closer to mine closure to assess the assumptions made regarding stability;
- SGMI will submit an integrated closure plan/CRAMP which includes all the operations; Drummond, Knocknacran East and Knocknacran West to ensure that all planned closure operations are coordinated. The integrated closure plan will be submitted to the relevant regulatory authorities (including the EPA, Monaghan Co. Co. and GSRO) for their consideration, in advance of the commencement of open-cast mining at Knocknacran West;
    - Stockpiles will be evaluated and monitored and kept stable for safety and to minimise erosion;
    - A maintenance schedule and operational procedure will be established by the contractor for silt and pollution control measures during the construction period. This will be undertaken in consultation with the relevant statutory authorities.

It is worth noting that the operational and restoration phases of the proposed Mine Development are co-existent and inter-related, as the material needed for the gradual restoration of the existing Knocknacran Open-Cast Mine is reliant upon the gradual excavation of the Knocknacran West site. In addition, following on from cessation of extraction at Knocknacran West, material temporarily stored onsite will also be used in the final restoration phase at Knocknacran West itself.

It is not expected that any excess material will need to be imported from another facility. This will minimise any long-term or lasting visible presence of the open-cast pit on the landscape and will help facilitate the re-establishment of hedgerows and pasture, and their accompanying ecological habitats.

The existing Knocknacran Mine will be restored to grassland. This land will consist of regular-sized fields bordered by field boundaries consisting of native vegetation; in other words, compatible and consistent with the topography, land use, historical field boundary arrangements, field sizes and field boundaries of agricultural lands bordering the site within the central study area. Such a restoration will reduce any long-term or lasting visible presence of the open-cast mine on the landscape and will help facilitate the re-establishment pasture, and its accompanying ecological habitat. This land will be dressed with ca. 0.3 m of topsoil (originally stored in stockpiles from the Knocknacran West excavation) and re-seeded with an agricultural grade grass seed mixture.

In addition, following cessation of mining, the site of the Knocknacran West Mine will be partially restored, with a waterbody (lake) towards the centre of the site. In this incremental working process, the site (i.e., both the existing Knocknacran Mine and the proposed Knocknacran West Mine) will never be revealed in its entirety as a completely excavated open-cast void/pit with bare faces (benches). By the time that the later stage sections of the site are excavated north of the R179 (i.e., Knocknacran West Mine), the existing Knocknacran Mine to the south of the R179 will have been restored. The majority of all extraction works, including vehicular movement, will take place in visually obscured areas towards the open-cast mine floor, and so will have reduced visual effects beyond the mine area.

Three distinct habitats will be created through the closure of the Knocknacran West Open-Cast Mine:

- Open Water Habitat.
- Shoreline / Washland Habitat.
- Open Ground Habitat.

Each of these habitats are quite different from the other and will require different measures to establish and support diverse and sustainable ecosystems.

A consideration that is quite unique to this project compared to other habitat creation projects is that the size of the open waterbody will increase year on year as the area rewaters, and as such the rehabilitation plan to establish the new habitats needs to be able to be flexible with this changing environment.

The priority is to introduce only native species and this work will be carried out under the guidance of an ecologist and as part of a Biodiversity Action Plan. Each of the habitats is presented in the Chapter 13.0 Landscape.

Open Water Habitat

The open water habitat will be akin to a lake. The water quality will be of suitable quality to support a diverse range of species. It will not be necessary to introduce any species as indigenous species will migrate from nearby waterbodies and colonise the open water. The shoreline of the lake will be of a suitable depth to support benthic populations of macroinvertebrates. It is known that disconnected virgin freshwaterbodies will over time develop a population of invertebrate life as species such as mayfly and stone fly etc can colonise these areas by flight. Species such as frogs can migrate to the waterbody and even fish eggs can be transported by vectors such as birds, so that fish populations can become established. There is no plan to introduce any vertebrate aquatic species such as fish and indeed protections may be installed at the outlet of the lake such as a gabion basket wall to ensure that fish life from the waterbody does not migrate into the receiving surface waterbody (Corduff Stream). Saint-Gobain will liaise with Inland Fisheries Ireland with respect to the open waterbody and associated habitat.

Q Rating tests will be conducted to monitor the establishment of macroinvertebrates within the waterbody and ecosystem, and this will also be a good measure of the biodiversity of the habitat.

Shoreline / Washland Habitat

A shoreline is a habitat that provides major opportunity for the development of diverse habitat. The washland is the land next to the shore that will become covered in water seasonally and during periods of heavy rainfall.

The shoreline will support benthic macro invertebrate populations, plants, and invertebrate populations including mammals and birds.

The shoreline is an important habitat and is capable of supporting a diverse population of flora and fauna. To maximise the potential of this area reprofiling of the open-cast at the projected elevation of the final shoreline will introduce inlets to maximise contact area between land and water, which will maximise the extent of this habitat.

Plant species will be introduced by transplanting from donor sites around the area, such that the species introduced will be indigenous. An amount of soil will be imported with the root system during the transfer of the donor species to enhance the growing media. A shallow cover of soil (from the stripping of the Site) will be introduced on the land that will become shoreline and then lakebed as the lake expands. The shoreline species will be introduced in the early years of rewatering as the initial shoreline is established and these species will push out naturally as the water rises and the shoreline expands.

No invertebrate or vertebrate species will be introduced, these species will colonize naturally once the habitat is established. Ecological surveys, including bird surveys will be conducted routinely to monitor the success of the habitat.

Open Ground Habitat

The open ground habitat will be planted with a selection of grasses, shrubs and plants to form a diverse habitat. It is proposed to seed areas of the Site with a range of seed mixes to increase the cover and to improve the habitat value. The grass mixes will be consistent with species in the surrounding lands. The first planting of pioneer grass species will occur following the final contouring of the open-cast mine slopes. Planting will be used to facilitate a long-term process of succession and colonization in order to create a diverse ecological habitat.

The open ground that will be above the elevation of the final water level will have a deeper cover of soil so that it can be planted with tree species such as birch and alder. These species tolerate harsh and exposed conditions and will create shelter for other tree species to be planted such as oak.

Hawthorn, hazel and dogwood will also be planted, and these woody plants will encourage bird species to establish in wooded areas and assist with the dispersal of seeds and the natural plantation of the Site. Tree and hedge plantations will be placed to create links with existing hedgerows creating corridors for fauna to move from area to area. They will also create habitat islands which will help in the dispersal of seed.

Habitat surveys will be completed to monitor the performance and success of the rehabilitation. In the early years pruning and general maintenance will be carried out to promote success but ultimately the habitat will be designed to be self-sustaining, with minimal input required from the landowner.

The following approaches / measures will also be undertaken:

- Physical stabilisation of slopes through precise profiling and contouring;
- Removal and remodelling of any conspicuous, 'unnatural-looking' localised contour profiles to ensure they seamlessly 'marry-in' with existing/undisturbed contour profiles;
- Safeguard that drainage of slopes does not adversely affect neighbouring lands or watercourses; and
- All mine plant, infrastructure and detritus will be permanently removed off-site.

8.7.6.2 Additional Mitigation: Restoration/Closure Phase: Mine Development

The following additional mitigation will be implemented onsite:

- Works will be undertaken in line with any conditions set by the IE licence and CRAMP (a provisional CRAMP is provided in Appendix 3.3);
- Any processing plant and / or mobile plant on the mine sites will be regularly maintained and kept in good working order;
- The designed intercept drainage system(s) and settling pond/filter system, for each stripping campaign, will be installed prior to stripping of material. The design will be updated throughout the stripping campaigns as the works progress. The design will be agreed with the relevant authorities prior to stripping;
- The contractor will organize the earthworks operations, whether in excavation or in restoration, so that all water shed onto the earthworks, or which enters the earthworks from any source is rapidly led away into a specifically designed intercept drainage system(s) and settling pond / filter system prior to discharge into the underlying mine workings, where it will enter the existing mine water management and treatment system;
- As the earthworks progress, the contractor will construct, maintain and revise, as necessary, all temporary ditches, sumps, pump lines and pumping units required for the effective disposal of all such water flows;
- The contractor will not commence main earthworks operations or continue with a section of main earthworks operations until a plan and programme of ditches, sumps, pump lines and pumping units has been agreed with SGMI's project manager;
- Depending on the area(s) to be stripped and restored, the contractor will construct a temporary de-silting settling pond / system at approximate location(s) to be agreed with SGMI's project manager prior to any stripping taking place;
- The contractor will construct surface water cut-off drains, ditches, swales and sumps, as required to ensure that the works are maintained free from standing water and to divert surface water and groundwater gathered to the drainage system via gravity and/or pumping. The cut-off drains will be a minimum of 600 mm deep and 400 mm wide at the base, and will have side slopes of no steeper than 1(V):2(H);
- The contractor's working surfaces in excavation and in filling will be sufficiently regular and will have such cross falls or longitudinal falls or both as are necessary to prevent standing water and to rapidly dispose

of water run-off. The contractor's earthworks slopes, whether in cutting or in filling, will be trimmed to regular profile and compacted so as to prevent ponding water and to rapidly dispose of water run-off without scour;

- The contractor's temporary ditches and sumps will be located such that when backfilled they shall not have any adverse effects on the strengths or stability of the completed works. When temporary ditches and sumps are no longer required in a particular area of the site by reason of progress of the work, the contractor will promptly remove all temporary pump pipelines and pumping units. All softened deposits will be removed from the ditches and these areas backfilled with suitable material. Filling, compaction and field quality control will be as specified for the adjacent earthworks operations;

- The contractor's temporary sumps, pumping units and fuel or power supply will have adequate capacities for the pumping loads and will be maintained regularly to ensure efficient and reliable operation. The contractor will provide adequate supervision to ensure continuous operation whenever this is required to ensure rapid disposal of water run-off and will have adequate standby arrangements available to cope with pump or power failures;

- To avoid siltation of watercourses from crossing point locations, silt traps will be placed beside temporary crossing points with an associated buffer strip. The silt-traps will be maintained and cleaned regularly during the course of the works; and

- Earthworks will be undertaken in accordance with best practice and adhere to the following guidelines:

    - Inland Fisheries Ireland (2016). Guidelines on Protection of Fisheries During Construction Works in and Adjacent to Waters.
    - CIRIA (2009). Control of Water Pollution from Construction Sites – Guidance for Consultants and Contactors (C532).
    - NRA Guidelines (2006). NRA Guidelines for the Crossing of Watercourses during the Construction of National Road Scheme.
    - Defra (Department for Environment, Food and Rural Affairs) (2009). Construction Code of Practice for the Sustainable Use of Soils on Construction Sites.

8.8 Monitoring

8.8.1 Monitoring: Construction Phase: Community Sports Complex

- The appointed Main Contractor will be required to produce a final Construction Management Plan (CMP), which will document appropriate procedures and responsible persons when working on and around utilities and services infrastructure within and around the site; and

- Any monitoring associated with authorisation or consents (e.g., construction discharges or those associated with operational activities) will be incorporated into the Main Contractor's CMP and will be adhered to.

8.8.2 Monitoring: Construction Phase: Mine Development

- The appointed Main Contractor will be required to produce a final CMP, which will document appropriate procedures and responsible persons when working within and around the site; and

- Any monitoring associated with authorisation or consents (e.g., construction discharges) will be incorporated into the Main Contractor's CMP and will be adhered to; and
- Water quality monitoring will continue on the Mine Development site, in addition, surface water quality monitoring will be carried out on the Magheracloone and Corduff Streams during the construction phase.

8.8.3 Monitoring: Operational Phase: Community Sports Complex

There is no proposed environmental monitoring of the Community Sports Complex and so this is not considered further here.

8.8.4 Monitoring: Operational Phase: Mine Development

- Monitoring will be undertaken in line with any conditions set by the IE Licence;
- The Applicant will continue to maintain a Complaints Register. This register will record complaints in relation to the operation of the mine and associated infrastructure. In each entry the Applicant will record the date and time of the complaint, the name of the complainant (if provided), and will give details of the nature of the complaint. A record shall also be kept of any response made in the case of each complaint;
- Regular monitoring of groundwater (levels and quality) will continue to take place using existing monitoring boreholes in compliance with IE Licence P0519-04;
- Monitoring locations "SW Flow C" and "SW Flow F" will be maintained on the Corduff Stream. "SW Flow C" will monitor any changes in the upper catchment of the Corduff stream, while "SW Flow F" will monitor Corduff stream discharge upgradient of Lough Fea;
- Monitoring will be undertaken on the Magheracloone/Lagan catchment twice yearly for quality to build up an improved profile of the river with sampling taking place at the location of "SW Flow A";
- Flow measurement and water quality sampling at all three locations will be carried out during February and August each year;
- The analytical suite for the samples will be consistent with the existing dataset (Appendix B of Appendix 8.1). Field measurements of TSS, TDS, pH and dissolved oxygen (DO) will also be taken each time the flow is measured; and
- During the initial 12 months of stripping during the operational phase, weekly sampling at both locations on the Corduff Stream will be carried out for total suspended solids (TSS), total dissolved solids (TDS) and pH.

8.8.5 Monitoring: Restoration/Closure Phase: Community Sports Complex

There is no proposed environmental monitoring of the Community Sports Complex and so this is not considered further here.

8.8.6 Monitoring: Restoration/Closure Phase: Mine Development

- Monitoring will be undertaken in line with any conditions set by the IE Licence and CRAMP (a provisional CRAMP is provided in Appendix 3.3). The physical closure works will be followed by a period of monitoring, during which time the mining company must carry out monitoring and measurements to demonstrate that the closure works have been successful, and that all environmental metrics for the Site are stable. This will be controlled by the EPA through the IE Licencing procedure. Following this, it is envisaged that the former mining areas will transition to an aftercare period, which will be of reduced scope and intensity to the monitoring carried out during the closure works;

- The same three surface water monitoring points (SW Flow A, C and F) will be retained throughout the period of restoration, using the same monitoring and sampling frequency. In addition, water levels will be measured in the impounded waterbody and water quality samples from the impounded water will also be taken; and

- Once overflow from the waterbody occurs, the flow at the outlet will be measured and water quality samples will be taken. The proposed sampling schedule is as follows:

- For the first 24 months following decommissioning of the Knocknacran West pumping system, the water level of the waterbody will be measured monthly, and a water sample will be taken quarterly. Field measurements of TSS, TDS, pH and DO will be taken each time the water level is measured.

- From 24 months up to the time of overflow, the water level of the waterbody will be measured quarterly, and a water sample will be taken every 6 months. Field measurements of TSS, TDS, pH and DO will be taken each time the water level is measured.

- For a minimum of 5 years after the time of the first overflow, the water level of the waterbody will be measured quarterly, and a water sample will be taken quarterly. Each time a water sample is taken from the impounded waterbody, the flow will be measured in the Corduff Stream at locations “SW Flow C” and “SW Flow F” and a water quality sample will also be taken. Field measurements of TSS, TDS, pH and DO will be taken each time the water level is measured.

8.9 Residual Effects

8.9.1 Community Sports Complex

Once the identified mitigation measures, appropriate design standards and operational infrastructure management plans are adhered to, it is considered that any effects surrounding the Proposed Development will be **Not Significant.**

8.9.2 Mine Development

The materials (gypsum) to be extracted from the Application Site will be used as a raw material in the construction industry, which is considered an acceptable use of the resource.

In the long-term, residual effects on the groundwater below the open-cast floor will be not significant as the proposed extraction and restoration will be carried out on a phased basis throughout the life of the mine in line with the Mine Development’s proposed Closure, Restoration, Aftercare and Management Plan (CRAMP) (Appendix 3.3).

Following cessation of mining from the Knocknacran West open-cast, the pump(s) will be shut down and an open waterbody will form, gradually rising to between about 38 and 39 m OD. Post-closure groundwater levels are expected to be very slightly higher than pre-mining because of the recharge that occurs to the surface of open water. The groundwater flow system around Knocknacran West will be similar to pre-mining, with slow discharge occurring across the boundaries of the hydrogeological block. Any potential minor groundwater flow to the south will be interrupted because of the low permeability backfill placed in the existing Knocknacran open-cast. This is considered to be a positive benefit and the residual effect is **Not Significant.**

8.10 Cumulative Effects

8.10.1 The Project – Community Sports Complex and Mine Development

The construction phases of the Community Sports Complex and the Mine Development occur simultaneously, however, no significant effects are identified for either and it is considered that there is no potential for cumulative effects on water between the two developments.

The construction phase of the Community Sports Complex overlaps with the first year of the operational life of the Mine Development, however, no significant effects are identified for either and it is considered that there is no potential for cumulative effects on water between the two developments.

The operational phase of the Community Sports Complex and mine development overlap, however, no significant effects are identified for either and it is considered that there is no potential for cumulative effects on water between the two developments.

The restoration phase of the mine development overlaps with the operational phase of the Community Sports Complex, however, no significant effects are identified for either and it is considered that there is no potential for cumulative effects on water between the two developments.

8.10.2 The Project and other offsite projects

The Proposed Development will take place below the water table and there will continue to be a discharge to surface water. The water balance model shows that any potential variation in the site water balance can be managed using the existing site infrastructure. The presence of the proposed Knocknacran West open-cast will provide more operational flexibility for temporary seasonal water storage, as necessary.

Drummond Mine and the Project occur within the same gypsum deposit. Although the mine areas are hydraulically connected, both the Drummond Mine and the proposed mine development area (the former Drumgoosat Mine) have been dewatered for many decades. This limits potential groundwater movement between the areas.

The geology does not facilitate the movement of groundwater into the proposed development area and Drummond Mine due to its low permeability, except through faults and fractures. The proposed development area has been extensively mined in the past, intersecting any faults and fractures within the deposit. This means that the potential for additional water ingress from fractures and faults is negligible (refer to Conceptual Model in Section 8.4.9).

No water is currently, or is proposed to be, pumped between the areas.

Hydrogeologically the Drummond Mine and the proposed development are currently of low relevance to each other.

It is proposed that dewatering of Drummond will continue for as long as mining continues in the existing Knocknacran Open-Cast Mine. Once mining ceases in Knocknacran open-cast, backfill (low permeability material stripped from Knocknacran West) will be placed in the existing Knocknacran open-cast void space as the planned mining of Knocknacran West commences, leading to a reduction of the hydraulic connection between Knocknacran open-cast and Drummond Mine. The hydrogeology of the Drummond Mine will therefore become independent of the hydrogeology of the existing Knocknacran Open-Cast Mine and the proposed Knocknacran West Open-Cast Mine.

They will remain of low hydrogeological relevance to each other and will not have a cumulative effect.

Other extractive industries near to the Application Site include four operational quarries within a radius of 5 km of the proposed development. These are; (i) Cormey Clay Pit, Breedon Brick Ltd.'s open-cast clay quarry, located ca. 1.5 km south of the Site. (ii) an associated site located ca. 4 km south of the Site, (iii) Limestone Industries Ltd limestone quarry, located ca. 2 km west of the Site, and (iv) Roadstone Barley Hill open-cast quarry located ca. 4 km southeast of the Site. As these facilities are not within the immediate vicinity of the Site, there will be no cumulative effect on the water environment that could be attributed to the interaction of several extractive industries in close proximity to each other.

Other reasonably foreseeable developments in the area include an extension to the existing TEREX MDS site ca. 800 m to the south which is still under planning consideration (Reg. Ref. 22/279). A review of the planning file (to date 10th February 2023) indicate that there will not be an overlap with this development. While it is noted from the application form that the facility uses a water mains connection, a well at this site has already been considered in the baseline assessment here and there will be no effect on the existing well, whether it is still in use or not.

Losset ADN Materials Ltd. also have a planning application under consideration (Reg. Ref. 22/254) and are located ca. 1 km to the north of the Project site. Based on a review of the current planning file data (to date 10th February 2023), this development is downstream of the site via the Corduff Stream, which has been assessed in this chapter.

Other industry currently operating within the wider area and forms part of the baseline water users, as such, these are inherently considered within Section 8.6.

The cumulative effects are deemed **Not Significant** between the Project and other offsite Projects.

8.11 Do-Nothing Scenario

In a 'Do Nothing' Scenario, the Knocknacran West Mine would not be mined out and by association, the former Drumgoosat underground workings would not be removed at all. The Knocknacran Mine site would close once the resource is extracted and in line with the existing closure plan (Reg. Ref. 17/217) resulting in a mixed use of agricultural lands and a waterbody onsite. The proposed Community Sports Complex would not be further expanded and would remain as currently constructed.

8.12 Difficulties Encountered

There were no particular difficulties encountered during the compilation of this chapter.

8.13 References

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- Cavan County Council (2011a) 'Establishment of groundwater source protection zones – Kingscourt Water Supply Scheme, Descart Boreholes'.
- Cavan County Council (2011b) 'Establishment of groundwater source protection zones – Kingscourt Water Supply Scheme, Mullantra Borehole'.
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- Minerex (2019b) 'Drummond Mine Water Ingress: Assessment of Impact on Groundwater Resources - Rev 1, June 2019. Doc. Ref.: 1632-2093 (Rev 3)'.
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- Piteau Associates (2020b) 'Hydrogeology study of Knocknacran Open-Cast and Drumgoosat and Drummond Underground mines'.
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- Piteau Associates (2021b) 'Knocknacran West Pit Lake Model and Restoration Plan'.
- SLR (2019) 'Drummond Mine Dewatering Plan (2019 to 2020) SLR Ref: 190311.501.00545.0004'.

APPENDIX 8.1
Magheracloone/Lagan (Lagan) and Corduff Stream Hydrology, Piteau, September 2022

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Memo: 4238_TM06v2

TECHNICAL MEMORANDUM

Date	12 September 2022
To	Pat O'Connor, Benson Plunkett Gyproc Ireland
From	Geoff Beale, James Lalor
RE:	**Magheracloone/Lagan (Lagan) and Corduff Stream Hydrology**

This report has been prepared in response to specific requests for further information (RFIs) by Monaghan County Council in relation to the application for planning permission to develop the former (Drumgoosat) underground mine by opencast mining methods for the purposes of gypsum extraction. The new open cast is termed Knocknacran West and is intended to mine into the abandoned Drumgoosat underground workings.

The purpose of this report is to document the current environmental setting of the Magheracloone/Lagan and Corduff streams, the headwaters of which drain the Drumgoosat mine area, and to assess any changes that may be caused by development of the proposed project. Both drainages form part of the headwaters of the Glyde River Catchment.

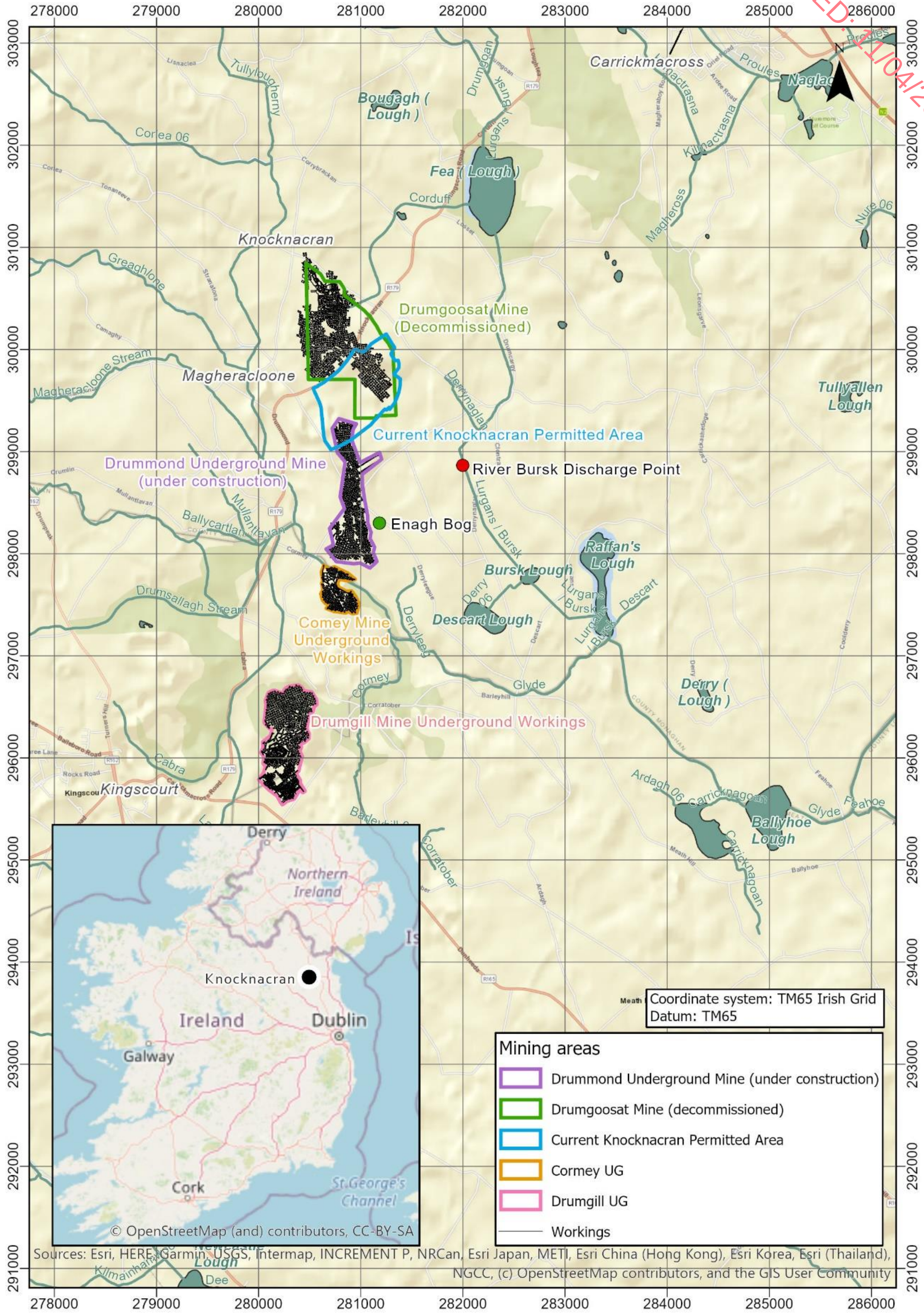
1 RIVER GLYDE CATCHMENT SUMMARY

The prominent overall drainage direction in the Kingscourt Gypsum mining district is to the south (Figure 1). Small ditches and streams flow off the mining areas towards the east and west and enter prominent south flowing streams on the east and west sides of the mining district.

Most of the Drumgoosat/Knocknacran West (KW) footprint area is drained by the Corduff stream which rises in the area above the Drumgoosat mine and flows north and east to Lough Fea, about 2 km northeast of the site. Lough Fea is part of the River Bursk catchment. The River Bursk (also known as River Rahans) runs north to south along the eastern boundary of the gypsum mining area. The River Bursk flows south into Bursk Lough, then Rahans Lough, and joins the River Lagan about 4 km to the southeast of the Drumgoosat area (Figure 1).

Any water which enters the current two operating mines (Knocknacran West open cast and Drummond underground) is pumped into the site water management system. All water from the site is pumped to the 'southeast lagoons' from where it is discharged to the River Bursk at the licensed discharge point to the southeast of Knocknacran open cast shown in Figure 1.

Figure 1 Location map of the Gyproc mining district



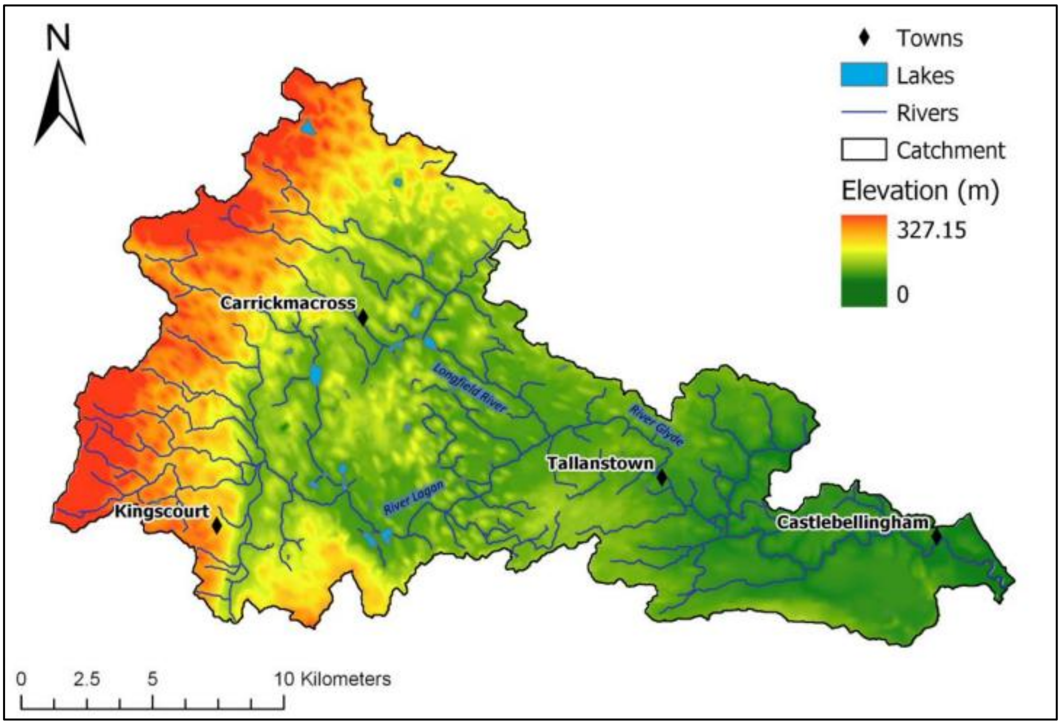
The Magheracloone/Lagan Stream drains a minor part of the Drumgoosat/Knocknacran West footprint area, in the southwest. Immediately to the west of Drumgoosat, it turns to the south and runs along the western boundary of the gypsum mining area. The Magheracloone/Lagan stream flows into the River Gylde (also known as the River Lagan).

The River Glyde turns to the east, and flows west to east between the active Drummond underground mine and the historic Cormey underground mine. The river continues in an easterly direction via Tallanstown and Castlebellingham and is joined by the River Dee just before discharging into the Irish Sea at Annagassan, Co. Louth. The Glyde River is 56 km long and has a catchment of 340 km2.

The topographic elevation of the western area of the River Glyde catchment is about 325-330 masl, while the east of the catchment is low-lying. The land in the west of the catchment is undulating, being located in the drumlin belt and becoming flatter as the river flows east.

Land use in the catchment area is mainly for various forms of agriculture/horticulture. The catchment area includes the towns of Carrickmacross, Kingscourt, Tallanstown and Catlebellingham. The River Glyde geographical catchment area is shown in Figure 2.

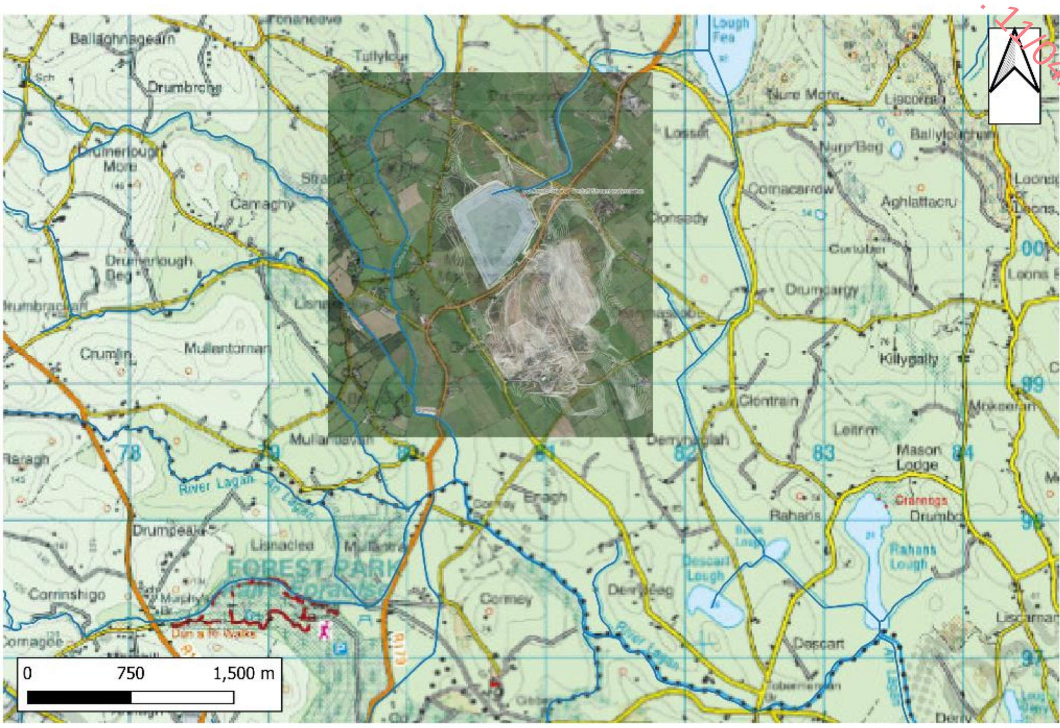
Figure 2 River Glyde topographical catchment map



Note: Figure courtesy of OPW and Inland Fisheries Ireland; IFI Report Number: IFI/2021/1- 4560

Figure 3 shows the geographical and hydrological setting of the Magheracloone/Lagan and Corduff streams in relation to the current Knocknacran and proposed Knocknacran West open cast.

Figure 3 Local Hydrology in relation to current and planned future development



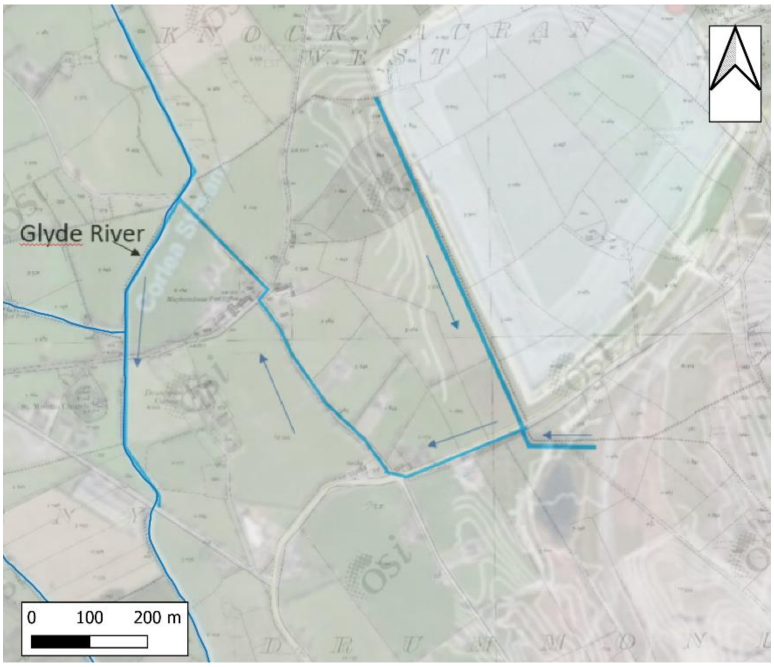
2 MAGHERACLOONE / LAGAN STREAM

The Magheracloone/Lagan stream rises in Bailieborough, Co. Cavan and is joined by the Corlea stream before crossing the R179 road 800 m southwest of the Knocknacran open cast. The Corlea stream runs from the north to the south to the west of the Knocknacran area and joins into the Magheracloone/Lagan stream to the southwest of the pit area.

Both the Magheracloone/Lagan and Corlea streams are referred to on maps as the Lagan River, but in other EPA resources as the Magheracloone/Lagan stream. The Corlea stream is the closest EPA recorded waterbody and occurs about 650 m to the west of the current Knocknacran open cast.

An OPW-maintained ditch (numbered Channel C43(3a) by OPW) occurs between the Knocknacran open cast and the Corlea stream. The channel is not mapped on the EPA Envision map but is known to carry flow from a small catchment north of the R179 road which is culverted across the road. The ditch is then culverted in a 600 mm diameter pipe under a filling station forecourt to the west, and then into a 900 mm diameter pipe, before discharging to the Corlea stream at the crossroads to the west of the site (Figure 4).

Figure 4 Corlea and Magheracloone/Lagan Streams to the southwest of Drumgoosat



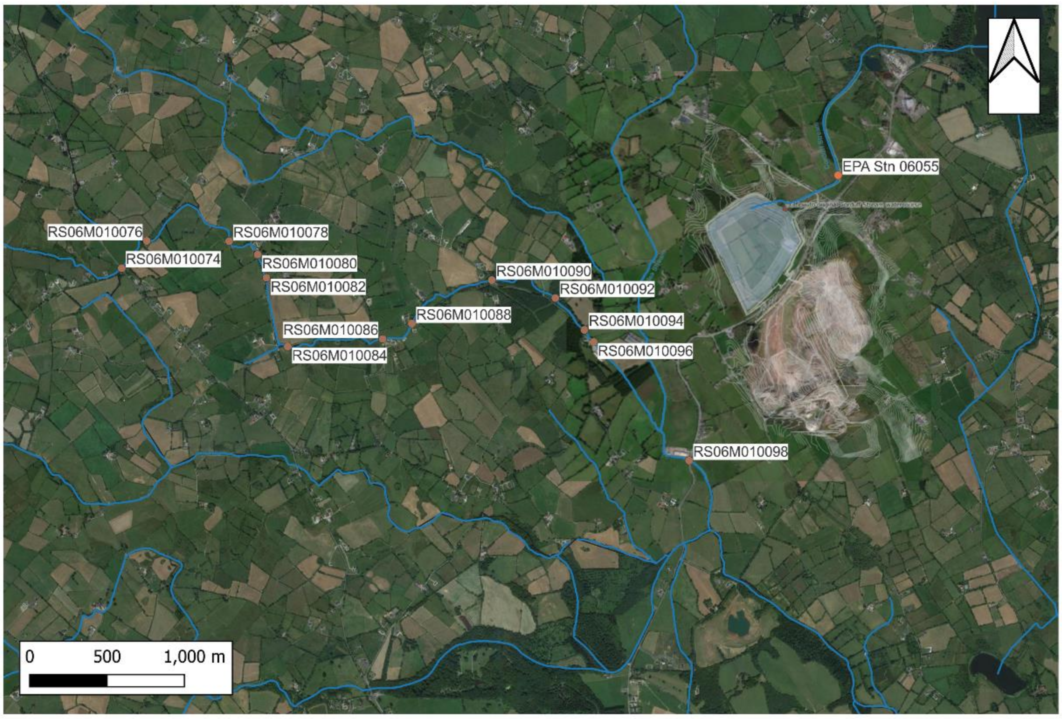
There are 13 EPA stations recorded along the Magheracloone/Lagan Stream by the EPA as shown in Table 1. Locations are shown on Figure 5. The closest OPW monitoring station is located at Aclint Bridge which is about 13.5 km downstream of RS06MO10098, where the Magheracloone/Lagan Stream crosses the R179 road.

Table 1 EPA Monitoring location on the Magheracloone/Lagan stream

Station ID	Station Name	EPA Station Type	X	Y
RS06M010074	MAGHERACLOONE/LAGAN STREAM - (NW) Br at Diamond Crossroads	PreWfd	676490	800000
RS06M010076	MAGHERACLOONE/LAGAN STREAM - Br NE of Diamond X-Rds(Main Rd)	PreWfd	676652	800176
RS06M010078	MAGHERACLOONE/LAGAN STREAM - 1st Br d/s St 0076 (Cul-de-Sac)	PreWfd	677184	800174
RS06M010080	MAGHERACLOONE/LAGAN STREAM - Br NE of BM 484?	PreWfd	677369	800088
RS06M010082	MAGHERACLOONE/LAGAN STREAM - Br E of Bench Mark 484'	PreWfd	677425	799938
RS06M010084	MAGHERACLOONE/LAGAN STREAM - 8th Br u/s Glyde Confl	PreWfd	677563	799494
RS06M010086	MAGHERACLOONE/LAGAN STREAM - 7th Br u/s Glyde Confl	PreWfd	678176	799543

Station ID	Station Name	EPA Station Type	X	Y
RS06M010088	MAGHERACLOONE/LAGAN STREAM - 6thBr u/s Glyde Confl	PreWfd	678365	799642
RS06M010090	MAGHERACLOONE/LAGAN STREAM - 5th Br u/s Glyde Confl	PreWfd	678882	799923
RS06M010092	MAGHERACLOONE/LAGAN STREAM - Br to NW of Magheracloone/Lagan	PreWfd	679292	799807
RS06M010094	MAGHERACLOONE/LAGAN STREAM - Br u/s Br N of Lisnakeeny	PreWfd	679480	799601
RS06M010096	Br N of Lisnakeeny	Operational	679539	799523
RS06M010098	MAGHERACLOONE/LAGAN STREAM - Br d/s Drumgoosat Branch Confl	Investigative	680156	798757

Figure 5 EPA monitoring locations



The EPA undertakes routine river biological quality surveys. Biotic indices ("Q Values") reflect the average water quality at any location, as described in Table 2. Sample results for three locations on the Magheracloone/Lagan are presented in Table 3. The EPA considers that the main threats to habitat along the Magheracloone/Lagan stream are primarily agricultural related.

Table 2 : EPA Biological Quality Ratings (Q Values)

Q Value*	WFD Status	Pollution Status	Condition **
Q5, Q4-5	High	Unpolluted	Satisfactory
Q4	Good	Unpolluted	Satisfactory
Q3-4	Moderate	Slightly polluted	Unsatisfactory
Q3, Q2-3	Poor	Moderately polluted	Unsatisfactory
Q2, Q1-2,	Bad	Seriously polluted	Unsatisfactory

** These Values are based primarily on the relative proportions of pollution sensitive to tolerant macroinvertebrates (the young stages of insects primarily but also snails, worms, shrimps etc.) resident at a river site. The intermediate values (Q1-2, 2-3, 3-4 etc.) denote transitional conditions.*

*** "Condition" refers to the likelihood of interference with beneficial or potential beneficial uses*

Table 3 Biological Q Values for selected Magheracloone/Lagan sampling locations

Station ID	RS06M010082	RS06M010096	RS06M010098
QLEGEND	High	Good	Poor
1990	5	04-May	N/A
1994	03-Apr	04-May	N/A
1997	04-May	04-May	N/A
2000	N/A	04-May	N/A
2003	N/A	4	N/A
2006	N/A	4	N/A
2009	N/A	4	N/A
2012	N/A	4	N/A
2015	N/A	4	N/A
2018	N/A	04-May	N/A
2020	N/A	4	3

The EPA notes that “Two sites were sampled on the Magheracloone/Lagan in 2020 (RS06M010096 and RS06M010098). The upper site at 0096 declined from high to good ecological condition. A new site was sampled at “br d/s Drumgoosat branch confluence” and it was assigned a Q3. The habitat was quite poor in this stretch of river with slow flow and turbid conditions”.

3 CORDUFF STREAM

Figures 3 and 5 show that the Corduff stream rises from the north/central part of the historic Drumgoosat mine footprint area and flows northeast into Lough Fea, about 2.2 km downstream of the proposed Knocknacran West footprint area. The outflow from Lough Fea eventually enters the River Bursk (WFD reach "GLYDE_030"). There is one historic EPA monitoring location on the Corduff stream, last recorded between November 1989 and October 1990 (and has a Station Name "Magheracloone/Lagan").

The total catchment area of the Corduff stream down to Lough Fea is about 6.1 km2. Of this, a drainage area of about 0.45 km2 will be captured by the proposed Knocknacran West opencast. However, within the proposed footprint area of the Knocknacran open cast, some surface water is already locally captured by the topographic depressions that are either natural or have been caused by historical mining activities, so the effective contributing area is less than 0.45 km2.

Historical maps indicate that the Corduff stream had a 14.5 ha flood basin historically (9% of catchment area) which has been significantly impacted by anthropogenic activities. On the historical maps, this area is described as being "liable to floods". It has been drained primarily for farming. Historically, there was a clay pipe factory here in the vicinity of the ADN Materials plant today. Clay was excavated from a pit covering about 1 ha that is flooded today.

The soils of the Corduff catchment are typically fine loamy drift with siliceous stones, overlying a till subsoil derived from Lower Palaeozoic sandstones and shales. The overburden is mapped as having and has a moderate permeability, although the eastern side of the catchment has low permeability till. Overburden thickness across the area varies due to the drumlin landscape. Alluvial deposits have been mapped along the line of the Corduff channel in the upper catchment (first 1-2 km), and peat deposits in the lower catchment. The presence of peat above a medium permeability subsoil shows the shallow water table is close to surface in this area, as would be expected due to the proximity to Lough Fea.

The source of the Corduff is mapped as being coincident with the contact between the Kingscourt Sandstone Formation to the west and the Kingscourt Gypsum Formation to the east. This suggests that the source occurs due to groundwater upwelling when the higher permeability sandstone formation contacts the lower permeability gypsum formation – although this has not been investigated.

The catchment area of the River Bursk to its inflow point to Rahans Lough is approximately 30 km2, so the catchment captured by the proposed open cast would represent only about 1.5% of the total drainage area. The proportion of catchment is small so the impact on streamflow in the Corduff stream and River Bursk would be expected to be negligible, particularly given the existing historical disturbance in the upper part of the catchment area.

The Kingscourt Descart PWS is within the GLYDE_030 reach but is downstream of the planned mine, approximately 1 km west of Raffans Lough, so is unlikely to be affected.

4 2022 FLOW AND WATER QUALITY MONITORING

Field visits and stream inspections were undertaken by Piteau Associates on 13th June 2022 and 13th July 2022. The objectives of the field visits were:

- Evaluate the condition of the drainages
- Collect stream flow data at designated locations on two dates.
- Collect water samples for analysis of hydrochemical and physiochemical parameters at the designated locations on the same dates.

4.1 MONITORING LOCATIONS

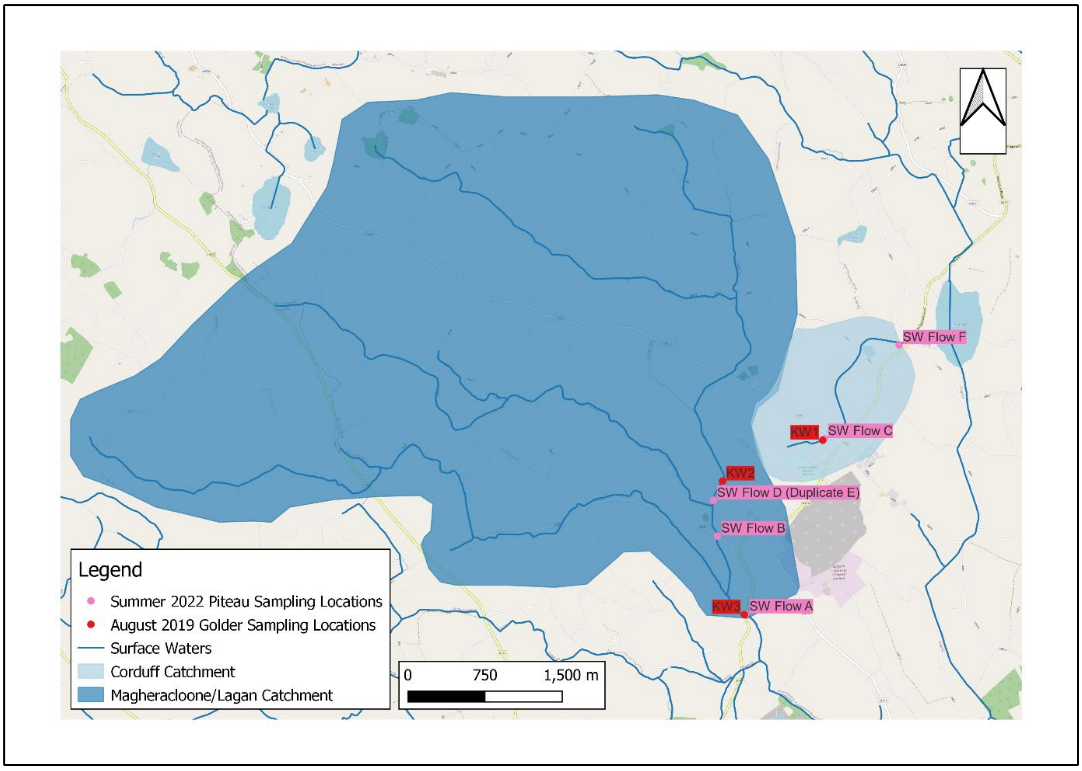
The Corduff stream monitoring locations for flow and quality measurements (2022 SW Flow C and F) are shown on Figure 6, together with the Magheracloone/Lagan stream monitoring locations (2022 SW Flow A, B and D; plus duplicate E). The Corduff stream catchment area upstream of sample point "SW Flow F" is about 169 ha. Sample location photographs are included in Appendix A.

The sampling locations identified for the work were chosen based on:

- Proximity to the proposed current and planned mine expansion (Knocknacran West).
- Ability to access private land.
- Ability to comply with the Saint Gobain Health and Safety policy.

Previously, three samples were collected by staff of Golder Associates in 2019. Two of these were at the same location as the recent 2022 Piteau work (KW1 and KW3). The third 2019 location (KW2) was located close to another 2022 Piteau sampling location. Locations are also shown in Figure 6.

Figure 6 Recent and historic sampling locations and catchment areas



The catchment area upstream of sample point "SW Flow A" comprises the Corlea stream and Magheracloone/Lagan stream and covers about 2,430 ha.

4.2 METHODOLOGY

An FP101 Global Water Flow Probe was used to measure surface water flows in the stream channels. The water velocity probe consists of a protected water turbo prop positive displacement sensor coupled with an expandable probe handle ending in a digital readout display. Flow measurements were executed and recorded as per Piteau Associates SOP Guidance notes.

Water samples were collected in sample bottles supplied by Fitz Scientific laboratory, an INAB accredited laboratory based in Drogheda, Co. Louth. A Hannah multi probe was used to record physiochemical parameters including temperature, dissolved oxygen, conductivity and pH. A WTW Oxi 3205 DO probe was used to record dissolved oxygen values. Samples were analysed for parameters as stipulated in the existing mine EPA License P0519-4 Schedule B parameters plus sulphate. The samples were stored in a fridge and transported to the laboratory within 24 hours.

4.3 STREAM FLOW RESULTS

Of the five locations sampled and monitored, three were on the Magheracloone/Lagan stream and two were on the Corduff stream. A duplicate sample was included for QA/QC purposes. Sample names and locations are shown in Table 4.

Table 4 June and July 2022 sample locations and measure flow rates

Sample locations				Flow (L/s)		Comments
ID Code	**Stream**	**X**	**Y**	**13/6/2022**	**14/7/2022**	
SW Flow A	Magheracloone/ Lagan	680152	798762	56	47	Overgrown. Cattle Watering D/S
SW Flow B	Magheracloone/ Lagan	679877	799520	57	31	Overgrown. Cattle Watering D/S
SW Flow D*	Magheracloone /Lagan	679837	799868	42	30	Overgrown. Deep sediment bed
SW Flow E*	Magheracloone /Lagan	679837	799868	42	30	Overgrown. Deep sediment bed
SW Flow C	Corduff	680915	800466	0.04	N/A**	Jug & timer used to measure flow.
SW Flow F	Corduff	681642	801377	5	2.5	Overgrown. Potential eutrophication

**SW Flow D and E are duplicate samples.*

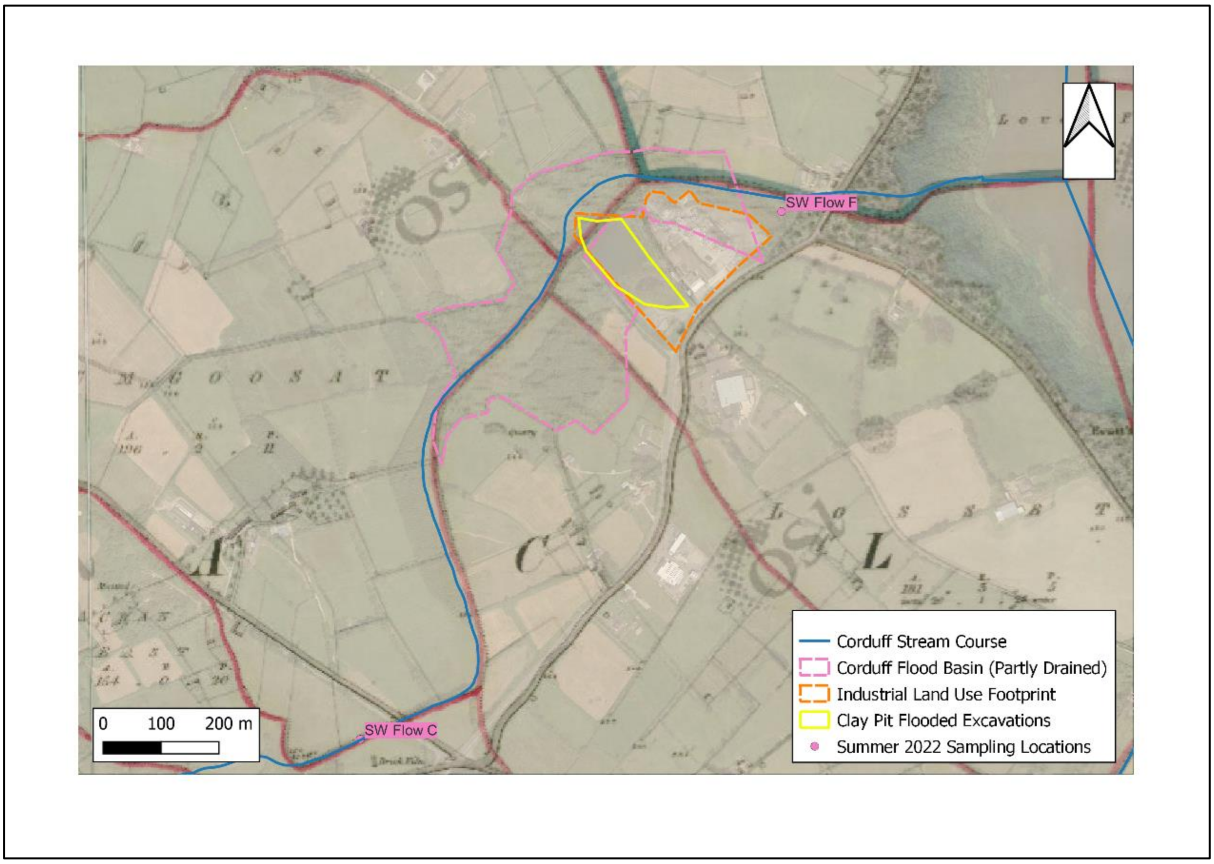
*** There was insufficient flow from this location to accurately measure a volumetric discharge.*

The two sets of samples were collected from the same locations 4 weeks apart, during what could be considered dry season conditions. The flows collected on the Magheracloone/Lagan stream SW (Flow A, SW Flow B and SW Flow D&E) reduced by 16%, 46% and 29%, respectively, between the June and July dates. The flow in the Corduff stream almost ceased at SW Flow C and reduced by 50% at SW Flow F.

For the Corduff stream, the monitoring results confirm that much of the summer flow occurs downstream of the planned Knocknacran West footprint area, and that the footprint area itself currently contributes little (if any) stream flow. The waters from the excavated clay pit are not thought to be directly connected to the Corduff stream, but it is possible that outflow from the pit to the stream may occur during the winter months or following periods of rainfall. Figure 7 shows the Corduff stream flow path in context of the flood plain and historic excavated pits.

For the Magheracloone/Lagan stream, flows were significantly impacted by the presence of alluvial sediments upstream and downstream of the sampling locations, and also significant growth of wet reeds and grasses. Also noted was the accessibility of livestock to the Magheracloone/Lagan. Livestock were using the stream for drinking during both sampling events.

Figure 7 2022 Corduff stream flow path and historic flood basin



4.4 STREAM HYDROCHEMISTRY RESULTS

The hydrochemistry results of the Magheracloone/Lagan are shown in Table 5, together with physiochemical results. The hydrochemistry results of the Corduff Stream are shown in Table 6, again with physiochemical results. Laboratory results are presented in Appendix B.

For the Corduff stream, increases in the levels of manganese and sulphate were noted for the second sampling event (lower flow rates). Nickel was elevated in the Corduff stream compared with the Magheracloone/Lagan stream.

Electrical conductivity and total suspended solids (TSS) were noted to increase, particularly in the Corduff headwaters. Both COD and BOD increased at point "SW Flow C" (Corduff headwaters).

Table 5 Surface water hydrochemistry, Magheracloone stream, June and July 2022

Location Name		Magheracloone Lower		Magheracloone Upper		Magheracloone Upper		Magheracloone Upper	
Location Code		SW_A		SW_B		SW_D (Duplicate)		SW_E (Duplicate)	
Parameter	Units	13/07/22	13/07/22	13/06/22	13/07/22	13/06/22	13/07/22	13/06/22	13/07/22
Ammonia	mg/L as N	0.04	0.05	0.03	0.04	0.05	0.04	0.05	0.04
BOD	mg/L	1.5	0.6	0.9	0.9	0.9	0.6	1	0.7
Chloride	mg/L	15.5	14.6	14.4	14.5	15	14.2	14.5	14.2
Chromium	ug/L	<1	<1	<1	<1	<1	<1	<1	<1
COD	mg/L	15	13	14	16	9	15	10	12
Copper	ug/L	<2	<2	<2	<2	<2	<2	<2	2
Manganese	ug/L	45	3	36	61	36	43	38	41
Nickel	ug/L	1	1	1	1	1	1	1	1
Phosphate	mg/L as P	0.06	0.04	0.06	0.06	0.07	0.06	0.07	0.06
Phosphorus	mg/L as P	0.08	0.1	0.08	0.12	0.16	0.19	0.41	0.12
Solids (Settleable)	mg/L	<1	<1	<1	<1	<1	<1	<1	<1
Solids (TSS)	mg/L	2	<2	2	3	2	2	2	7
Sulphate	mg/L as SO_4	18	15	17	16	20	21	20	21
Physiochemistry									
pH	Units	6.45	7.04	6.39	6.95	6.81	6.55	6.82	6.56
Conductivity	µS/cm	336	345	320	325	317	318	315	319
DO	mg/L	10.3	10.37	10.75	10.44	10.71	9.18	10.75	8.22
Temperature	Deg C	12.7	15.6	12.2	13.3	13	13.6	13.6	13.7
TSS	ppm	168	173	160	162	158	159	158	159

Table 6 Surface Water Hydrochemistry, Corduff stream, June and July 2022

Location Name		Corduff Headwaters		Corduff D/s	
Location Code		SW_C		SW_F	
Parameter	Units	13/06/22	13/07/22	13/06/22	13/07/22
Ammonia	mg/L as N	0.16	0.19	0.24	0.19
BOD	mg/L	1.2	1.5	1.2	1.2
Chloride	mg/L	20.3	10.6	29	26.9
Chromium	ug/L	<1	<1	<1	<1
COD	mg/L	25	40	26	29
Copper	ug/L	2	2	2	<2
Manganese	ug/L	343	2073	702	1204
Mineral	ug/L	<2.5	<2.5	<2.5	<2.5
Nickel	ug/L	3	4	2	2
Phosphate	mg/L as P	0.02	0.1	0.09	0.06

Location Name		Corduff Headwaters		Corduff D/s	
Location Code		**SW_C**		**SW_F**	
Parameter	**Units**	**13/06/22**	**13/07/22**	**13/06/22**	**13/07/22**
Phosphorus	mg/L as P	0.05	0.31	0.2	0.28
Solids (Settleable)	mg/L	<1	<1	<1	<1
Solids (TSS)	mg/L	7	41	8	7
Sulphate	mg/L as SO4	654	1061	65	43
Physiochemistry					
pH	Units	7.56	6.75	6.96	6.5
Conductivity	µS/cm	1484	2057	548	520
DO	mg/L	7.8	9.75	10.37	10.01
Temperature	Deg C	14.7	14.4	13.3	14.2
TSS	ppm	739	1030	277	261

Table 7 shows the results of the 2019 sampling (sampling locations shown on Figure 6). Laboratory results are presented in Appendix C. Sulphate levels in the Corduff headwaters were also elevated. Dissolved concentrations of calcium, magnesium, manganese, sodium, zinc and nickel were also noted.

The Corduff stream has been subjected to historical and more recent anthropogenic activities (see above). The area around the source waters (west of "SW Flow C") has been drained and has had drainage channels realigned in recent years. The partly drained flood basin and flooded clay pits are also of interest, as the chemical signature differs between "SW Flow C" and "SW Flow F" for several parameters, particularly sulphate, despite a linear distance of about 1.5 km with no discrete inflow ditches occurring over that reach.

The 2019 data show an elevated hydrocarbon signature (Ethylbenzene and Xylene) in the KW2 sample. This location is downstream of a local fuel station.

Table 7 Historic Sampling Results, Golder Associates August 2022

Parameters	Units	KW1 (SW C)	KW2 (SW E&D)	KW2 (Duplicate)	KW3 (SW A)
Dissolved Aluminium #	ug/l	<20	<20	<20	22
Dissolved Arsenic #	ug/l	<2.5	<2.5	<2.5	<2.5
Dissolved Barium #	ug/l	25	41	39	56
Dissolved Cadmium #	ug/l	<0.5	<0.5	<0.5	<0.5
Dissolved Calcium #	mg/l	160.0	34.1	38.5	36.6
Total Dissolved Chromium #	ug/l	<1.5	<1.5	<1.5	<1.5
Dissolved Copper #	ug/l	<7	<7	<7	<7
Total Dissolved Iron #	ug/l	70	164	163	203
Dissolved Lead #	ug/l	<5	<5	7	5
Dissolved Magnesium #	mg/l	17.2	5.6	6.2	5.7
Dissolved Manganese #	ug/l	505	22	21	32
Dissolved Mercury #	ug/l	<1	<1	<1	<1

Parameters	Units	KW1 (SW C)	KW2 (SW E&D)	KW2 (Duplicate)	KW3 (SW A)
Dissolved Nickel #	ug/l	3	<2	<2	<2
Dissolved Potassium #	mg/l	3.6	5.0	6.4	5.5
Dissolved Selenium #	ug/l	<3	<3	<3	<3
Dissolved Sodium #	mg/l	11.9	7.6	8.6	8.3
Dissolved Zinc #	ug/l	5	<3	<3	<3
Methyl Tertiary Butyl Ether #	ug/l	<0.1	<0.1	<0.1	<0.1
Benzene #	ug/l	<0.5	<0.5	<0.5	<0.5
Toluene #	ug/l	<5	<5	<5	<5
Ethylbenzene #	ug/l	<1	2	3	<1
m/p-Xylene #	ug/l	<2	12	24	<2
o-Xylene #	ug/l	<1	4	8	<1
Surrogate Recovery Toluene D8	%	106	106	104	106
Surrogate Recovery 4-Bromofluorobenzene	%	103	103	100	101
EPH (C8-C40) #	ug/l	<10	<10	<10	<10
Sulphate as SO4 #	mg/l	316.1	13.6	13.5	14.0
Chloride #	mg/l	10.7	11.5	11.3	12.0
Nitrate as NO3 #	mg/l	2.0	7.4	5.9	4.7
Nitrite as NO2 #	mg/l	<0.02	0.05	0.05	0.05
Ortho Phosphate as PO4 #	mg/l	0.20	0.16	0.16	0.09
Total Oxidised Nitrogen as N #	mg/l	0.5	1.7	1.3	1.1
Total Ammonia as N #	mg/l	0.08	0.06	0.06	0.06
Total Alkalinity as CaCO3 #	mg/l	162	120	114	108
Dissolved Oxygen	mg/l	8	7	7	9
Total Organic Carbon #	mg/l	10	12	12	12
Total Dissolved Solids #	mg/l	665	157	162	153
Total Suspended Solids #	mg/l	<10	15	<10	<10

4.5 ASSIMILATIVE CAPACITY

During operations and post-closure while the pit lake develops, water will not be discharged to the Corduff Stream from Knocknacran West, therefore an assimilative capacity study was not completed for this period.

For long-term closure, once a pit lake has formed, discharge will occur from the lake to the Corduff and, therefore, assessment is appropriate. However, the Knocknacran West pit is located at the head of the Corduff catchment so discharge from the pit will be the primary water source in the upper catchment. For this reason, a 'standard' assimilative capacity for a receiving water body is not appropriate. For the purposes of this report, a comparison has been made between the 2022 water quality results, the proposed pit lake discharge quality (Piteau, 2021) and the EQS (Table 8).

This shows that the Corduff is currently elevated (no assimilative capacity) for ammonia and phosphate. Both are related to agricultural practices. The post-closure pit lake is predicted to have phosphate concentrations of 0.03 mg/L, less than the EQS of 0.035 mg/L. Ammonia has not been predicted but without the agricultural influence, it is also likely to meet EQS after closure.

All other parameters where comparisons are available, but no EQS show that the water quality will be broadly similar to current conditions. The exception is sulphate which will increase in post-closure to around 150 mg/L. AECOM (2022) completed a Natural Impact Statement (NIS) for the project which concluded that a discharge (from the sedimentation ponds) of between 200 and 250 mg/L would have "*no significant effect on QI habitats or SCI species, that conservation objectives will not be compromised, and therefore that there will be No Adverse Effect on the integrity of Dundalk Bay SPA, Dundalk Bay SAC or Stabannan-Braganstown SPA from the Proposed Development either alone or in-combination with other projects or plans*."

Table 8 Comparison of current and predicted post-closure water quality of the Corduff Stream at SW_F

Parameter	Unit	EQS AA*	Corduff D/s SW_F 13/06/2022	Predicted Pit Lake Discharge Post-Closure
Ammonia	mg/L as N	0.065	**0.24**	
BOD	mg/L	1.5	1.2	
Chloride	mg/L	-	29	7
Chromium	mg/L	-	<0.001	
COD	mg/L	-	26	
Copper	mg/L	0.03	0.002	0.0006
Manganese	mg/L	-	0.702	0.06
Nickel	mg/L	0.02	0.002	0.016
Phosphate	mg/L as P	0.035	**0.09**	0.03
Phosphorus	mg/L as P	-	0.2	
Solids (Settleable)	mg/L	-	<1	
Solids (TSS)	mg/L	-	8	
Sulphate	mg/L as SO4	-	65	150
pH	Units	-	6.96	
Conductivity	µS/cm	-	548	
DO	mg/L	-	10.37	
Temperature	Deg C	-	13.3	
TSS	ppm	-	277	

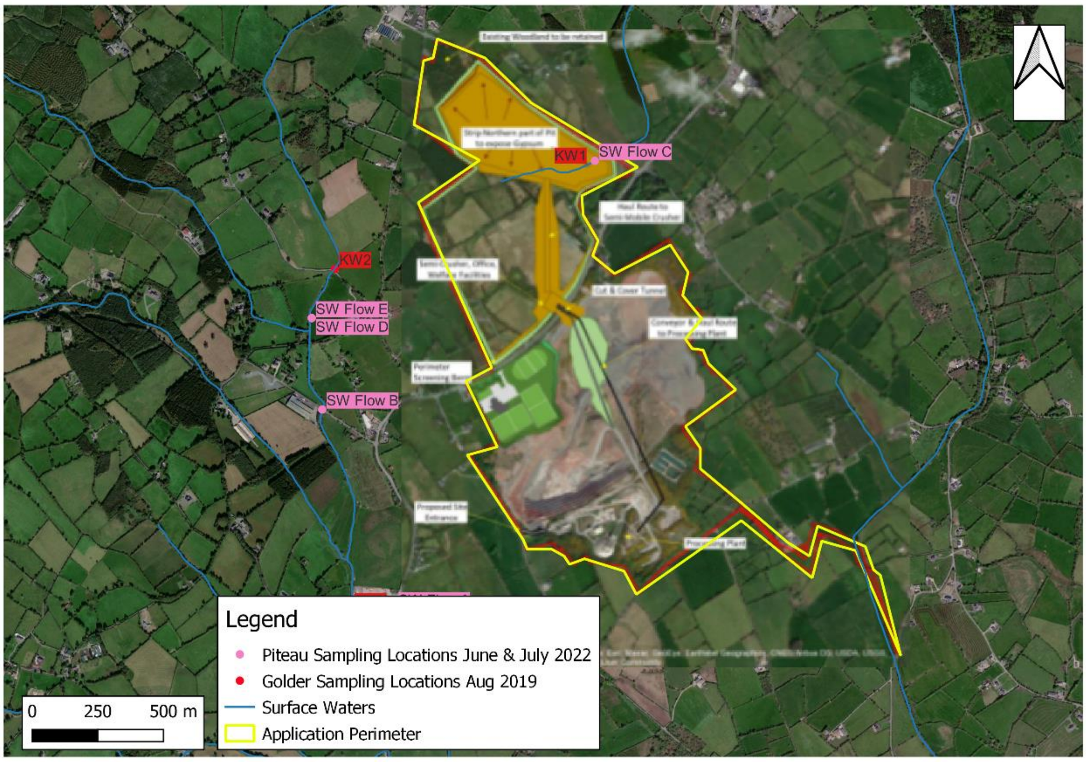
5 IMPLICATIONS FOR THE PROPOSED DEVELOPMENT

5.1 OPEN CAST OPERATIONS

The following pre-mining construction work is planned for the proposed Knocknacran West development:

- Screening berms – around entire site perimeter of the open cast.
- Demolition of 4 houses on the Knocknacran West site, which are not in close proximity to the Magheracloone/Lagan stream or to the Corduff stream.
- Relocation of Knocknacran mine entrance about 10 m north.
- Cut and cover tunnel and R179 temporary diversion, which will also be away from the local water courses (see Figure 8).

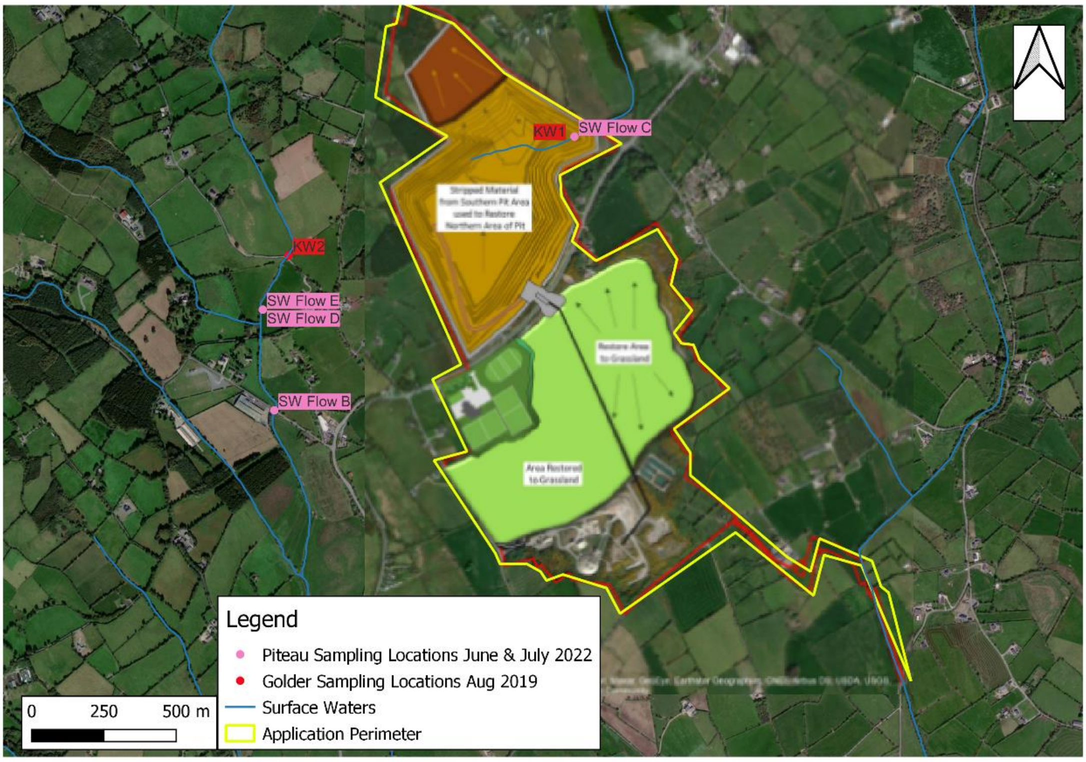
Figure 8 Planned pre-mining development of the Knocknacran West area



During the second planned phase of development, further stripping of the overburden in the northern area of the planned open cast will be progressed, with excavated material being transported and backfilled in the Knocknacran area as part of the restoration program. As the Knocknacran restoration fill nears completion, further stripping of material in Knocknacran West will be placed in the northern area of Knocknacran West (Figure 9).

Sediment control will be put in place for the stripping activities when there is the potential for surface water runoff to discharge from the site to local watercourses. Following the initial stripping, all water generated within the site boundary will be contained, routed to sumps and pumped to the existing sedimentation ponds to the south. During operations, no water will be discharged directly from the Knocknacran West site to local watercourses.

Figure 9 Knocknacran West development plan

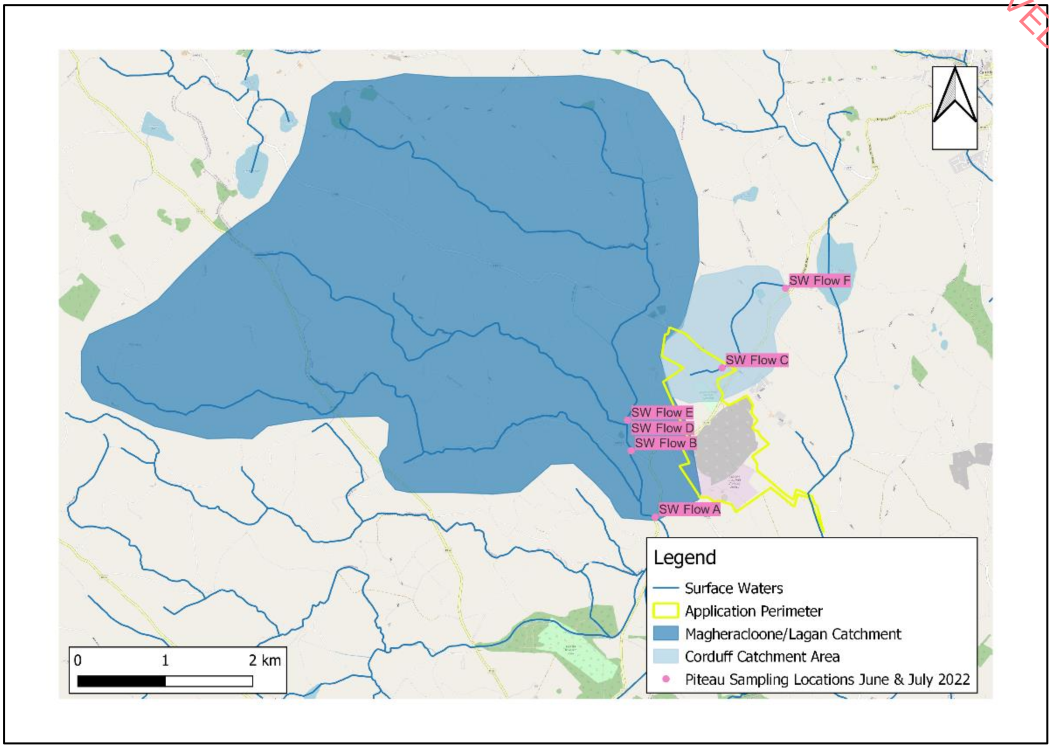


The results of the 2019 and 2022 sampling indicate the proposed development will have little impact on either of the two streams during the period of active excavation. Figure 10 shows both the Magheracloone/Lagan catchment and Corduff catchment in relation to the planning application perimeter.

For the Corduff stream, the affected drainage area is relatively small compared with the overall catchment down to Lough Fea, particularly when considering that some of the runoff is already captured; and given the historical disturbance. The area outlined as the upper catchment of the Corduff stream could best be described as ephemeral, the flows recorded at SW Flow C are negligible during drier months, as indicated by the recent flow measurements and sampling. Flows entering Lough Fea in June and July 2022 were estimates between 5 and 2.5 L/s.

For the Magheracloone/Lagan stream, the map shows that the impact of the application on the Magheracloone catchment is minimal. The effected catchment area is minimal and the monitored flows were low. The EPA notes the great threat relates to potential impacts from agriculture.

Figure 10 Planning application perimeter and affected catchments



5.2 OPEN CAST RESTORATION

Upon completion of the proposed Knocknacran West development, it is predicted that the open cast void will fill slowly with water and that a permanent water body will develop (Piteau, 2021). The predicted final area of the water body is approximately 25 ha, or about 15% of the current Corduff stream catchment upstream of “SW Flow F”.

As shown in Figure 11, the restoration plan is for the water body to eventually discharge via an outflow to the Corduff stream. The presence of the waterbody will increase the effective catchment of the Corduff stream by 11 about ha, extending the Corduff catchment area to Lough Fea from about 169 hectares to about 180 hectares. The estimated average annual outflow from the waterbody is within the range 500-700 m3/d (5.8–8.1 L/s), varying seasonally from zero in the summer up to over 1,000 m3/d (11.6 L/s) in the winter months. Table 9 shows the predicted outflow from the planned waterbody compared with measured flows in the Corduff stream.

Figure 11 shows the outflow location from the planned Knocknacran West water body. The presence of the water body will marginally increase the catchment of the Corduff stream (Figure 12). In the summer, the waterbody will have little impact because there is already virtually no flow in the upper headwaters of the Corduff stream. In the winter, the water body will provide a sustained and steady outflow which will marginally reduce the magnitude of high water in the stream. The monitoring results suggest it is unlikely that flow would exceed 11 L/s in wettest months in this area of the catchment. The plan for the restoration program includes flow and water quality monitoring at both locations on the Corduff stream.

Table 9 Predicted outflow from the planned water body in Knocknacran West compared with measured flows in the Corduff stream

Location	Actual Flows (L/s)		% of Average Modelled Flow	% of Peak Modelled Flow
Corduff catchment	**13/06/2022**	**13/07/2022**		
SW Flow C	0.04	0	0.58	0.35
SW Flow F	5	2.5	72	43

Figure 11 Final Knocknacran West water body with discharge from the eastern pit rim to the original Corduff Stream

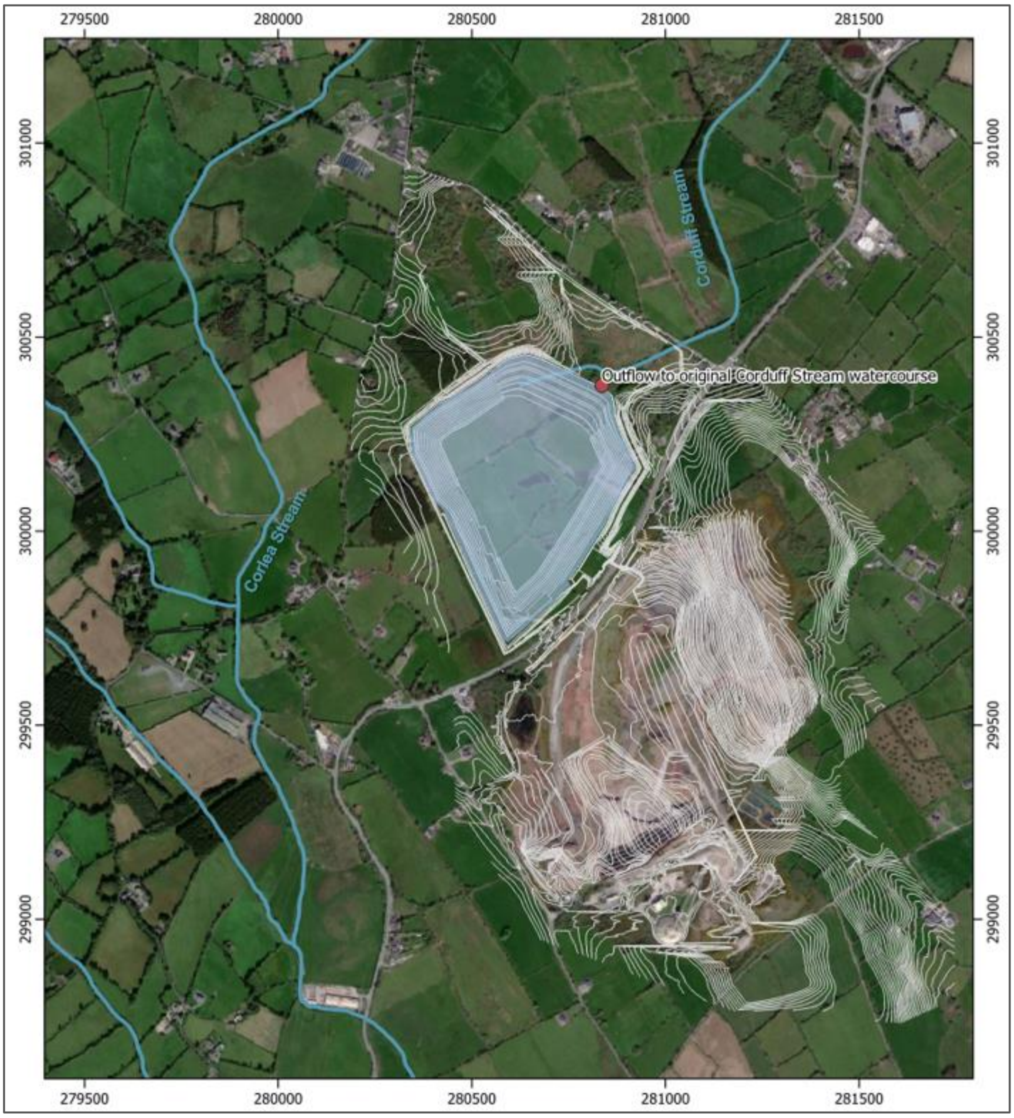
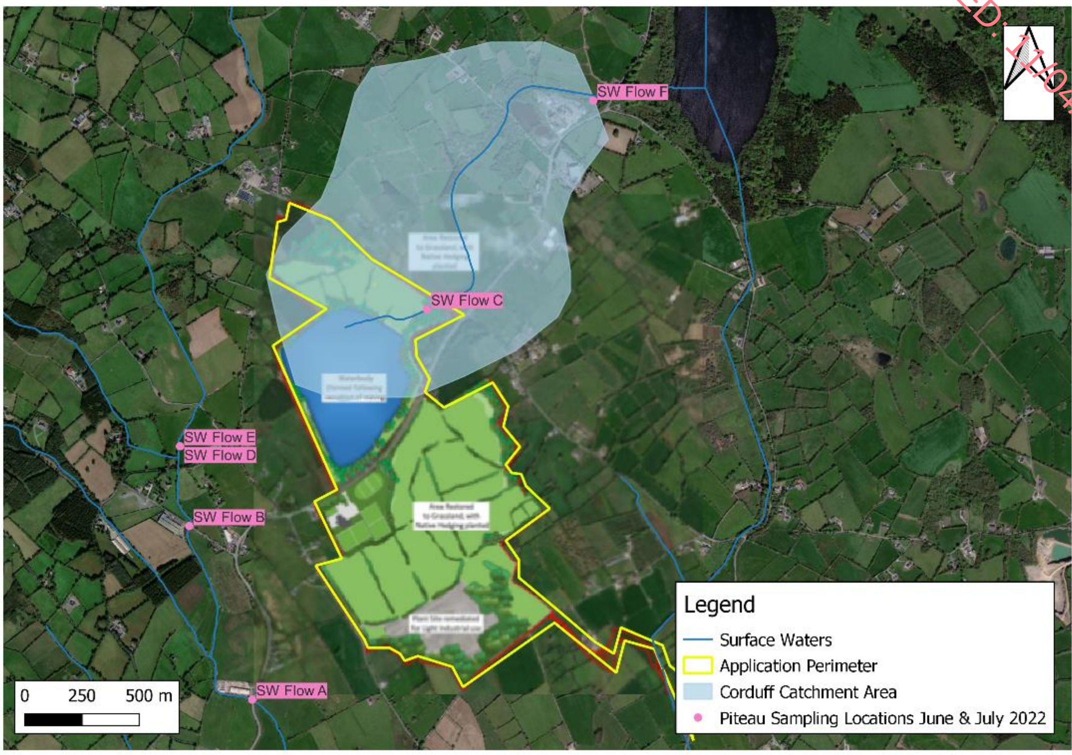


Figure 12 Corduff stream catchment with predicted post restoration water body



The long-term chemistry of the waterbody in Knocknacran West was simulated by Piteau (2021) and is summarized in Table 10 for Year 10, and also for the point where outflow first occurs to the Corduff stream. When the water body starts to discharge, the total dissolved solids (TDS) concentration is predicted to be 400-550 mg/l. Sulfate values are predicted to be about 149 mg/l, with calcium about 73 mg/l. The water is predicted to have a near-neutral to slightly alkaline pH. It should be noted that outflow will mostly occur during the months of October to March when flows in surrounding ditches and streams are also high. The observed background hydrochemistry also indicates that the discharge from the water body will have minimal impact to the existing stream water quality.

Table 10 Predicted quality of the impounded water body in Year 10 and the time that the water overflows the crest of the open cast (38-39 m OD)

Parameter	Concentration at 10 years post-closure (mg/L)	Concentration at the time of overflow (mg/L)	Observed water chemistry at SW_C		Observed water chemistry at SW_F	
			13/06/22	13/07/2	13/06/22	13/07/22
Potassium	3.2	2.4	-	-	-	-
Sodium	30.4	19.5	-	-	-	-
Calcium	132.1	73	-	-	-	-
Magnesium	26.6	18.3	-	-	-	-
Chloride	9	7	20	11	29	27
Sulphate	**321**	**148.9**	**654**	**1061**	**65**	**43**
Nitrate	0.52	0.5	-	-	-	-
Phosphate	0.05	0.03	0.02	0.1	0.09	0.06
Alkalinity	185.7	154.7	-	-	-	-
Aluminium	0.1	0.05	-	-	-	-
Zinc	0.027	0.023	-	-	-	-
Iron	0.12	0.06	-	-	-	-
Lead	0.0003	0.0003	-	-	-	-
Manganese	0.07	0.06	0.34	2.07	0.70	1.20
Nickel	0.019	0.016	0.003	0.004	0.002	0.002
Tin	0.00033	0.00029	-	-	-	-
Copper	0.0007	0.0006	0.002	0.002	0.002	<0.002

6 MONITORING PLAN

6.1 STREAMFLOW MONITORING DURING OPERATIONS

The main focus of any future monitoring should be on the Corduff stream. Monitoring locations "SW Flow C" and "SW Flow F" will be maintained (Figure 13). "SW Flow C" will monitor any changes in the upper catchment of the Corduff stream, while "SW Flow F" will monitor Corduff stream discharge upgradient of Lough Fea.

It would also be prudent to monitor the health of the Magheracloone/Lagan catchment twice yearly for flow and quality to build up an improved profile of the river with sampling taking place at the location of "SW Flow A", also shown in Figure 13. This location is preferred as it is also the location at which the EPA undertakes Biological Quality Surveys (Station No. RS06M010098).

Flow measurement and water quality sampling at all three locations will be carried out during February and August each year. The analytical suite for the samples will be consistent with the existing dataset (Appendix B). Field measurements of TSS, TDS, pH and dissolved oxygen (DO) will also be taken each time the flow is measured. This level of monitoring would provide both a dry and wet weather data set, providing flow and water quality data in the context of the Gyproc license obligations P0519-4 (plus sulphate).

In addition, during the initial 12 months of stripping and placement of the screening berms, weekly sampling at both locations on the Corduff stream will be carried out for total suspended solids (TSS), total dissolved solids (TDS) and pH.

6.2 STREAMFLOW MONITORING DURING RESTORATION

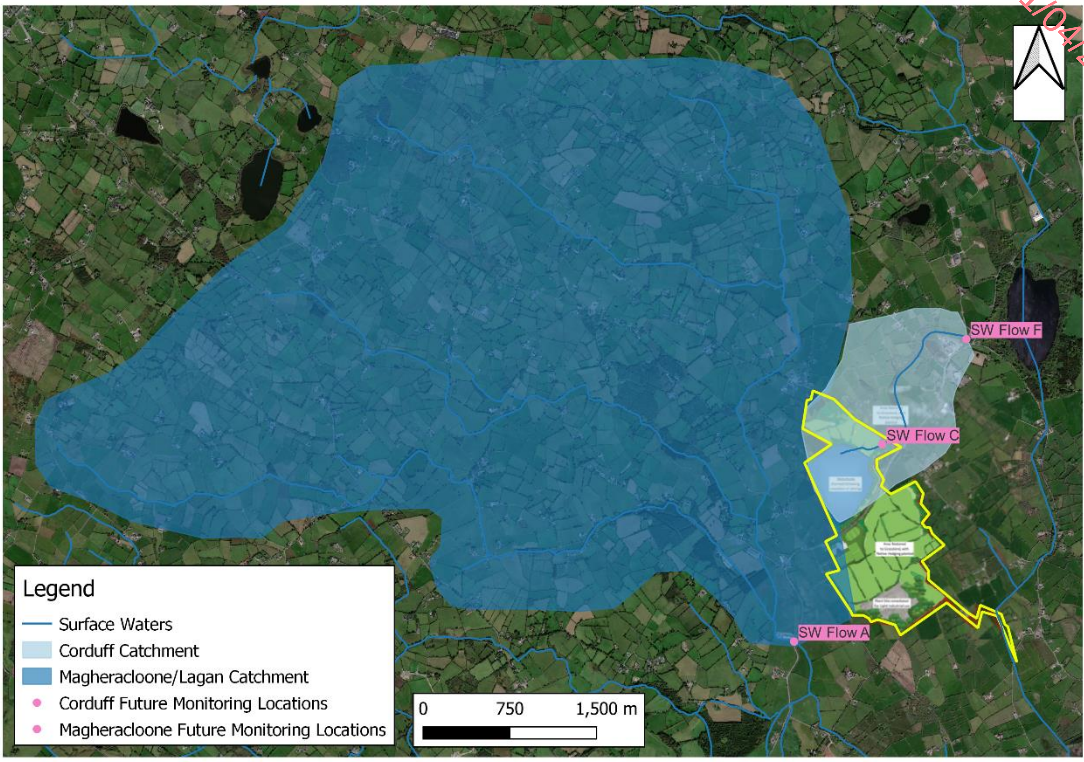
The same three monitoring points will be retained throughout the period of restoration, using the same monitoring and sampling frequency. In addition, water levels will be measured in the impounded water body and water quality samples from the impounded water will also be taken.

Once overflow from the water body occurs, the flow at the outlet will be measured and water quality samples will be taken. The proposed sampling schedule is as follows:

- For the first 24 months following decommissioning of the Knocknacran West pumping system, the water level of the water body will be measured monthly, and a water sample will be taken quarterly. Field measurements of TSS, TDS, pH and DO will be taken each time the water level is measured.
- From 24 months up to the time of overflow, the water level of the water body will be measured quarterly, and a water sample will be taken every 6 months. Field measurements of TSS, TDS, pH and DO will be taken each time the water level is measured.
- For a minimum of 5 years after the time of the first overflow, the water level of the water body will be measured quarterly, and a water sample will be taken quarterly. Each time a water sample is taken from the impounded water body, the flow will be measured in the Corduff stream at locations “SW Flow C” and “SW Flow F” and a water quality sample will also be taken. Field measurements of TSS, TDS, pH and DO will be taken each time the water level is measured.

It is currently planned that the analytical suite for the samples will remain consistent with the existing dataset (Appendix B), but a reduced parameter suite may be recommended as the understanding of conditions in the impounded water body becomes confirmed. At the end of 5 years of outflow from the impounded water body, all data will be reviewed and the need for on-going monitoring will be determined.

Figure 13 Proposed hydrological sampling locations shown with the planned post-restoration water body in Knocknacran West



7 LIMITATIONS

This investigation has been conducted using a standard of care consistent with that expected of scientific and engineering professionals undertaking similar work under similar conditions in the United Kingdom. No warranty is expressed or implied.

This memorandum is prepared for the sole use of Gyproc Ireland. Any use, interpretation, or reliance on this information by any third party, is at the sole risk of that party, and Piteau accepts no liability for such unauthorised use.

8 CLOSING

We trust the above is adequate for your current needs. If you have any questions regarding the above, or we can be of further service, please do not hesitate to contact us.

Respectfully submitted,

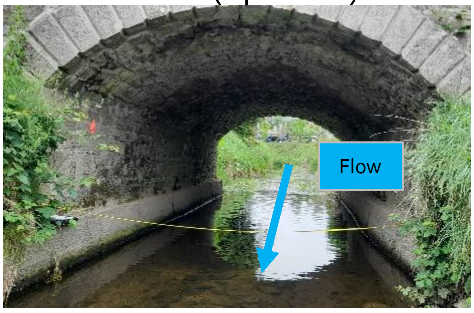
PITEAU ASSOCIATES

Geoff Beale

APPENDIX A

Fieldwork photographs summer 2022

SW Flow A U/S (Upstream) and D/S (Downstream) of monitoring location



June 13th 2022

July 13th 2022

SW Flow B U/S and D/S of monitoring location (includes staff gauge)

June 13th 2022

July 13th 2022

13th of June Staff Reading

13th of July Staff Reading

SW Flow C U/S and D/S of monitoring location

June 13th 2022

July 13th 2022

SW Flow D & E (Duplicate sample) U/S and D/S of monitoring location

June 13th 2022

July 13th 2022

SW Flow F U/S and D/S of monitoring location

June 13th 2022

July 13th 2022

APPENDIX B

June and July 2022 sampling results

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Email: info@fitzsci.ie

RECEIVED: 11/04/2023

Customer supplied information appear in italics.

Customer	*Kevin Breslin Saint Gobain Mining Ltd. Kingscourt Co Cavan*	Lab Report Ref. No.	0911/216/01
		Date of Receipt	14/06/2022
		Sampled On	*13/06/2022*
		Date Testing Commenced	14/06/2022
		Received or Collected	Courier
		Condition on Receipt	Acceptable
Customer PO		Date of Report	06/07/2022
Customer Ref	*SWA*	*Sample Type*	*Surface Water*
Ref 2	*13/06/2022*		
Ref 3			

CERTIFICATE OF ANALYSIS

Test Parameter	SOP	Analytical Technique	Result	Units	Acc.
Ammonia (Surface Water)	114	Colorimetry	0.04	mg/L as N	INAB
BOD (Surface Water)	113	Electrometry	1.5	mg/L	INAB
Chloride (Surface Water)	100	Colorimetry	15.5	mg/L	INAB
Chromium (Surface Water)	177	ICPMS	<1	ug/L	INAB
COD (Surface Water)	107	Colorimetry	15	mg/L	INAB
Copper (Surface Water)	177	ICPMS	<2	ug/L	INAB
Manganese (Surface Water)	177	ICPMS	45	ug/L	INAB
Mineral Oil by Calculation	188	GC-FID	<2.5	ug/L	
Nickel (Surface Water)	177	ICPMS	1	ug/L	INAB
Phosphate (Ortho) Surface Water	117	Colorimetry	0.06	mg/L as P	INAB
Phosphorus (Total) Surface Water	166	Colorimetry	0.08	mg/L as P	INAB
Solids (Settleable)	122	Gravimetry	<1	mg/L	
Solids (Total Suspended)	106	Gravimetry	2	mg/L	
Sulphate (Surface Water)	119	Colorimetry	18	mg/L as S04	INAB

Signed: A Harmon **Date: 06/07/2022**

Aoife Harmon - Laboratory Supervisor

Acc. : Accredited Parameters by ISO/IEC 17025:2017

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For bacterial analysis a result of 0 means none detected in volume examined
All organic results are analysed as received and all results are corrected for dry weight at 104 C
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Results contained in this report relate only to the samples tested (P) : Presumptive Results

** : The test result for this parameter may be invalid as it has exceeded the recommended holding time (BS EN ISO 5667-3:2018)

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	Saint Gobain Mining Ltd.	Date of Receipt	14/06/2022
	Kingscourt	*Sampled On*	*13/06/2022*
		Date Testing Commenced	14/06/2022
		Received or Collected	Courier
	Co Cavan	Condition on Receipt	Acceptable
Customer PO		Date of Report	06/07/2022
Customer Ref	*SWB*	*Sample Type*	*Surface Water*
Ref 2	*13/06/2022*		
Ref 3			

CERTIFICATE OF ANALYSIS

Test Parameter	SOP	Analytical Technique	Result	Units	Acc.
Ammonia (Surface Water)	114	Colorimetry	0.03	mg/L as N	INAB
BOD (Surface Water)	113	Electrometry	0.9	mg/L	INAB
Chloride (Surface Water)	100	Colorimetry	14.4	mg/L	INAB
Chromium (Surface Water)	177	ICPMS	<1	ug/L	INAB
COD (Surface Water)	107	Colorimetry	14	mg/L	INAB
Copper (Surface Water)	177	ICPMS	<2	ug/L	INAB
Manganese (Surface Water)	177	ICPMS	36	ug/L	INAB
Mineral Oil by Calculation	188	GC-FID	<2.5	ug/L	
Nickel (Surface Water)	177	ICPMS	1	ug/L	INAB
Phosphate (Ortho) Surface Water	117	Colorimetry	0.06	mg/L as P	INAB
Phosphorus (Total) Surface Water	166	Colorimetry	0.08	mg/L as P	INAB
Solids (Settleable)	122	Gravimetry	<1	mg/L	
Solids (Total Suspended)	106	Gravimetry	2	mg/L	
Sulphate (Surface Water)	119	Colorimetry	17	mg/L as S04	INAB

Signed: A Harmon **Date: 06/07/2022**

Aoife Harmon - Laboratory Supervisor

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	Saint Gobain Mining Ltd.	Date of Receipt	14/06/2022
	Kingscourt	*Sampled On*	*13/06/2022*
		Date Testing Commenced	14/06/2022
		Received or Collected	Courier
	Co Cavan	Condition on Receipt	Acceptable
Customer PO		Date of Report	06/07/2022
Customer Ref	*SWC*	*Sample Type*	*Surface Water*
Ref 2	*13/06/2022*		
Ref 3			

CERTIFICATE OF ANALYSIS

Test Parameter	SOP	Analytical Technique	Result	Units	Acc.
Ammonia (Surface Water)	114	Colorimetry	0.16	mg/L as N	INAB
BOD (Surface Water)	113	Electrometry	1.2	mg/L	INAB
Chloride (Surface Water)	100	Colorimetry	20.3	mg/L	INAB
Chromium (Surface Water)	177	ICPMS	<1	ug/L	INAB
COD (Surface Water)	107	Colorimetry	25	mg/L	INAB
Copper (Surface Water)	177	ICPMS	2	ug/L	INAB
Manganese (Surface Water)	177	ICPMS	343	ug/L	INAB
Mineral Oil by Calculation	188	GC-FID	<2.5	ug/L	
Nickel (Surface Water)	177	ICPMS	3	ug/L	INAB
Phosphate (Ortho) Surface Water	117	Colorimetry	0.02	mg/L as P	INAB
Phosphorus (Total) Surface Water	166	Colorimetry	0.05	mg/L as P	INAB
Solids (Settleable)	122	Gravimetry	<1	mg/L	
Solids (Total Suspended)	106	Gravimetry	7	mg/L	
Sulphate (Surface Water)	119	Colorimetry	654	mg/L as S04	INAB

Signed: A Harmon **Date: 06/07/2022**

Aoife Harmon - Laboratory Supervisor

Acc. : Accredited Parameters by ISO/IEC 17025:2017

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	Saint Gobain Mining Ltd.	Date of Receipt	14/06/2022
	Kingscourt	*Sampled On*	*13/06/2022*
		Date Testing Commenced	14/06/2022
		Received or Collected	Courier
	Co Cavan	Condition on Receipt	Acceptable
Customer PO		Date of Report	06/07/2022
Customer Ref	*SWD*	*Sample Type*	*Surface Water*
Ref 2	*13/06/2022*		
Ref 3			

CERTIFICATE OF ANALYSIS

Test Parameter	SOP	Analytical Technique	Result	Units	Acc.
Ammonia (Surface Water)	114	Colorimetry	0.05	mg/L as N	INAB
BOD (Surface Water)	113	Electrometry	0.9	mg/L	INAB
Chloride (Surface Water)	100	Colorimetry	15.0	mg/L	INAB
Chromium (Surface Water)	177	ICPMS	<1	ug/L	INAB
COD (Surface Water)	107	Colorimetry	9	mg/L	INAB
Copper (Surface Water)	177	ICPMS	<2	ug/L	INAB
Manganese (Surface Water)	177	ICPMS	36	ug/L	INAB
Mineral Oil by Calculation	188	GC-FID	<2.5	ug/L	
Nickel (Surface Water)	177	ICPMS	1	ug/L	INAB
Phosphate (Ortho) Surface Water	117	Colorimetry	0.07	mg/L as P	INAB
Phosphorus (Total) Surface Water	166	Colorimetry	0.16	mg/L as P	INAB
Solids (Settleable)	122	Gravimetry	<1	mg/L	
Solids (Total Suspended)	106	Gravimetry	2	mg/L	
Sulphate (Surface Water)	119	Colorimetry	20	mg/L as S04	INAB

Signed: A Harmon **Date: 06/07/2022**

Aoife Harmon - Laboratory Supervisor

Acc. : Accredited Parameters by ISO/IEC 17025:2017

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	Kingscourt	*Sampled On*	*13/06/2022*
		Date Testing Commenced	14/06/2022
		Received or Collected	Courier
	Co Cavan	Condition on Receipt	Acceptable
Customer PO		Date of Report	06/07/2022
Customer Ref	*SWE*	*Sample Type*	*Surface Water*
Ref 2	*13/06/2022*		
Ref 3			

CERTIFICATE OF ANALYSIS

Test Parameter	SOP	Analytical Technique	Result	Units	Acc.
Ammonia (Surface Water)	114	Colorimetry	0.05	mg/L as N	INAB
BOD (Surface Water)	113	Electrometry	1.0	mg/L	INAB
Chloride (Surface Water)	100	Colorimetry	14.5	mg/L	INAB
Chromium (Surface Water)	177	ICPMS	<1	ug/L	INAB
COD (Surface Water)	107	Colorimetry	10	mg/L	INAB
Copper (Surface Water)	177	ICPMS	<2	ug/L	INAB
Manganese (Surface Water)	177	ICPMS	38	ug/L	INAB
Mineral Oil by Calculation	188	GC-FID	<2.5	ug/L	
Nickel (Surface Water)	177	ICPMS	1	ug/L	INAB
Phosphate (Ortho) Surface Water	117	Colorimetry	0.07	mg/L as P	INAB
Phosphorus (Total) Surface Water	166	Colorimetry	0.41	mg/L as P	INAB
Solids (Settleable)	122	Gravimetry	<1	mg/L	
Solids (Total Suspended)	106	Gravimetry	2	mg/L	
Sulphate (Surface Water)	119	Colorimetry	20	mg/L as S04	INAB

Signed: A Harmon **Date: 06/07/2022**

Aoife Harmon - Laboratory Supervisor

Acc. : Accredited Parameters by ISO/IEC 17025:2017

ilac-MRA

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For bacterial analysis a result of 0 means none detected in volume examined
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Email: info@fitzsci.ie

Customer supplied information appear in italics.

Customer	*Kevin Breslin*	Lab Report Ref. No.	0911/216/06
	Saint Gobain Mining Ltd.	Date of Receipt	14/06/2022
	Kingscourt	*Sampled On*	*13/06/2022*
		Date Testing Commenced	14/06/2022
		Received or Collected	Courier
	Co Cavan	Condition on Receipt	Acceptable
Customer PO		Date of Report	06/07/2022
Customer Ref	*SWF*	*Sample Type*	*Surface Water*
Ref 2	*13/06/2022*		
Ref 3			

CERTIFICATE OF ANALYSIS

Test Parameter	SOP	Analytical Technique	Result	Units	Acc.
Ammonia (Surface Water)	114	Colorimetry	0.24	mg/L as N	INAB
BOD (Surface Water)	113	Electrometry	1.2	mg/L	INAB
Chloride (Surface Water)	100	Colorimetry	29.0	mg/L	INAB
Chromium (Surface Water)	177	ICPMS	<1	ug/L	INAB
COD (Surface Water)	107	Colorimetry	26	mg/L	INAB
Copper (Surface Water)	177	ICPMS	2	ug/L	INAB
Manganese (Surface Water)	177	ICPMS	702	ug/L	INAB
Mineral Oil by Calculation	188	GC-FID	<2.5	ug/L	
Nickel (Surface Water)	177	ICPMS	2	ug/L	INAB
Phosphate (Ortho) Surface Water	117	Colorimetry	0.09	mg/L as P	INAB
Phosphorus (Total) Surface Water	166	Colorimetry	0.20	mg/L as P	INAB
Solids (Settleable)	122	Gravimetry	<1	mg/L	
Solids (Total Suspended)	106	Gravimetry	8	mg/L	
Sulphate (Surface Water)	119	Colorimetry	65	mg/L as S04	INAB

Signed: A Harmon **Date: 06/07/2022**

Aoife Harmon - Laboratory Supervisor

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Customer supplied information appear in italics.

Customer	*Kevin Breslin*	Lab Report Ref. No.	0911/226/01
	Saint Gobain Mining Ltd.	Date of Receipt	14/07/2022
	Kingscourt	*Sampled On*	*13/07/2022*
		Date Testing Commenced	14/07/2022
		Received or Collected	Courier
	Co Cavan	Condition on Receipt	Acceptable
Customer PO		Date of Report	27/07/2022
Customer Ref	*SWA*	*Sample Type*	*Surface Water*
Ref 2	*13/07/2022*		
Ref 3			

CERTIFICATE OF ANALYSIS

Test Parameter	SOP	Analytical Technique	Result	Units	Acc.
Ammonia (Surface Water)	114	Colorimetry	0.05	mg/L as N	INAB
BOD (Surface Water)	113	Electrometry	0.6	mg/L	INAB
Chloride (Surface Water)	100	Colorimetry	14.6	mg/L	INAB
Chromium (Surface Water)	177	ICPMS	<1	ug/L	INAB
COD (Surface Water)	107	Colorimetry	13	mg/L	INAB
Copper (Surface Water)	177	ICPMS	<2	ug/L	INAB
Manganese (Surface Water)	177	ICPMS	3	ug/L	INAB
Mineral Oil by Calculation	188	GC-FID	<2.5	ug/L	
Nickel (Surface Water)	177	ICPMS	1	ug/L	INAB
Phosphate (Ortho) Surface Water	117	Colorimetry	0.04	mg/L as P	INAB
Phosphorus (Total) Surface Water	166	Colorimetry	0.10	mg/L as P	INAB
Solids (Settleable)	122	Gravimetry	<1	mg/L	
Solids (Total Suspended)	106	Gravimetry	<2	mg/L	
Sulphate (Surface Water)	119	Colorimetry	15	mg/L as S04	INAB

Signed: A Harman **Date: 27/07/2022**

Aoife Harmon - Laboratory Supervisor

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Customer supplied information appear in italics.

Customer	*Kevin Breslin*	Lab Report Ref. No.	0911/226/02
	Saint Gobain Mining Ltd.	Date of Receipt	14/07/2022
	Kingscourt	*Sampled On*	*13/07/2022*
		Date Testing Commenced	14/07/2022
		Received or Collected	Courier
	Co Cavan	Condition on Receipt	Acceptable
Customer PO		Date of Report	27/07/2022
Customer Ref	*SWB*	*Sample Type*	*Surface Water*
Ref 2	*13/07/2022*		
Ref 3			

CERTIFICATE OF ANALYSIS

Test Parameter	SOP	Analytical Technique	Result	Units	Acc.
Ammonia (Surface Water)	114	Colorimetry	0.04	mg/L as N	INAB
BOD (Surface Water)	113	Electrometry	0.9	mg/L	INAB
Chloride (Surface Water)	100	Colorimetry	14.5	mg/L	INAB
Chromium (Surface Water)	177	ICPMS	<1	ug/L	INAB
COD (Surface Water)	107	Colorimetry	16	mg/L	INAB
Copper (Surface Water)	177	ICPMS	<2	ug/L	INAB
Manganese (Surface Water)	177	ICPMS	61	ug/L	INAB
Mineral Oil by Calculation	188	GC-FID	<2.5	ug/L	
Nickel (Surface Water)	177	ICPMS	1	ug/L	INAB
Phosphate (Ortho) Surface Water	117	Colorimetry	0.06	mg/L as P	INAB
Phosphorus (Total) Surface Water	166	Colorimetry	0.12	mg/L as P	INAB
Solids (Settleable)	122	Gravimetry	<1	mg/L	
Solids (Total Suspended)	106	Gravimetry	3	mg/L	
Sulphate (Surface Water)	119	Colorimetry	16	mg/L as S04	INAB

Signed: A Harmon **Date: 27/07/2022**

Aoife Harmon - Laboratory Supervisor

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Customer	*Kevin Breslin*	Lab Report Ref. No.	0911/226/03
	Saint Gobain Mining Ltd.	Date of Receipt	14/07/2022
	Kingscourt	*Sampled On*	*13/07/2022*
		Date Testing Commenced	14/07/2022
		Received or Collected	Courier
	Co Cavan	Condition on Receipt	Acceptable
Customer PO		Date of Report	27/07/2022
Customer Ref	*SWC*	*Sample Type*	*Surface Water*
Ref 2	*13/07/2022*		
Ref 3			

CERTIFICATE OF ANALYSIS

Test Parameter	SOP	Analytical Technique	Result	Units	Acc.
Ammonia (Surface Water)	114	Colorimetry	0.19	mg/L as N	INAB
BOD (Surface Water)	113	Electrometry	1.5	mg/L	INAB
Chloride (Surface Water)	100	Colorimetry	10.6	mg/L	INAB
Chromium (Surface Water)	177	ICPMS	<1	ug/L	INAB
COD (Surface Water)	107	Colorimetry	40	mg/L	INAB
Copper (Surface Water)	177	ICPMS	2	ug/L	INAB
Manganese (Surface Water)	177	ICPMS	2073	ug/L	INAB
Mineral Oil by Calculation	188	GC-FID	<2.5	ug/L	
Nickel (Surface Water)	177	ICPMS	4	ug/L	INAB
Phosphate (Ortho) Surface Water	117	Colorimetry	0.10	mg/L as P	INAB
Phosphorus (Total) Surface Water	166	Colorimetry	0.31	mg/L as P	INAB
Solids (Settleable)	122	Gravimetry	<1	mg/L	
Solids (Total Suspended)	106	Gravimetry	41	mg/L	
Sulphate (Surface Water)	119	Colorimetry	1061	mg/L as S04	INAB

Signed: A Harmon **Date: 27/07/2022**

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Customer supplied information appear in italics.

Customer	*Kevin Breslin*	Lab Report Ref. No.	0911/226/04
	Saint Gobain Mining Ltd.	Date of Receipt	14/07/2022
	Kingscourt	*Sampled On*	*13/07/2022*
		Date Testing Commenced	14/07/2022
		Received or Collected	Courier
	Co Cavan	Condition on Receipt	Acceptable
Customer PO		Date of Report	27/07/2022
Customer Ref	*SWD*	*Sample Type*	*Surface Water*
Ref 2	*13/07/2022*		
Ref 3			

CERTIFICATE OF ANALYSIS

Test Parameter	SOP	Analytical Technique	Result	Units	Acc.
Ammonia (Surface Water)	114	Colorimetry	0.04	mg/L as N	INAB
BOD (Surface Water)	113	Electrometry	0.6	mg/L	INAB
Chloride (Surface Water)	100	Colorimetry	14.2	mg/L	INAB
Chromium (Surface Water)	177	ICPMS	<1	ug/L	INAB
COD (Surface Water)	107	Colorimetry	15	mg/L	INAB
Copper (Surface Water)	177	ICPMS	<2	ug/L	INAB
Manganese (Surface Water)	177	ICPMS	43	ug/L	INAB
Mineral Oil by Calculation	188	GC-FID	<2.5	ug/L	
Nickel (Surface Water)	177	ICPMS	1	ug/L	INAB
Phosphate (Ortho) Surface Water	117	Colorimetry	0.06	mg/L as P	INAB
Phosphorus (Total) Surface Water	166	Colorimetry	0.19	mg/L as P	INAB
Solids (Settleable)	122	Gravimetry	<1	mg/L	
Solids (Total Suspended)	106	Gravimetry	2	mg/L	
Sulphate (Surface Water)	119	Colorimetry	21	mg/L as S04	INAB

Signed: A Harmon **Date: 27/07/2022**

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Customer	*Kevin Breslin*	Lab Report Ref. No.	0911/226/05
	Saint Gobain Mining Ltd.	Date of Receipt	14/07/2022
	Kingscourt	*Sampled On*	*13/07/2022*
		Date Testing Commenced	14/07/2022
		Received or Collected	Courier
	Co Cavan	Condition on Receipt	Acceptable
Customer PO		Date of Report	27/07/2022
Customer Ref	*SWE*	*Sample Type*	*Surface Water*
Ref 2	*13/07/2022*		
Ref 3			

CERTIFICATE OF ANALYSIS

Test Parameter	SOP	Analytical Technique	Result	Units	Acc.
Ammonia (Surface Water)	114	Colorimetry	0.04	mg/L as N	INAB
BOD (Surface Water)	113	Electrometry	0.7	mg/L	INAB
Chloride (Surface Water)	100	Colorimetry	14.2	mg/L	INAB
Chromium (Surface Water)	177	ICPMS	<1	ug/L	INAB
COD (Surface Water)	107	Colorimetry	12	mg/L	INAB
Copper (Surface Water)	177	ICPMS	2	ug/L	INAB
Manganese (Surface Water)	177	ICPMS	41	ug/L	INAB
Mineral Oil by Calculation	188	GC-FID	<2.5	ug/L	
Nickel (Surface Water)	177	ICPMS	1	ug/L	INAB
Phosphate (Ortho) Surface Water	117	Colorimetry	0.06	mg/L as P	INAB
Phosphorus (Total) Surface Water	166	Colorimetry	0.12	mg/L as P	INAB
Solids (Settleable)	122	Gravimetry	<1	mg/L	
Solids (Total Suspended)	106	Gravimetry	7	mg/L	
Sulphate (Surface Water)	119	Colorimetry	21	mg/L as S04	INAB

Signed: A Harmon **Date: 27/07/2022**

Aoife Harmon - Laboratory Supervisor

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Customer supplied information appear in italics.

Customer	*Kevin Breslin*	Lab Report Ref. No.	0911/226/06
	Saint Gobain Mining Ltd.	Date of Receipt	14/07/2022
	Kingscourt	*Sampled On*	*13/07/2022*
		Date Testing Commenced	14/07/2022
		Received or Collected	Courier
	Co Cavan	Condition on Receipt	Acceptable
Customer PO		Date of Report	27/07/2022
Customer Ref	*SWF*	*Sample Type*	*Surface Water*
Ref 2	*13/07/2022*		
Ref 3			

CERTIFICATE OF ANALYSIS

Test Parameter	SOP	Analytical Technique	Result	Units	Acc.
Ammonia (Surface Water)	114	Colorimetry	0.19	mg/L as N	INAB
BOD (Surface Water)	113	Electrometry	1.2	mg/L	INAB
Chloride (Surface Water)	100	Colorimetry	26.9	mg/L	INAB
Chromium (Surface Water)	177	ICPMS	<1	ug/L	INAB
COD (Surface Water)	107	Colorimetry	29	mg/L	INAB
Copper (Surface Water)	177	ICPMS	<2	ug/L	INAB
Manganese (Surface Water)	177	ICPMS	1204	ug/L	INAB
Mineral Oil by Calculation	188	GC-FID	<2.5	ug/L	
Nickel (Surface Water)	177	ICPMS	2	ug/L	INAB
Phosphate (Ortho) Surface Water	117	Colorimetry	0.06	mg/L as P	INAB
Phosphorus (Total) Surface Water	166	Colorimetry	0.28	mg/L as P	INAB
Solids (Settleable)	122	Gravimetry	<1	mg/L	
Solids (Total Suspended)	106	Gravimetry	7	mg/L	
Sulphate (Surface Water)	119	Colorimetry	43	mg/L as S04	INAB

Signed: A Harmon **Date: 27/07/2022**

Aoife Harmon - Laboratory Supervisor

Acc. : Accredited Parameters by ISO/IEC 17025:2017

ilac-MRA INAB ISO 17025 ACCREDITED TESTING DETAILED IN SCOPE REG NO.389T

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APPENDIX C: AUGUST 2019 SAMPLING RESULTS

Element Materials Technology

Client Name: Golder Associates Ltd
Reference: 19121210
Location: Knocknacran West
Contact: Barry Balding
EMT Job No: 19/13689

Report : **Liquid**

Liquids/products: V=40ml vial, G=glass bottle, P=plastic bottle
$H=H_2SO_4$, Z=ZnAc, N=NaOH, $HN=HNO_3$

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Please see attached notes for all abbreviations and acronyms

EMT Sample No.	1-8	9-16	17-24	25-32	33-40	41-48	49-56	57-64	65-72	73-79			
Sample ID	KW1	KW2	KW2A	KW3	KC-19 A1	KC-19 A2	KC-19 B1	KC-19 B2	KC-19 C1	TRIP BLANK			
Depth													
COC No / misc													
Containers	V H HN P G	V H HN P G	V H HN P G	V H HN P G	V H HN P G	V H HN P G	V H HN P G	V H HN P G	V H HN P G	V H HN P G			
Sample Date	21/08/2019	22/08/2019	22/08/2019	22/08/2019	21/08/2019	22/08/2019	20/08/2019	21/08/2019	21/08/2019	21/08/2019			
Sample Type	Surface Water	Surface Water	Surface Water	Surface Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Trip Blank (water)			
Batch Number	1	1	1	1	1	1	1	1	1	1	LOD/LOR	Units	Method No.
Date of Receipt	24/08/2019	24/08/2019	24/08/2019	24/08/2019	24/08/2019	24/08/2019	24/08/2019	24/08/2019	24/08/2019	24/08/2019			
Dissolved Aluminium #	<20	<20	<20	22	<20	<20	61	<20	<20	<20	<20	ug/l	TM30/PM14
Dissolved Arsenic #	<2.5	<2.5	<2.5	<2.5	4.3	3.9	4.9	6.6	2.5	<2.5	<2.5	ug/l	TM30/PM14
Dissolved Barium #	25	41	39	56	49	11	17	15	3	<3	<3	ug/l	TM30/PM14
Dissolved Cadmium #	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	ug/l	TM30/PM14
Dissolved Calcium #	160.0	34.1	38.5	36.6	182.0	320.9$_{AA}$	316.9$_{AA}$	541.8$_{AA}$	266.2$_{AA}$	<0.2	<0.2	mg/l	TM30/PM14
Total Dissolved Chromium #	<1.5	<1.5	<1.5	<1.5	<1.5	1.6	7.2	6.9	<1.5	<1.5	<1.5	ug/l	TM30/PM14
Dissolved Copper #	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	ug/l	TM30/PM14
Total Dissolved Iron #	70	164	163	203	<20	<20	<20	<20	<20	<20	<20	ug/l	TM30/PM14
Dissolved Lead #	<5	<5	7	5	<5	9	<5	5	11	<5	<5	ug/l	TM30/PM14
Dissolved Magnesium #	17.2	5.6	6.2	5.7	15.0	164.1$_{AA}$	60.6	38.4	33.6	<0.1	<0.1	mg/l	TM30/PM14
Dissolved Manganese #	505	22	21	32	19	578	264	651	29	<2	<2	ug/l	TM30/PM14
Dissolved Mercury #	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	ug/l	TM30/PM14
Dissolved Nickel #	3	<2	<2	<2	8	<2	<2	<2	<2	<2	<2	ug/l	TM30/PM14
Dissolved Potassium #	3.6	5.0	6.4	5.5	10.1	10.2	5.7	8.9	6.5	<0.1	<0.1	mg/l	TM30/PM14
Dissolved Selenium #	<3	<3	<3	<3	8	<3	<3	<3	<3	<3	<3	ug/l	TM30/PM14
Dissolved Sodium #	11.9	7.6	8.6	8.3	78.6	53.0	57.0	140.1	55.6	<0.1	<0.1	mg/l	TM30/PM14
Dissolved Zinc #	5	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	ug/l	TM30/PM14
Methyl Tertiary Butyl Ether #	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	ug/l	TM15/PM10
Benzene #	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	ug/l	TM15/PM10
Toluene #	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	ug/l	TM15/PM10
Ethylbenzene #	<1	2	3	<1	<1	<1	<1	<1	<1	<1	<1	ug/l	TM15/PM10
m/p-Xylene #	<2	12	24	<2	<2	<2	<2	<2	<2	<2	<2	ug/l	TM15/PM10
o-Xylene #	<1	4	8	<1	<1	<1	<1	<1	<1	<1	<1	ug/l	TM15/PM10
Surrogate Recovery Toluene D8	106	106	104	106	108	108	109	110	112	110	<0	%	TM15/PM10
Surrogate Recovery 4-Bromofluorobenzene	103	103	100	101	103	103	105	105	108	106	<0	%	TM15/PM10
EPH (C8-C40) #	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	ug/l	TM5/PM30
Sulphate as SO4 #	316.1	13.6	13.5	14.0	546.5	1140.3	776.6	1348.6	519.3	<0.5	<0.5	mg/l	TM38/PM0
Chloride #	10.7	11.5	11.3	12.0	21.1	19.9	25.1	23.6	16.7	<0.3	<0.3	mg/l	TM38/PM0
Nitrate as NO3 #	2.0	7.4	5.9	4.7	0.6	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	mg/l	TM38/PM0
Nitrite as NO2 #	<0.02	0.05	0.05	0.05	0.11	0.03	<0.02	<0.02	<0.02	<0.02	<0.02	mg/l	TM38/PM0
Ortho Phosphate as PO4 #	0.20	0.16	0.16	0.09	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	mg/l	TM38/PM0
Total Oxidised Nitrogen as N #	0.5	1.7	1.3	1.1	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	mg/l	TM38/PM0
Total Ammonia as N #	0.08	0.06	0.06	0.06	1.37	0.23	0.06	0.09	0.05	<0.03	<0.03	mg/l	TM38/PM0
Total Alkalinity as CaCO3 #	162	120	114	108	354	208	204	84	100	18	<1	mg/l	TM75/PM0
Dissolved Oxygen	8	7	7	9	7	5	5	6	5	8	<1	mg/l	TM58/PM0
Total Organic Carbon #	10	12	12	12	7	<2	<2	6	<2	<2	<2	mg/l	TM60/PM0
Total Dissolved Solids #	665	157	162	153	1021	1938	1381	2100	1042	<35	<35	mg/l	TM20/PM0
Total Suspended Solids #	<10	15	<10	<10	946	2662	184	71	284	<10	<10	mg/l	TM37/PM0

Please include all sections of this report if it is reproduced
All solid results are expressed on a dry weight basis unless stated otherwise.

APPENDIX 8.2
Aquatic baseline report for the Corduff Stream, Knocknacran West Project, Co. Monaghan, Triturus, October 2022

Aquatic baseline report for the Corduff Stream, Knocknacran West Project, Co. Monaghan

Prepared by Triturus Environmental Ltd. for O'Donnell Environmental Ltd.

October 2022

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Table of contents

1. Methodology

1.1 Aquatic Survey Area

The aquatic survey area was focused on the Corduff Stream catchment (EPA code: 06C70), that drains the Drumgoosat/ Knocknacran West area, rising above the old Drumgoosat mine workings and flows north and east into Lough Fea (**Figure 1**). The Corduff Stream then forms part of the River Bursk (Lurgans) sub-catchment (EPA code: 06L06) south of Lough Fea and the Lagan (Glyde) River catchment (EPA code: 06G02) south of Rahans Lough.

1.2 Aquatic site survey

Aquatic surveys of the Corduff Stream Stream (EPA code: 06C70) were conducted on Friday 9th September 2022. Survey effort focused on both instream and riparian habitats at each aquatic sampling location (**Table 1 & Figure 1**). Surveys at each of these sites included a fisheries habitat appraisal, macrophyte & aquatic bryophyte survey and biological water quality sampling (Q-sampling).

Surveys were also cognisant of aquatic invasive species listed on the Third Schedule of the European Communities (Birds and Natural Habitats) Regulations 2011-2021 (S.I. 477/2011) or high-risk invasive species in Ireland (after O' Flynn *et al*., 2014). This survey approach ensured that any habitats and species of high conservation value would be detected to best inform mitigation for the development.

In addition to the ecological characteristics of the site, a broad aquatic and riparian habitat assessment was conducted utilising elements of the methodology given in the Environment Agency's 'River Habitat Survey in Britain and Ireland Field Survey Guidance Manual 2003' (EA, 2003) and the Irish Heritage Council's 'A Guide to Habitats in Ireland' (Fossitt, 2000). This broad characterisation helped define the watercourses' conformity or departure from naturalness. All sites were assessed in terms of:

- Physical watercourse/waterbody characteristics (i.e. width, depth etc.) including associated evidence of historical drainage
- Substrate type, listing substrate fractions in order of dominance (i.e. bedrock, boulder, cobble, gravel, sand, silt etc.)
- Flow type by proportion of riffle, glide and pool in the sampling area
- An appraisal of the macrophyte and aquatic bryophyte community at each site
- Riparian vegetation composition

Table 1 Location of *n*=2 aquatic survey sites on the Corduff Stream, in the vicinity of the Knocknacran West project site area (the existing Knocknacran Open-Cast Mine and proposed Knocknacran West Open-Cast Mine sites), Co. Monaghan.

Site no.	Watercourse	EPA code	Location	X (ITM)	Y (ITM)
1	Corduff Stream	06C70	Drumgoosat	281044	300480
2	Corduff Stream	06C70	Corrybrackan (West of Lough Fea)	281726	301387

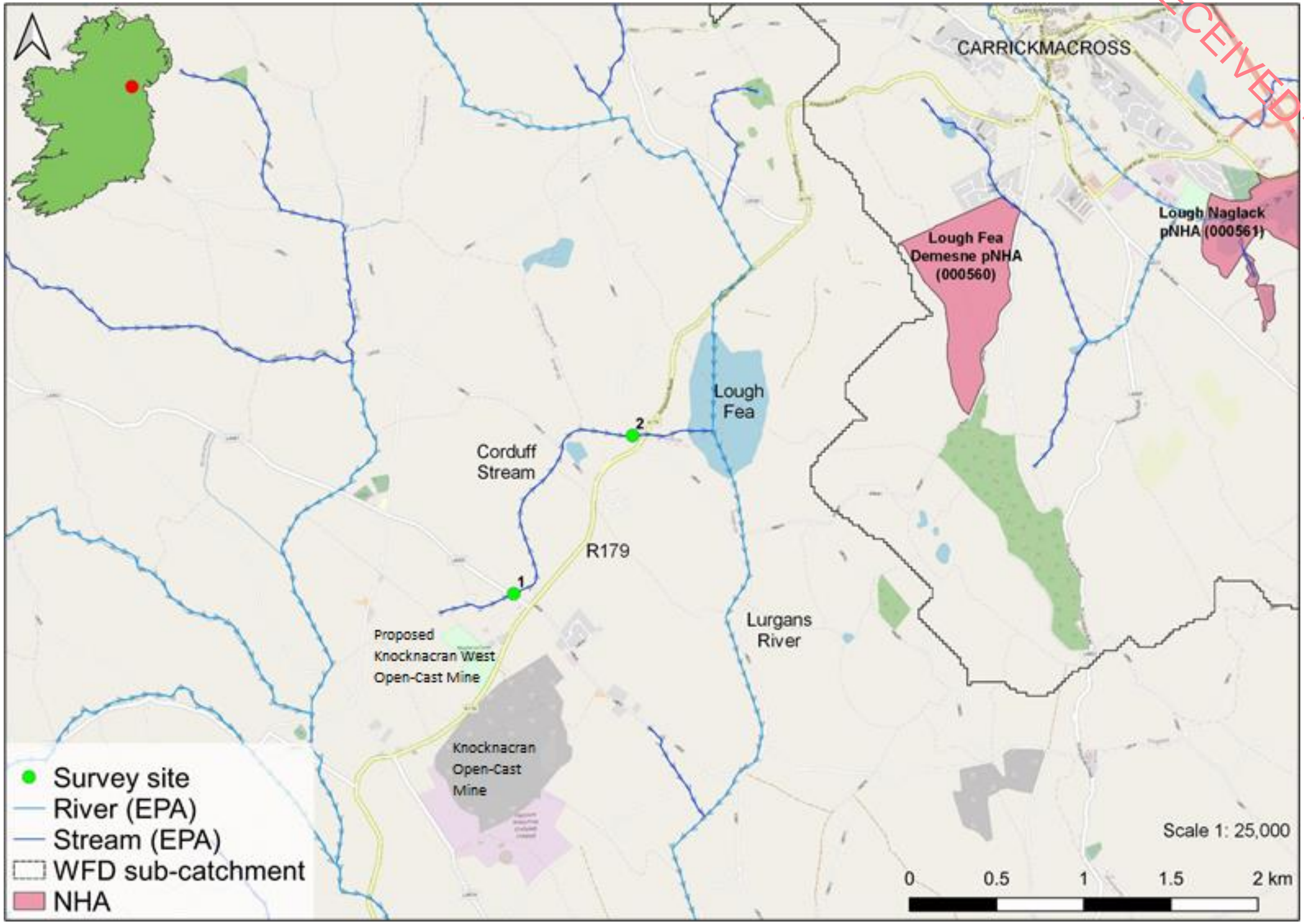

Figure 1 Overview of the *n*=2 aquatic survey locations on the Corduff Stream in the vicinity of the existing Knocknacran Open-Cast Mine and proposed Knocknacran West Open-Cast Mine, Co. Monaghan

Triturus

1.3 Fisheries Appraisal

A fisheries appraisal of the Corduff Stream was undertaken at the two survey locations at Drumgoosat and Corrybrackan, west of Lough Fea. The survey examined key characteristics of habitat capable of supporting fish of high conservation value (e.g. salmonids, European eel and lamprey). This included suitable nursery, spawning and holding areas for salmonids. It also examined for habitat capable of supporting lamprey species e.g. soft sediment for ammocoetes and nearby spawning in mixed finer gravels. European eel nursery habitat identified by rivers with good flow diversity, boulder and cobble refugia with cover from predators was also examined for. The habitat characteristics informed the likelihood of the Corduff Stream to support these species inclusive of their known distribution in the catchment.

1.4 Biological water quality (Q-sampling)

The *n*=2 aquatic survey sites were assessed for biological water quality through Q-sampling on the 9th September 2022 (**Figure 2**). All samples were taken with a standard kick sampling hand net (250mm width, 500µm mesh size) from areas of riffle/glide utilising a 2-minute kick sample, as per Environmental Protection Authority (EPA) methodology (Feeley et al., 2020). Large cobble was also washed at each site for 1-minute (where present) to collect attached macro-invertebrates (as per Feeley et al., 2020). Samples were elutriated and fixed in 70% ethanol for subsequent laboratory identification. Samples were converted to Q-ratings as per Toner et al. (2005) and assigned to WFD status classes.

Table 2.4 Reference categories for EPA Q-ratings (Q1 to Q5)

Q Value	WFD status	Pollution status	Condition
Q5 or Q4-5	High status	Unpolluted	Satisfactory
Q4	Good status	Unpolluted	Satisfactory
Q3-4	Moderate status	Slightly polluted	Unsatisfactory
Q3 or Q2-3	Poor status	Moderately polluted	Unsatisfactory
Q2, Q1-2 or Q1	Bad status	Seriously polluted	Unsatisfactory

1.5 Aquatic ecological evaluation

The evaluation of aquatic ecological receptors contained within this report uses the geographic scale and criteria defined in the 'Guidelines for Assessment of Ecological Impacts of National Road Schemes' (NRA, 2009).

1.6 Biosecurity

A strict biosecurity protocol following IFI (2010) and the Check-Clean-Dry approach was adhered to during surveys for all equipment and PPE used. Disinfection of all equipment and PPE before and after use with Virkon™ was conducted to prevent the transfer of pathogens or invasive propagules between survey sites. Equipment was also thoroughly dried (through UV exposure) between survey areas by using duplicate equipment. Surveys were undertaken at sites in a downstream order to minimise the risk of upstream propagule mobilisation. Any aquatic invasive species or pathogens recorded within or adjoining the survey areas were geo-referenced. All Triturus staff are certified in 'Good fieldwork practice: slowing the spread of invasive non-native species' by the University of Leeds.

2. Results of aquatic surveys

The following section summarises each of the *n*=2 survey sites in terms of aquatic habitats, physical characteristics and overall value for invertebrates, fish and macrophyte/aquatic bryophyte communities. Biological water quality (Q-sample) results are also summarised for each site and in **Table 2.1.** Habitat codes are according to Fossitt (2000). Scientific names are provided at first mention only. An evaluation of the aquatic ecological importance of each survey site based on these aquatic surveys is provided and summarised in **Table 3.2**.

2.1 Aquatic survey site results

Site 1 – Corduff Stream at Drumgossatt

The Corduff stream at site 1 was situated west of the local road crossing in the Drumgoosat townland southeast of the Drumgoosat National School (**Figure 1**). The low order stream emerged from a box culvert east of the road crossing and was representative of a heavily modified lowland depositing stream channel (FW2). The channel was 1-1.5m wide with 1-2m bank heights, being trapezoidal in shape. The stream was evidently historically deepened as part of drainage works. The stream was between 0.3m and 0.7m deep with stagnant water at the time of the survey. The stream had a deep silt and clay bed with no hard substrata. The silt was anoxic (black) in places when disturbed. The stream supported several common macrophyte species including abundant fool's watercress (*Apium nodiflorum*) with localised branched bur-reed (*Sparganium erectum*) and brooklime (*Veronica beccabunga*). Common duckweed (*Lemna minor*) was also frequent in the stream indicating enrichment. The riparian areas supported mature hawthorn (*Crataegus monoygna*), oak (*Quercus* sp.) and ivy (*Hedera hibernica*) with heavily scrubbed over understories with species including hedge bindweed (*Calystegia sepium*), bramble (*Rubus fruticosus*), great willowherb (*Epilobium hirsutum*), nettle (*Urtica dioica*) and wild angelica (*Angelica sylvestris*). The bordering land uses were of improved pasture (GA1).

The Corduff Stream at site 1 was not of any value to salmonids due to the absence flows, heavy enrichment and siltation. The bed was too compacted due to the clay content and with insufficient flows (being stagnant at the time of the survey) to support lamprey. It was considered to be of low value to eel given the absence of coarse substrata, limited deeper pool and heavily vegetated nature of the channel. The channel was not of value to crayfish given poor riverine conditions i.e. absence of flow, enrichment, heavy siltation and the absence of coarse substrata.

Biological water quality, based on Q-sampling, was calculated tentatively as **Q2-3 (poor status)**. No macro-invertebrate species of conservation value greater than 'least concern', according to national red lists, were recorded via Q-sampling. Given the absence of any aquatic species of high importance or of any significant fisheries value at site 1, the aquatic ecological evaluation was of **local importance (higher value) (Table 3.2).**

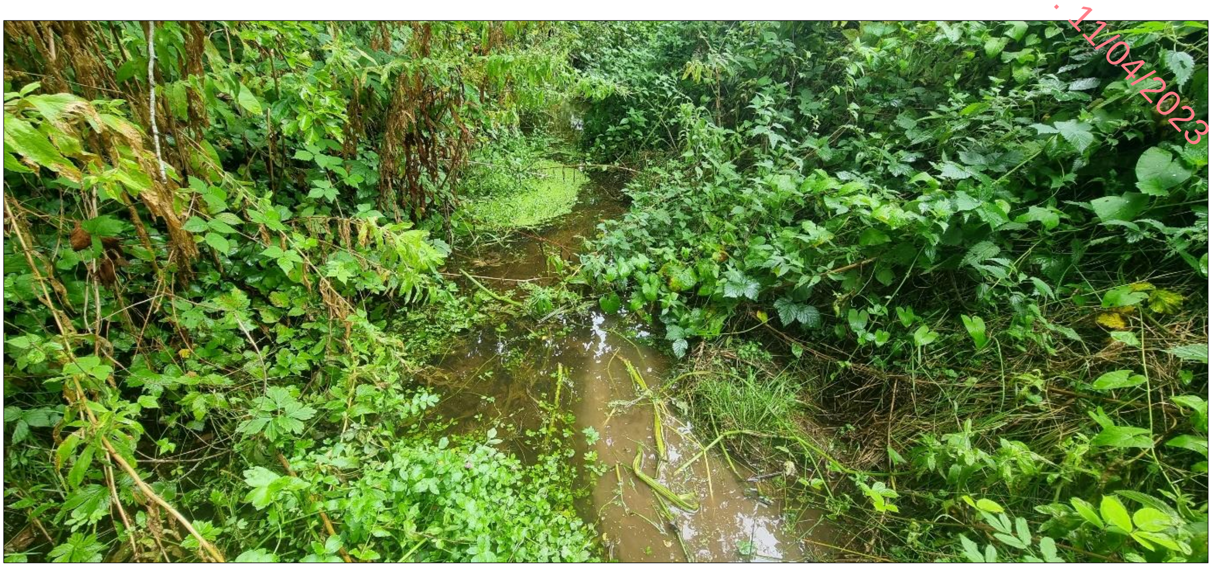

Plate 1 Representative image of site 1 on the Corduff Stream

Site 2 – Corduff Stream, west of Lough Fea

Site 2 was located on the Corduff Stream, west of Lough Fea and the R179 road crossing (**Figure 1**). The Corduff stream at the survey area was a 3m wide heavily modified lowland depositing channel (FW2). The channel was 0.3m-0.6m deep with steep 5-8m bank heights and had a trapezoidal channel profile. The channel had evidently been historically extensively deepened and had a deep silt and clay bed. Large accumulations of silt and clay were visible on the bed of the stream and on entry into the channel silt plumes were visible indicating gross siltation. The stream supported no macrophytes apart from frequent common water starwort (*Callitriche stagnalis*) and abundant invasive least duckweed (*Lemna minuta*). The riparian areas were densely scrubbed over with bramble, nettle, cleavers (*Galium aparine*), great willowherb and ivy with scattered mature sycamore (*Acer pseudoplatanus*) and crack willow (*Salix fragilis* agg.). The bordering land uses were of built land. The stream was a poor salmonid nursery due to gross siltation and enrichment but likely supports a small residual adult brown trout (*Salmo trutta*) population. The stream bed may support a small brook lamprey (*Lampetra planeri*) population due to suitable lamprey ammocoete burial habitat albeit spawning habitat was absent. The stream was considered to be of limited value for European eel (*Anguilla anguilla*) but a population due to the degraded nature but a small population may exist given the species presence in downstream connecting Lough Fea. The stream had no suitability for crayfish due to gross enrichment, siltation and very limited hard substrata.

Biological water quality, based on Q-sampling, was calculated tentatively as **Q2-3 (poor status)**. No macro-invertebrate species of conservation value greater than 'least concern', according to national red lists, were recorded via Q-sampling. Given that the Corduff Stream at site 2 may support brook lamprey and a small trout population and or European eel, the aquatic ecological evaluation was of **local importance (higher value) (Table 3.2).**

Plate 2 Representative image of site 2 on the Corduff Stream

2.2 Biological water quality (macro-invertebrates)

Both sampling sites collected from the Corduff Stream during September 2022 achieved **Q2-3 (poor status)** water quality (moderately polluted) (**Table 2**). In light of the results both sampling sites failed to meet target good status (≥Q4) requirements of the European Union Environmental Objectives (Surface Waters) (Amendment) Regulations 2019 and the Water Framework Directive (2000/60/EC) (**Figure 2 below**).

Poor status water quality was achieved given the absence of EPA group A clean water indicator species, the presence of a single group B species only (i.e. *Coenagrion* sp. damselfly that are tolerant of enrichment) and a dominance of EPA group C species (moderate water quality indicator species). The group C species recorded included common coleopteran species i.e. *Hydroporus tessellatus* and *Haliplus* spp. with common snail species such as such as *Bithynia tentaculata* and non-native *Potamopyrgus antipodarum* also being present. There were also pollution tolerant EPA Group D species in the samples including the snail *Ampullacaena balthica* and the freshwater hoglouse (*Asellus aquaticus*). Furthermore, very pollution tolerant species were also present e.g. *Chironomus* sp. (EPA Group E). The community composition at both sites was therefore indicative of **Q2-3** (Poor Status) water quality (**Table 2**).

Table 2 Macro-invertebrate Q-sampling results for sites on the

Group	Family	Species	Site 1	Site 2	EPA Group
Odonata	*Coenagrionidae*	*Coenagrion* sp.	1		B
Amphipoda	Gammaridae	*Gammarus duebeni*		17	C
Coleoptera	Dytiscidae	*Agabus paludosus*	1		C
Coleoptera	Dytiscidae	*Hydroporus tessellatus*	2		C
Coleoptera	Halipliidae	*Haliplus ruficollis group*	1		C
Coleoptera	Halipliidae	*Haliplus lineatocollis*	1		C
Diptera	Chironomidae	*Non-Chironomus spp.*	6	2	C
Diptera	Dixidae	sp. indet.		3	C
Mollusca	Tateidae	*Potamopyrgus antipodarum*	39		C
Mollusca	Bithyniidae	*Bithynia tentaculata*		2	C
Hirudinea	Glossiphonidae	sp. indet.		2	D
Isopoda	*Asellidae*	*Asellus aquaticus*	62		D
Mollusca	*Lymnaeidae*	*Ampullacaena balthica*	2		D
Mollusca	*Sphaeriidae*	sp. indet.			D
Diptera	*Chironomidae*	*Chironomus* spp.		26	E
Oligochaeta	*Annelidae*	sp. indet.		2	N/A
Abundance			82	167	
Q-rating			**2-3**[1]	**2-3**	
WFD status			**Poor**	**Poor**	

[1] Tentative Q Rating applied given absence of riffle and glide habitat which is required for a definitive Q Rating determination.

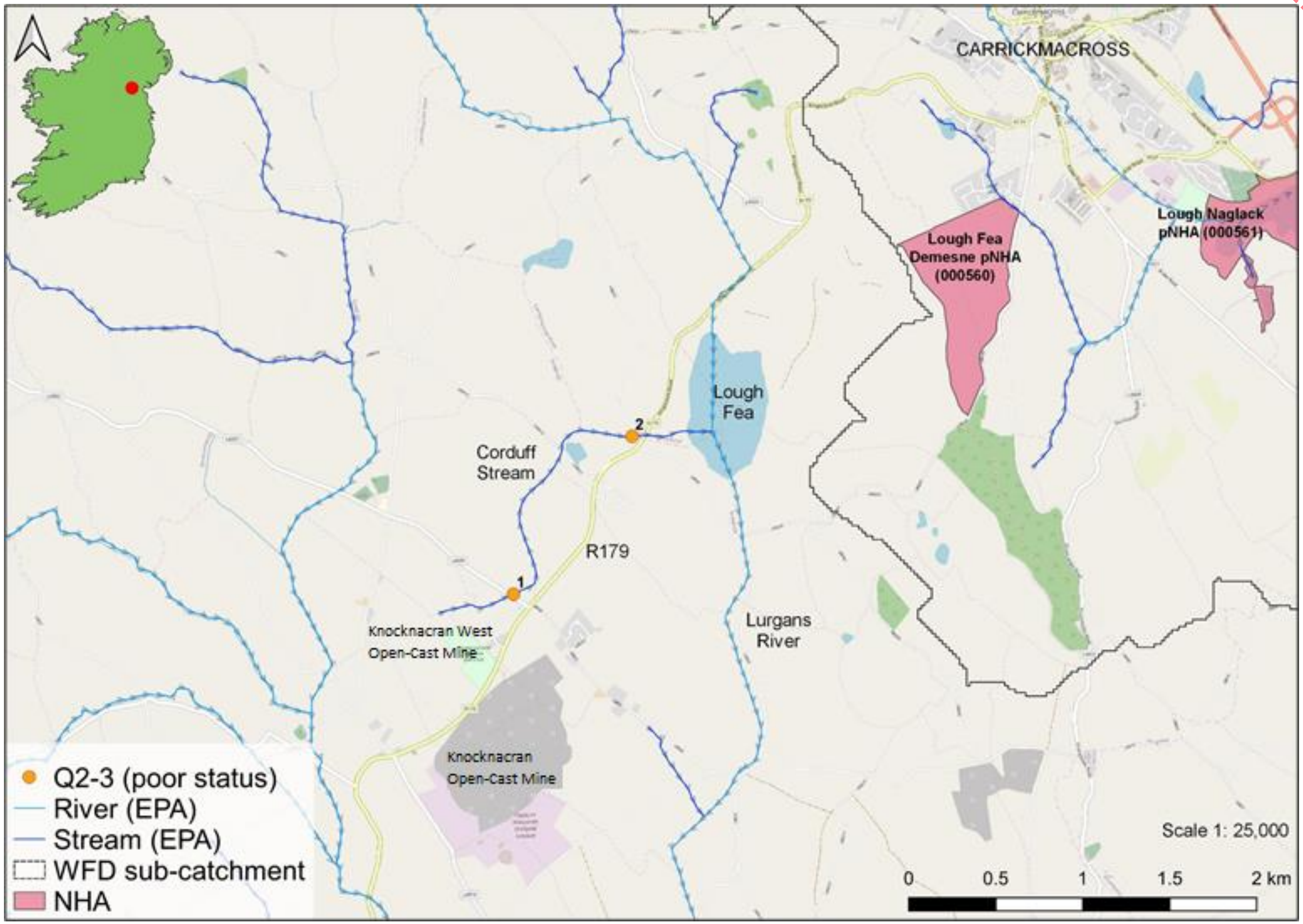

Figure 2 Overview of the biological water quality recorded in the Corduff Stream in the vicinity of the existing Knocknacran Open-Cast Mine and proposed Knocknacran West Open-Cast Mine, Co. Monaghan

2.3 Aquatic ecological evaluation

An aquatic ecological evaluation of each survey site was based on the results of the fisheries habitat assessments (including electro-fishing), the presence of protected or rare species or habitats and the biological water quality status of the survey sites (**Table 3**).

Survey site 1 at Drumgoosat on the Corduff Stream was evaluated as of **local importance (lower value)**. Primarily, this evaluation was due to the low aquatic ecological value for invertebrates, macrophytes and fisheries (Table 1). The Corduff Stream was also heavily modified in nature with evident heavy enrichment and siltation. Survey site 2, west of Lough Fea had improved flows and more semi-natural riverine conditions that resulted in the stream having some improved fisheries value for brown trout, lamprey and European eel. These attributes indicated that the Corduff Stream at site 2 was of **local importance (higher value)**.

Table 3 Aquatic ecological evaluation summary of the Corduff Stream survey sites in vicinity of the Knocknacran West Project, Co. Monaghan, according to NRA (2009) criteria.

Site no.	Watercourse	EPA code	Evaluation of importance	Rationale summary
1	Corduff Stream at Drumgoosat	06C70	**Local importance (lower value)**	Small, very heavily modified lowland stream that was heavily overgrown with commonly occurring macrophyte vegetation. The stream was historically straightened and deepened with no visible water flows, deep silt base and heavy enrichment, poor indicators of habitat quality. Of no inherent value to fish of high conservation value including salmonids, lamprey and European eel; no suitability for crayfish and none recorded; Q2-3 (poor status) water quality.
2	Corduff Stream west of Lough Fea	06C70	**Local importance (higher value)**	Small, heavily modified lowland stream but retaining some semi-natural characteristics including swift flowing water and coarse substrata locally. The stream was historically deepened and had a bed dominated by silt with heavy enrichment that are poor indicators of habitat quality. Of some lower value to lamprey given soft sediment burial habitat present; too enriched and silted to support a healthy salmonid population albeit some adult brown trout may exist (trout are known from Lough Fea & adjoining tributaries). Low suitability for eel but the presence of eel populations in Lough Fea may indicate the species presence in the Corduff Stream at site 2; no suitability for crayfish and none recorded; Q2-3 (poor status) water quality.

Conservation value: Atlantic salmon (*Salmo salar*), sea lamprey (*Petromyzon marinus*), brook lamprey (*Lampetra planeri*), river lamprey (*Lampetra fluviatilis*) and white-clawed crayfish (*Austropotamobius pallipes*) are listed under Annex II of the Habitats Directive [92/42/EEC]. Atlantic salmon, river lamprey, freshwater pearl mussel, white-clawed crayfish and otter are also listed under Annex V of the Habitats Directive [92/42/EEC]. European eel are 'critically endangered' according to most recent ICUN red list (Pike et al., 2020) and listed as 'critically engendered' in Ireland (King et al., 2011). With the exception of the Fisheries Acts 1959 to 2019, brown trout have no legal protection in Ireland.

3. Discussion

The Corduff Stream in the vicinity of the Knocknacran West Project and, indeed, through much of its course as far as Lough Fea has been historically modified (including straightening, deepening, road culverts and bank reinforcements), with resulting impacts to hydromorphology and the quality of aquatic habitats present. Furthermore, the stream suffers from low seasonal flow (particularly at site 1 near Drumgoosat) with siltation and water quality enrichment pressures evident. Both survey sites achieved Q2-3 (poor status) water quality in September 2022, with no rare or protected macro-invertebrates recorded present (**Table 2**). The poor habitat quality, limited aquatic and fisheries value at site 1 near Drumgoosat accounted for the low ecological evaluation i.e. **local importance (lower value).**

However, despite evident historical and current pressures on the Corduff Stream, the stream may support a small adult brown trout population at site 2, west of Lough Fea where improved flows existed. Brown trout and brook lamprey are also known from the upper Glyde catchment in the vicinity of Lough Fea (Fleming *et al.* 2021). Furthermore, the improved flows and soft sediment at survey site 2 west of Lough Fea may support a small brook lamprey and European population, the latter species of which is Red-listed in Ireland (King *et al.,* 2011) and critically endangered according to the IUCN (Pike et al., 2020). The improved fisheries value of the Corduff Stream at site 2 accounted for the higher evaluation than at site 1, i.e. **local importance** (**higher value)**.

The proposed mine development must, therefore, ensure impacts to the Corduff Stream are mitigated in respect of salmonid, European eel and general fisheries habitat, by preventing further deterioration of the already degraded Corduff Stream catchment.

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APPENDIX 8.3
Surface Water Quality Data

"B"		2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Antimony µg/l	Min						2.9	3	3	3	3	3	3
	Max						2.9	3	3	3	3	3	3
Arsenic µg/l	Min						0.32	1	1	1	1	1	1
	Max						0.32	1	1	1	1	1	1
BOD mg/l	Min						6	2	1.1	1.4	1.2	0.3	1.3
	Max						6	2	1.1	1.4	1.2	0.3	1.3
Cadmium µg/l	Min						0.01	1	1	1	1	1	1
	Max						0.01	1	1	1	1	1	1
Chromium µg/l	Min						0.58	1	1	1	1	1	1
	Max						0.58	1	1	1	1	1	1
Conductivity uS/cm	Min	258	272	256	224	270						297	336
	Max	347	445	395	425	496						368	361
Copper µg/l	Min						0.21	3	2	19	3	2	3
	Max						0.21	3	2	19	3	2	3
Lead µg/l	Min						0.02	1	1	1	1	1	1
	Max						0.02	1	1	1	1	1	1
Mercury µg/l	Min						0.03	0.03	0.05	0.05	0.05	0.05	0.21
	Max						0.03	0.03	0.05	0.05	0.05	0.05	0.21
MRP (as P) mg/l	Min						0.026	0.039	0.02	0.063	0.03	0.03	0.03
	Max						0.026	0.039	0.02	0.063	0.03	0.03	0.03
Nickel µg/l	Min						0.27	2	1	3	3	1	3
	Max						0.27	2	1	3	3	1	3
Nitrate mg/l	Min	0.074	0.11	0.11	0.22	0.11						0.51	1.9
	Max	1.34	1.24	1.77	1.94	1.39						3.57	1.9
Selenium µg/l	Min						0.54	1	1	1	1	1	1
	Max						0.54	1	1	1	1	1	1
Sulphate mg/l	Min	16.11	12.66	14.96	2.05	14.02						12	
	Max	23.35	24.68	23.35	21.66	306.66						22	
Suspended Solids mg/l	Min	2	2	2	2	2						2	
	Max	13	9	4	8	12						6	
Tellurium µg/l	Min						5	5	5	5	5	5	5
	Max						5	5	5	5	5	5	5
Thallium µg/l	Min						0.05	1	1	1	1	1	1
	Max						0.05	1	1	1	1	1	1
Tin µg/l	Min						2.8	2.8	1	1	1	1	1
	Max						2.8	2.8	1	1	1	1	1
Total Ammonia (as N) mg/l	Min						0.054	0.11	0.14	0.12	0.08	0.07	0.15
	Max						0.054	0.11	0.14	0.12	0.08	0.07	0.15
Total Heavy Metals µg/l	Min						0.542	7	1	28	8		7
	Max						0.542	7	1	28	8		7
Total Phosphorous mg/l	Min						0.037	0.082	0.033	0.08	0.06	0.04	0.11
	Max						0.037	0.082	0.033	0.08	0.06	0.04	0.11

CP-01		2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Barium mg/l	Min						0.03814	0.041	0.007	0.035	0.011	0.006	
	Max						0.055	0.061	58	0.053	0.053	0.061	
Conductivity uS/cm	Min	333	348	306	281	467	392	337	496	505	537	338	989
	Max	684	654	798	749	978	900	1673	916	1498	1311	1239	989
Nitrate mg/l	Min	0.074	0.11	0.11	0.33	0.11	0.11	0.14	2.52	0.51	0.51	0.73	
	Max	1.56	1.23	1.7	1.83	1.29	2.59	4.38	2.87	1.8	2	2.54	
Sulphate mg/l	Min	21.95	15.46	32.3	39.53	82.55	52.25	17.37	110	84	119	21	
	Max	214.37	234.25	192.25	236.81	313.02	212.23	751	319	657	520	486	
Suspended Solids mg/l	Min	2	2	2	2	2	2	2	2	2	2	3	
	Max	18	15	9	16	8	5	11	2	11	9	9	
Temperature oC	Min	0.7	2.9	1.5	4.3	1.9	3.9	2.5	11.4	6.3	5.9	7.8	9.3
	Max	16.7	17.3	18.4	20.2	22.6	17.6	20.7	17.5	19.4	20.1	18.9	9.3

DM01		2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Antimony µg/l	Min						2.9	3	3	3	3	3	3
	Max						3	3	4	3	3	3	3
Arsenic µg/l	Min						0.501	1	1	1	1	1	1
	Max						1	1	1	1	1	1	1
BOD mg/l	Min	2	2	2	2	2					0	0.2	0.9
	Max	2	2	2	2	8					0.7	2.1	0.9
Cadmium µg/l	Min						0.01	1	1	1	1	1	1
	Max						1	1	1	1	1	1	1
Chloride mg/l	Min	18.84	19.73	22.19	20.72	20.09							
	Max	47.25	42.32	33.59	28.42	46.63							
Chromium µg/l	Min						0.58	1	1	1	1	1	1
	Max						1	3	1	1	1	1	1
COD mg/l	Min	5	5	5	5	5					5	5	5
	Max	23	16	18	9	9					5	22	5
Conductivity uS/cm	Min	2329	2267	2335	2113	1926					1994	1930	2036
	Max	2554	2605	2525	2722	2690					2408	2403	2446
Copper µg/l	Min	0.21	0.21	0.243	0.393	0.21	0.535	1	2	2	2	2	2
	Max	5.614	18.02	10	6.427	8.089	1	3	3	2	2	2	2
Dissolved Oxygen mg/l	Min	6.95	8.62	9.38	8.44	8.3					9.85	7.04	8.65
	Max	11.74	11.99	11.46	11.64	10.98					11.21	11.86	10.72
Lead µg/l	Min						0.274	1	1	1	1	1	2
	Max						1	1	1	1	1	1	2
Manganese µg/l	Min	0.96	21.81	25.85	26.4	31.6							
	Max	53.19	74.46	68.95	210.8	141.9							
Mercury µg/l	Min						0.03	0.03	0.03	0.05	0.05	0.05	0.11
	Max						0.03	0.03	0.38	0.05	0.05	0.5	0.11
Mineral Oil mg/l	Min	0.0025	0.0025	0.0025	0.0025	0.0025					0.0025	0.0025	0.0025
	Max	0.0025	0.079	0.15	0.0025	0.0025					0.0025	0.0025	0.0025
Nickel µg/l	Min						5	4	5	2	2	2	14
	Max						7.883	12	6	5	5	14	14
Nitrate mg/l	Min	0.074	0.11	0.14	0.18	0.11					0.51	0.53	0.85
	Max	0.97	3.16	1.05	1.45	2.46					1.3	1.09	0.85
pH	Min	6.46	6.36	7.47	7.33	7.02					7.64	6.82	7.35
	Max	7.59	8.29	8.26	8.08	7.89					7.77	7.67	7.47

Selenium µg/l	**Min**						0.54	1	1	1	1	1	2
	Max						1	1	2	1	1	1	2
Settleable Solids ml/l	**Min**	1	1	1	1	1					1	1	
	Max	1	1	1	1	1					1	1	
Sulphate mg/l	**Min**	721.99	1018.11	899.11	1259.32	11.35					971	923	1282
	Max	1519.96	1715.61	1480.3	1633.27	1568.6					1133	1224	1282
Suspended Solids mg/l	**Min**	8	7	2	12	11					19	5	33
	Max	29	24	47	103	134					52	118	33
Tellurium µg/l	**Min**						5	5	5	5	5	5	5
	Max						5	5	5	5	5	5	5
Temperature ºC	**Min**	9.9	9.5	10.1	10	10.7					13	11.8	12.1
	Max	16.1	15.3	16.8	17.3	16.6					17.9	18	15.8
Thallium µg/l	**Min**						0.05	1	1	1	1	1	1
	Max						1	1	1	1	1	1	1
Tin µg/l	**Min**						2.8	2.8	1	1	1	1	
	Max						2.8	2.8	2	3	1	1	
Total Ammonia mg/l	**Min**	0.01	0.01	0.01	0.01	0.01					0.02	0.01	0.02
	Max	0.428	1.17	0.203	0.132	0.382					0.2	0.04	0.02
Total Heavy Metals µg/l	**Min**						7	9	11	2	2	2	22
	Max						10.695	17	21	8	6	17	22
Total Phosphorous mg/l	**Min**	0.007	0.021	0.021	0.021	0.021					0.05	0.03	0.07
	Max	0.038	0.084	0.04	0.096	0.064					0.06	0.25	0.07

MSE1		**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**
BOD mg/l	**Min**	2	2	2	0.2	2	1.2	0.1	0.9	0.3	0.6	0.9	1.1
	Max	2	2	2	2	9	2	2	2	2	2	2.9	1.1
Chloride mg/l	**Min**	19.3	23.45	12.11	14.86	20.87	21.6	30	65.9	39.7	46.3	51.4	46.3
	Max	88.44	73.8	93.39	79.27	58	114.29	105.2	89.2	125.3	111.4	138.4	36.3
COD mg/l	**Min**	5	5	5	5	5	5	5	5	5	5	5	5
	Max	17	16	27	20	15	20	16	8	22	30	12	5
Conductivity uS/cm	**Min**	2125	1823	1628	1284	1664	1711	1857	2324	972	1853	1569	2022
	Max	2866	2914	2905	3130	2934	3218	2998	3260	2879	2640	2830	14088
Dissolved Oxygen mg/l	**Min**	5.95	7.98	7.68	6.57	6.97	5.81	4.2	7.8	8.15	8.58	5.48	11.05
	Max	13.52	12.83	13.42	12.9	11.98	12.53	19.02	11.22	12.25	12.26	13.62	12.97
Manganese µg/l	**Min**	1.34	22.48	5.874	0.96	0.96	9.6	16	36	27	28	4	28
	Max	33.35	103.3	41.62	35.93	61.82	29.56	282	54	48	49	119	28
Mineral Oil mg/l	**Min**	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025
	Max	0.0025	0.0025	0.02	0.0025	0.0025	2.5	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025
MRP (as P) mg/l	**Min**					0.006	0.006	0.01	0.014	0.01	0.01	0.01	0.01
	Max					0.006	0.01	0.02	0.014	0.014	0.02	0.02	0.01
Nitrate mg/l	**Min**	0.074	0.11	0.31	0.26	0.11	0.11	0.16	0.51	0.51	0.51	0.62	0.71
	Max	8.24	1.19	0.87	1.43	1.72	3.056	2.24	1.77	2.02	1.36	1.8	0.71
pH	**Min**	6.06	6.03	7.02	6.88	6.98	6.34	6.36	7.18	7.64	7.64	7.07	7.18
	Max	8.2	8.56	8.57	8.12	8.13	8.91	8.98	7.97	8.25	8.21	8.05	7.54
Settleable Solids ml/l	**Min**	1	1	1	1	1	1	1	1	1	1	1	1
	Max	1	1	1	1	1	1	1	1	1	1	1	1
Sulphate mg/l	**Min**	685.9	219.87	884.15	697.07	990.34	975.93	1112	1153	954	1040	985	1052

	Max	1571.34	1496.81	1568.18	1521.91	1448.7	1580.6	1761	1317	1372	1280	1383	
Suspended Solids mg/l	**Min**	2	8	3	2	2	2	2	2	2	2	2	5
	Max	36	24	22	50	19	38	19	15	18	19	42	18
Temperature oC	**Min**	2.1	2	1.1	3.9	1.5	3.1	1.9	2.9	5.2	6.4	9.1	6.4
	Max	19.7	18.4	20.9	22.3	22.2	21	22.7	15.7	19.8	24.2	20.5	16.2
Total Ammonia mg/l	**Min**	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.04
	Max	0.087	0.245	0.468	0.159	0.106	0.106	0.19	0.07	0.06	0.04	0.05	0.04
Total Phosphorous mg/l	**Min**	0.007	0.021	0.021	0.021	0.014	0.021	0.021	0.021	0.03	0.03	0.03	0.12
	Max	0.139	0.054	0.056	0.396	0.056	0.09	0.1	0.021	0.06	0.04	0.1	0.12

MSW1		2012	2013	2014	2015	2016	2017	2018	2019	2020
BOD mg/l	**Min**	2	2	2	2	2	2	1.8	1.3	2
	Max	2	3	6	2	12	10	6	2.6	2
Calcium mg/l	**Min**	166	105.3	150.4	128.5	115	1	224	230	153
	Max	262.9	240	344.67	207.72	224.5	180.2	507	371	153
Conductivity µS/cm	**Min**	987	912	815	751	805	862	941	1110	915
	Max	1607	1504	1728	1430	1026	1144	1899	1464	915
pH	**Min**	5.75	6.33	7.06	7.25	7.01	6.66	6.82	6.65	7.03
	Max	7.51	7.35	7.55	7.46	7.58	7.86	7.69	7.01	7.03
Sulphate mg/l	**Min**	368.88	144.68	290.81	268.28	259.73	328.31	306	420	471
	Max	751.61	436.6	648.03	513.32	374.63	538.2	827	617	471
Temperature ºC	**Min**	10.2	5.1	4.6	5.1	6.5	7.5	5.3	9.6	8.2
	Max	15.2	13.6	11.5	15.8	16.6	14.9	12.5	12.7	8.2
Total Nitrogen mg/l	**Min**	1	1	1	1	1	1.13	2.15	1.21	1.2
	Max	1.5	1.79	3.07	4.48	2.24	5.68	7.2	2.45	1.2
Total Phosphorous mg/l	**Min**	0.02	0.026	0.021	0.031	0.021	0.021	0.04	0.031	0.16
	Max	0.106	0.062	0.021	0.045	0.059	0.074	0.081	0.072	0.16

APPENDIX 8.4
Mine Site - Groundwater Hydrochemistry Data

Mine Site - Groundwater Hydrochemistry

Parameter	Units	Reported parameter	Date	S.I. No. 366 of 2016 Groundwater Regulations	EPA Interim Guideline Values (IGV) 2000	Dolerite in Mudstone: Lower MW4-P1-D	Middle MW1-P1	Middle MW5-P1	01JP-D	Lower guideline value (Note 1)	Upper guideline value (Note 2)	Mudstone: Middle 95A1-D	Middle MW3-P2	Upper MW1-P3	Lower guideline value (Note 1)	Upper guideline value (Note 2)
Alkalinity - total	mg/l	$CaCO_3$	06/2020	**No limit**	**No Abnormal change**	138	NR-NEW	132	Broken	**188**	**1000**	NR-NEW	283	51	**304**	[illegible]
Ammoniacal Nitrogen	mg/l	N	06/2020	**0.065 - 0.175**	**0.15**	0.108	NR-NEW	0.0151	Broken			NR-NEW	0.254	0.363		
Calcium - dissolved	mg/l	Ca	06/2020	**No limit**	**200**	107.0	NR-NEW	62.1	Broken	**301**	**574**	NR-NEW	481	11	**405**	**1081**
Chloride	mg/l	Cl	06/2020	**24.0 - 187.5**	**30**	21.6	NR-NEW	18.0	Broken	**21**	**54**	NR-NEW	40	17	**50**	**378**
Electrical conductivity	uS/cm	EC	06/2020	**800 - 1875**	**1000**	894	NR-NEW	486	Broken	**1716**	**3478**	NR-NEW	2637	1352	**2451**	**5483**
Magnesium - dissolved	mg/l	Mg	06/2020	**No limit**	**50**	23.9	NR-NEW	18.0	Broken	**35**	**85**	NR-NEW	74	1	**45**	**167**
Nitrate as N	mg/l	N	06/2020	**8.47**	**25**	<0.0677	NR-NEW	<0.0677	Broken			NR-NEW	<0.0677	<0.0677		
pH	pH units	pH	06/2020	**No limit**	**>6.5 <9.5**	7.74	NR-NEW	7.90	Broken	**8.5**	**13.3**	NR-NEW	7.8	9.5	**9.2**	**13.8**
Potassium	mg/l	K	06/2020	**No limit**	**5**	4.78	NR-NEW	2.23	Broken	**12.0**	**116.0**	NR-NEW	7.92	3.50	**12.0**	**55.0**
Sodium	mg/l	Na	06/2020	**No limit**	**150**	65.2	NR-NEW	12.9	Broken	**83**	**625**	NR-NEW	71.20	9.2	**122**	**693**
Sulphate	mg/l	SO4	06/2020	**187.5**	**200**	110	NR-NEW	36.0	Broken	**962**	**3459**	NR-NEW	507.00	2.8	**1224**	**4288**
Aliphatics >C10-C12	µg/l	TPH	06/2020			<10	NR-NEW	<10	Broken			NR-NEW	<10	<10		
Aliphatics >C12-C16 (aq)	µg/l	TPH	06/2020			<10	NR-NEW	<10	Broken			NR-NEW	<10	<10		
Aliphatics >C16-C21 (aq)	µg/l	TPH	06/2020			<10	NR-NEW	<10	Broken			NR-NEW	<10	<10		
Aliphatics >C21-C35 (aq)	µg/l	TPH	06/2020			<10	NR-NEW	<10	Broken			NR-NEW	2290.00	40.0		
Aliphatics >C5-C6	µg/l	TPH	06/2020			<10	NR-NEW	<10	Broken			NR-NEW	<10	<10		
Aliphatics >C6-C8	µg/l	TPH	06/2020			<10	NR-NEW	<10	Broken			NR-NEW	<10	<10		
Aliphatics >C8-C10	µg/l	TPH	06/2020			<10	NR-NEW	<10	Broken			NR-NEW	<10	<10		
Aromatics >EC10-EC12	µg/l	TPH	06/2020			<10	NR-NEW	<10	Broken			NR-NEW	<10	<10		
Aromatics >EC12-EC16 (aq)	µg/l	TPH	06/2020			<10	NR-NEW	<10	Broken			NR-NEW	<10	<10		
Aromatics >EC16-EC21 (aq)	µg/l	TPH	06/2020			<10	NR-NEW	<10	Broken			NR-NEW	<10	<10		
Aromatics >EC21-EC35 (aq)	µg/l	TPH	06/2020			<10	NR-NEW	<10	Broken			NR-NEW	150.00	<10		
Aromatics >EC5-EC7	µg/l	TPH	06/2020			<10	NR-NEW	<10	Broken			NR-NEW	<10	<10		
Aromatics >EC7-EC8	µg/l	TPH	06/2020			<10	NR-NEW	<10	Broken			NR-NEW	<10	<10		
Aromatics >EC8-EC10	µg/l	TPH	06/2020			<10	NR-NEW	<10	Broken			NR-NEW	<10	<10		
Benzene	µg/l	TPH	06/2020	**0.75**	**1**	<7	NR-NEW	<7	Broken			NR-NEW	<7	<7		
Ethylbenzene	µg/l	TPH	06/2020		**10**	<5	NR-NEW	<5	Broken			NR-NEW	<5	<5		
GRO >C5-C12	µg/l	TPH	06/2020			<50	NR-NEW	<50	Broken			NR-NEW	<50	<50		
GRO Surrogate % recovery**	%	TPH	06/2020			115	NR-NEW	117	Broken			NR-NEW	118.00	99.0		
m,p-Xylene	µg/l	TPH	06/2020		**10**	<8	NR-NEW	<8	Broken			NR-NEW	<8	<8		
Methyl tertiary butyl ether (MTBE)	µg/l	TPH	06/2020	**10**	**30**	<3	NR-NEW	<3	Broken			NR-NEW	<3	<3		
o-Xylene	µg/l	TPH	06/2020		**10**	<3	NR-NEW	<3	Broken			NR-NEW	<3	<3		
Sum of detected BTEX	µg/l	TPH	06/2020			<28	NR-NEW	<28	Broken			NR-NEW	<28	<28		
Sum of detected Xylenes	µg/l	TPH	06/2020			<11	NR-NEW	<11	Broken			NR-NEW	<11	<11		
Toluene	µg/l	TPH	06/2020	**525**	**10**	<4	NR-NEW	<4	Broken			NR-NEW	<4	<4		
Total Aliphatics & Aromatics >C5-35 (aq	µg/l	TPH	06/2020	**7.5**		<10	NR-NEW	<10	Broken			NR-NEW	2440	41		
Total Aliphatics >C12-C35 (aq)	µg/l	TPH	06/2020			<10	NR-NEW	<10	Broken			NR-NEW	2290	40		
Total Aromatics >EC12-EC35 (aq)	µg/l	TPH	06/2020			<10	NR-NEW	<10	Broken			NR-NEW	150	<10		
Aliphatics >C16-C35 Aqueous	µg/l	TPH	06/2020			<10	NR-NEW	<10	Broken			NR-NEW	2290	40		

	Higher than lower guideline value (average value):
Note 1	**For each parameter in each geological unit the average value recorded is equal to the lower guideline value as per section 3.1.3 of Minerex Report 1632-863 (Final)**
	Higher than upper guideline value (Upper value):
Note 2	**For each parameter in each geological unit the upper value recorded is equal to the upper guideline value as per section 3.1.3 of Minerex Report 1632-863 (Final)**
	Higher than IGV where no lower or upper guideline values has been given - Ammoniacal Nitrogen and Nitrate Only
NR-D (No Result-Dry)	No result available because borehole was dry or practically dry
NR-NEW (No Result-Not Enough Water)	No result available for this parameter because there was not enough of water available from the borehole
NR-NS (No Result - Not scheduled)	No results available as it was not scheduled for analysis in error

Minerex Environmental

Mine Site - Groundwater Hydrochemistry						Dolerite in Mudstone						Mudstone				
Parameter	Units	Reported parameter	Date	S.I. No. 366 of 2016 Groundwater Regulations	EPA Interim Guideline Values (IGV) 2000	MW4-P1-D Lower	MW1-P1 Middle	MW5-P1 Middle	01JP-D	Lower guideline value (Note 1)	Upper guideline value (Note 2)	95A1-D Middle	MW3-P2 Middle	MW1-P3 Upper	Lower guideline value (Note 1)	Upper guideline value (Note 2)
Alkalinity - total	mg/l	$CaCO_3$	12/2020	No limit	change	137	NR-NEW	133	Broken	188	1000	NR-NEW	184	60	304	1190
Ammoniacal Nitrogen	mg/l	N	12/2020	0.065 - 0.175	0.15	0.0650	NR-NEW	<0.01	Broken			NR-NEW	0.295	0.038		
Calcium - dissolved	mg/l	Ca	12/2020		200	105	NR-NEW	62	Broken	301	574	NR-NEW	589	531	405	1081
Chloride	mg/l	Cl	12/2020	24.0 - 187.5	30	21.9	NR-NEW	19	Broken	21	54	NR-NEW	43	27	50	378
Electrical conductivity	uS/cm	EC	12/2020	800 - 1875	1000	955	NR-NEW	528	Broken	1716	3478	NR-NEW	2917	2814	2451	5483
Magnesium - dissolved	mg/l	Mg	12/2020		50	22	NR-NEW	17.5	Broken	35	85	NR-NEW	87	110	45	167
Nitrate as N	mg/l	N	12/2020	8.47	25	<0.0677	NR-NEW	<0.0677	Broken			NR-NEW	<0.0677	<0.0677		
pH	pH units	pH	12/2020		>6.5 <9.5	7.76	NR-NEW	7.85	Broken	8.5	13.3	NR-NEW	7	8	9.2	13.8
Potassium	mg/l	K	12/2020		5	4.35	NR-NEW	2.06	Broken	12.0	116.0	NR-NEW	12	6	12.0	55.0
Sodium	mg/l	Na	12/2020		150	61.8	NR-NEW	12.6	Broken	83	625	NR-NEW	80	96	122	693
Sulphate	mg/l	SO4	12/2020	187.5	200	317	NR-NEW	107	Broken	962	3459	NR-NEW	1610	1560	1224	4288
Aliphatics >C10-C12	µg/l	TPH	12/2020			<10	NR-NEW	<10	Broken			NR-NEW	<10	<10		
Aliphatics >C12-C16 (aq)	µg/l	TPH	12/2020			<10	NR-NEW	<10	Broken			NR-NEW	<40	<10		
Aliphatics >C16-C21 (aq)	µg/l	TPH	12/2020			<10	NR-NEW	<10	Broken			NR-NEW	<40	<10		
Aliphatics >C21-C35 (aq)	µg/l	TPH	12/2020			<10	NR-NEW	<10	Broken			NR-NEW	107	43		
Aliphatics >C5-C6	µg/l	TPH	12/2020			<10	NR-NEW	<10	Broken			NR-NEW	<10	<10		
Aliphatics >C6-C8	µg/l	TPH	12/2020			<10	NR-NEW	<10	Broken			NR-NEW	<10	<10		
Aliphatics >C8-C10	µg/l	TPH	12/2020			<10	NR-NEW	<10	Broken			NR-NEW	<10	<10		
Aromatics >EC10-EC12	µg/l	TPH	12/2020			<10	NR-NEW	<10	Broken			NR-NEW	<10	<10		
Aromatics >EC12-EC16 (aq)	µg/l	TPH	12/2020			<10	NR-NEW	<10	Broken			NR-NEW	<40	<10		
Aromatics >EC16-EC21 (aq)	µg/l	TPH	12/2020			<10	NR-NEW	<10	Broken			NR-NEW	<40	<10		
Aromatics >EC21-EC35 (aq)	µg/l	TPH	12/2020			<10	NR-NEW	<10	Broken			NR-NEW	<40	<10		
Aromatics >EC5-EC7	µg/l	TPH	12/2020			<10	NR-NEW	<10	Broken			NR-NEW	<10	<10		
Aromatics >EC7-EC8	µg/l	TPH	12/2020			<10	NR-NEW	<10	Broken			NR-NEW	<10	<10		
Aromatics >EC8-EC10	µg/l	TPH	12/2020			<10	NR-NEW	<10	Broken			NR-NEW	<10	<10		
Benzene	µg/l	TPH	12/2020	0.75	1	<7	NR-NEW	<7	Broken			NR-NEW	<7	<7		
Ethylbenzene	µg/l	TPH	12/2020		10	<5	NR-NEW	<5	Broken			NR-NEW	<5	<5		
GRO >C5-C12	µg/l	TPH	12/2020			<50	NR-NEW	<50	Broken			NR-NEW	<50	<50		
GRO Surrogate % recovery**	%	TPH	12/2020			120	NR-NEW	118	Broken			NR-NEW	117	117		
m,p-Xylene	µg/l	TPH	12/2020		10	<8	NR-NEW	<8	Broken			NR-NEW	<8	<8		
Methyl tertiary butyl ether (MTBE)	µg/l	TPH	12/2020	10	30	<3	NR-NEW	<3	Broken			NR-NEW	<3	<3		
o-Xylene	µg/l	TPH	12/2020		10	<3	NR-NEW	<3	Broken			NR-NEW	<3	<3		
Sum of detected BTEX	µg/l	TPH	12/2020			<28	NR-NEW	<28	Broken			NR-NEW	<28	<28		
Sum of detected Xylenes	µg/l	TPH	12/2020			<11	NR-NEW	<11	Broken			NR-NEW	<11	<11		
Toluene	µg/l	TPH	12/2020	525	10	<4	NR-NEW	<4	Broken			NR-NEW	<4	<4		
Total Aliphatics & Aromatics >C5-35 (aq	µg/l	TPH	12/2020	7.5		<10	NR-NEW	<10	Broken			NR-NEW	115	52		
Total Aliphatics >C12-C35 (aq)	µg/l	TPH	12/2020			<10	NR-NEW	<10	Broken			NR-NEW	107	43		
Total Aromatics >EC12-EC35 (aq)	µg/l	TPH	12/2020			<10	NR-NEW	<10	Broken			NR-NEW	<40	<10		
Aliphatics >C16-C35 Aqueous	µg/l	TPH	12/2020			<10	NR-NEW	<10	Broken			NR-NEW	107	43		

	Higher than lower guideline value (average value):
Note 1	**For each parameter in each geological unit the average value recorded is equal to the lower guideline value as per section 3.1.3 of Minerex Report 1632-863 (Final)**
	Higher than upper guideline value (Upper value):
Note 2	**For each parameter in each geological unit the upper value recorded is equal to the upper guideline value as per section 3.1.3 of Minerex Report 1632-863 (Final)**
	Higher than IGV where no lower or upper guideline values has been given - Ammoniacal Nitrogen and Nitrate Only
NR-D (No Result-Dry)	No result available because borehole was dry or practically dry
NR-NEW (No Result-Not Enough Water)	No result available for this parameter because there was not enough of water available from the borehole
NR-NS (No Result - Not scheduled)	No results available as it was not scheduled for analysis in error

Mine Site - Groundwater Hydrochemistry — Parameter	Units	Reported parameter	Date	S.I. No. 366 of 2016 Groundwater Regulations	EPA Interim Guideline Values (IGV) 2000	Overburden: MW2-P1	Overburden: 95A1-S	Overburden: MW5-P2	Overburden: Lower guideline value (Note 1)	Overburden: Upper guideline value (Note 2)	Upper Gypsum: 01JP-S	Upper Gypsum: Lower guideline value (Note 1)	Upper Gypsum: Upper guideline value (Note 2)	Namurian/ Westphalian: MW6-P1	Namurian/ Westphalian: MW3-P1	Namurian/ Westphalian: Lower guideline value (Note 1)	Namurian/ Westphalian: Upper guideline value (Note 2)
Alkalinity - total	mg/l	$CaCO_3$	06/2020	**No limit**	**No Abnormal change**	500	NR-D	218	**214**	**466**	88	**666**	**3000**	172	92	**16[illegible]**	**538**
Ammoniacal Nitrogen	mg/l	N	06/2020	**0.065 - 0.175**	**0.15**	0.149	NR-D	0.0203			0.0455			0.0743	0.115		
Calcium - dissolved	mg/l	Ca	06/2020	**No limit**	**200**	251	NR-D	61.2	**212**	**529**	88	**673**	**1252**	88.9	479	**351**	**864**
Chloride	mg/l	Cl	06/2020	**24.0 - 187.5**	**30**	59.1	NR-D	8.7	**22**	**53**	4.6	**25**	**70**	15.9	26.1	**26**	**164**
Electrical conductivity	uS/cm	EC	06/2020	**800 - 1875**	**1000**	1550	NR-D	462	**1299**	**2231**	442	**3748**	**11638**	640	2630	**1562**	**3186**
Magnesium - dissolved	mg/l	Mg	06/2020	**No limit**	**50**	43.9	NR-D	16.7	**50**	**100**	1.13	**52**	**148**	22.8	68.8	**57**	**284**
Nitrate as N	mg/l	N	06/2020	**8.47**	**25**	<0.0677	NR-D	<0.0677			0.568			<0.0677	<0.0677		
pH	pH units	pH	06/2020	**No limit**	**>6.5 <9.5**	6.51	NR-D	7.8	**7**	**12.8**	10.66	**9**	**13.8**	7.72	7.42	**7**	**8**
Potassium	mg/l	K	06/2020	**No limit**	**5**	1.42	NR-D	1.51	**4.3**	**9.0**	2.72	**32.0**	**162.0**	3.65	6.07	**9.0**	**69.0**
Sodium	mg/l	Na	06/2020	**No limit**	**150**	27.9	NR-D	17.7	**50**	**96**	6	**122**	**296**	23.3	65.7	**57**	**168**
Sulphate	mg/l	SO4	06/2020	**187.5**	**200**	90	NR-D	7.3	**504**	**1775**	57	**1164**	**3197**	54.3	510.00	**1018**	**2533**
Aliphatics >C10-C12	µg/l	TPH	06/2020			<10	NR-D	<10			<10			<10	<10		
Aliphatics >C12-C16 (aq)	µg/l	TPH	06/2020			<10	NR-D	<10			<10			<10	<10		
Aliphatics >C16-C21 (aq)	µg/l	TPH	06/2020			<10	NR-D	<10			<10			<10	<10		
Aliphatics >C21-C35 (aq)	µg/l	TPH	06/2020			<10	NR-D	<10			<10			<10	198.00		
Aliphatics >C5-C6	µg/l	TPH	06/2020			<10	NR-D	<10			<10			<10	<10		
Aliphatics >C6-C8	µg/l	TPH	06/2020			<10	NR-D	<10			<10			<10	<10		
Aliphatics >C8-C10	µg/l	TPH	06/2020			<10	NR-D	<10			<10			<10	<10		
Aromatics >EC10-EC12	µg/l	TPH	06/2020			<10	NR-D	<10			<10			<10	<10		
Aromatics >EC12-EC16 (aq)	µg/l	TPH	06/2020			<10	NR-D	<10			<10			<10	<10		
Aromatics >EC16-EC21 (aq)	µg/l	TPH	06/2020			<10	NR-D	<10			<10			<10	<10		
Aromatics >EC21-EC35 (aq)	µg/l	TPH	06/2020			<10	NR-D	<10			<10			<10	<10		
Aromatics >EC5-EC7	µg/l	TPH	06/2020			<10	NR-D	<10			<10			<10	<10		
Aromatics >EC7-EC8	µg/l	TPH	06/2020			<10	NR-D	<10			<10			<10	<10		
Aromatics >EC8-EC10	µg/l	TPH	06/2020			<10	NR-D	<10			<10			<10	<10		
Benzene	µg/l	TPH	06/2020	0.75	**1**	<7	NR-D	<7			<7			<7	<7		
Ethylbenzene	µg/l	TPH	06/2020		**10**	<5	NR-D	<5			<5			<5	<5		
GRO >C5-C12	µg/l	TPH	06/2020			<50	NR-D	<50			<50			<50	<50		
GRO Surrogate % recovery**	%	TPH	06/2020			96	NR-D	121			118			116	117.00		
m,p-Xylene	µg/l	TPH	06/2020		**10**	<8	NR-D	<8			<8			<8	<8		
Methyl tertiary butyl ether (MTBE)	µg/l	TPH	06/2020	10	**30**	<3	NR-D	<3			<3			<3	<3		
o-Xylene	µg/l	TPH	06/2020		**10**	<3	NR-D	<3			<3			<3	<3		
Sum of detected BTEX	µg/l	TPH	06/2020			<28	NR-D	<28			<28			<28	<28		
Sum of detected Xylenes	µg/l	TPH	06/2020			<11	NR-D	<11			<11			<11	<11		
Toluene	µg/l	TPH	06/2020	525	**10**	<4	NR-D	<4			<4			<4	<4		
Total Aliphatics & Aromatics >C5-35 (aq)	µg/l	TPH	06/2020	7.5		<10	NR-D	<10			<10			<10	198		
Total Aliphatics >C12-C35 (aq)	µg/l	TPH	06/2020			<10	NR-D	<10			<10			<10	198		
Total Aromatics >EC12-EC35 (aq)	µg/l	TPH	06/2020			<10	NR-D	<10			<10			<10	<10		
Aliphatics >C16-C35 Aqueous	µg/l	TPH	06/2020			<10	NR-D	<10			<10			<10	198		

	Higher than lower guideline value (average value):
Note 1	**For each parameter in each geological unit the average value recorded is equal to the lower guideline value as per section 3.1.3 of Minerex Report 1632-863 (Final)**
	Higher than upper guideline value (Upper value):
Note 2	**For each parameter in each geological unit the upper value recorded is equal to the upper guideline value as per section 3.1.3 of Minerex Report 1632-863 (Final)**
	Higher than IGV where no lower or upper guideline values has been given - Ammoniacal Nitrogen and Nitrate Only
NR-D (No Result-Dry)	No result available because borehole was dry or practically dry
NR-NEW (No Result-Not Enough Water)	No result available for this parameter because there was not enough of water available from the borehole
NR-NS (No Result - Not scheduled)	No results available as it was not scheduled for analysis in error

Mine Site - Groundwater Hydrochemistry						Overburden					Upper Gypsum			Namurian/ Westphalian			
Parameter	Units	Reported parameter	Date	S.I. No. 366 of 2016 Groundwater Regulations	EPA Interim Guideline Values (IGV) 2000	MW2-P1	95A1-S	MW5-P2	Lower guideline value (Note 1)	Upper guideline value (Note 2)	01JP-S	Lower guideline value (Note 1)	Upper guideline value (Note 2)	MW6-P1	MW3-P1	Lower guideline value (Note 1)	Upper guideline value (Note 2)
Alkalinity - total	mg/l	$CaCO_3$	12/2020	No limit	change	456	NR-D	177	214	466	189	666	3000	173	92.50	108	538
Ammoniacal Nitrogen	mg/l	N	12/2020	0.065 - 0.175	0.15	0.067	NR-D	<0.01			0.031			0.039	0.07		
Calcium - dissolved	mg/l	Ca	12/2020		200	379	NR-D	48.1	212	529	139	673	1252	87.3	562	351	864
Chloride	mg/l	Cl	12/2020	24.0 - 187.5	30	75.2	NR-D	7.6	22	53	13.0	25	70	16.6	29	26	164
Electrical conductivity	uS/cm	EC	12/2020	800 - 1875	1000	1913	NR-D	420	1299	2231	1044	3748	11638	693	2492	1562	3186
Magnesium - dissolved	mg/l	Mg	12/2020		50	56.4	NR-D	12.4	50	100	0.421	52	148	21.2	66.20	57	284
Nitrate as N	mg/l	N	12/2020	8.47	25	<0.0677	NR-D	<0.0677			0.372			<0.0677	<0.0677		
pH	pH units	pH	12/2020		>6.5 <9.5	6.50	NR-D	7.7	7	12.8	11.88	9	13.8	7.7	7.4	7	8
Potassium	mg/l	K	12/2020		5	1.39	NR-D	1.22	4.3	9.0	6.0	32.0	162.0	3.25	5.48	9.0	69.0
Sodium	mg/l	Na	12/2020		150	35.2	NR-D	15.7	50	96	15	122	296	21.2	62.7	57	168
Sulphate	mg/l	SO4	12/2020	187.5	200	596	NR-D	23.1	504	1775	235	1164	3197	163.0	1490	1018	2533
Aliphatics >C10-C12	µg/l	TPH	12/2020			<10	NR-D	<10			<10			<10	<10		
Aliphatics >C12-C16 (aq)	µg/l	TPH	12/2020			<10	NR-D	<10			<10			<10	<10		
Aliphatics >C16-C21 (aq)	µg/l	TPH	12/2020			<10	NR-D	<10			20			<10	<10		
Aliphatics >C21-C35 (aq)	µg/l	TPH	12/2020			<10	NR-D	<10			308			10	205		
Aliphatics >C5-C6	µg/l	TPH	12/2020			<10	NR-D	<10			<10			<10	<10		
Aliphatics >C6-C8	µg/l	TPH	12/2020			<10	NR-D	<10			<10			<10	<10		
Aliphatics >C8-C10	µg/l	TPH	12/2020			<10	NR-D	<10			<10			<10	<10		
Aromatics >EC10-EC12	µg/l	TPH	12/2020			<10	NR-D	<10			<10			<10	<10		
Aromatics >EC12-EC16 (aq)	µg/l	TPH	12/2020			<10	NR-D	<10			<10			<10	<10		
Aromatics >EC16-EC21 (aq)	µg/l	TPH	12/2020			<10	NR-D	<10			<10			<10	<10		
Aromatics >EC21-EC35 (aq)	µg/l	TPH	12/2020			<10	NR-D	<10			29			<10	<10		
Aromatics >EC5-EC7	µg/l	TPH	12/2020			<10	NR-D	<10			<10			<10	<10		
Aromatics >EC7-EC8	µg/l	TPH	12/2020			<10	NR-D	<10			<10			<10	<10		
Aromatics >EC8-EC10	µg/l	TPH	12/2020			<10	NR-D	<10			<10			<10	<10		
Benzene	µg/l	TPH	12/2020	0.75	1	<7	NR-D	<7			<7			<7	<7		
Ethylbenzene	µg/l	TPH	12/2020		10	<5	NR-D	<5			<5			<5	<5		
GRO >C5-C12	µg/l	TPH	12/2020			<50	NR-D	<50			<50			<50	<50		
GRO Surrogate % recovery**	%	TPH	12/2020			113	NR-D	123			122			120	122		
m,p-Xylene	µg/l	TPH	12/2020		10	<8	NR-D	<8			<8			<8	<8		
Methyl tertiary butyl ether (MTBE)	µg/l	TPH	12/2020	10	30	<3	NR-D	<3			<3			<3	<3		
o-Xylene	µg/l	TPH	12/2020		10	<3	NR-D	<3			<3			<3	<3		
Sum of detected BTEX	µg/l	TPH	12/2020			<28	NR-D	<28			<28			<28	<28		
Sum of detected Xylenes	µg/l	TPH	12/2020			<11	NR-D	<11			<11			<11	<11		
Toluene	µg/l	TPH	12/2020	525	10	<4	NR-D	<4			<4			<4	<4		
Total Aliphatics & Aromatics >C5-35 (aq)	µg/l	TPH	12/2020	7.5		<10	NR-D	<10			366			12	209		
Total Aliphatics >C12-C35 (aq)	µg/l	TPH	12/2020			<10	NR-D	<10			328			10	205		
Total Aromatics >EC12-EC35 (aq)	µg/l	TPH	12/2020			<10	NR-D	<10			29			<10	<10		
Aliphatics >C16-C35 Aqueous	µg/l	TPH	12/2020			<10	NR-D	<10			328			10	205		

	Higher than lower guideline value (average value):
Note 1	**For each parameter in each geological unit the average value recorded is equal to the lower guideline value as per section 3.1.3 of Minerex Report 1632-863 (Final)**
	Higher than upper guideline value (Upper value):
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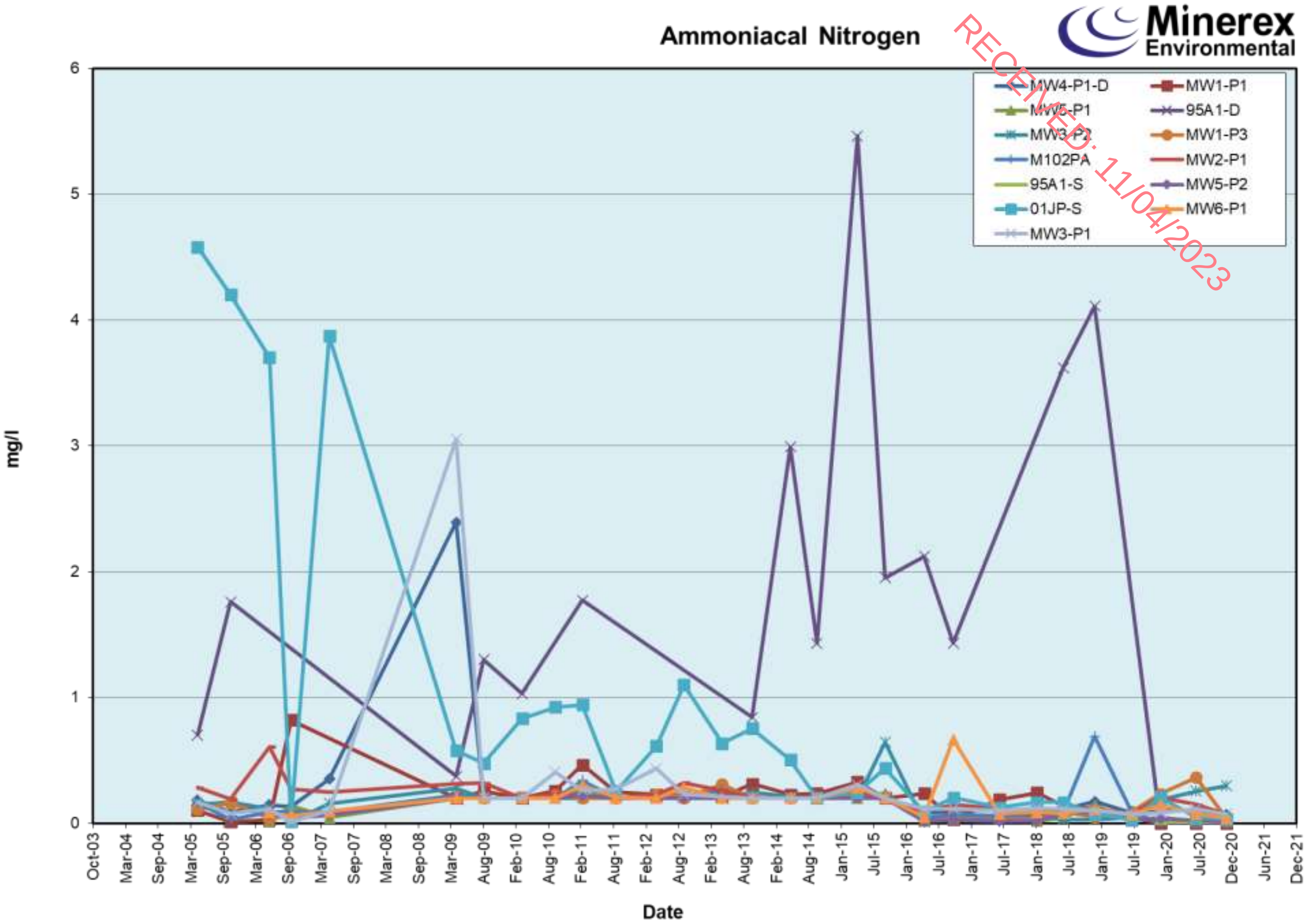
NR-D (No Result-Dry)	No result available because borehole was dry or practically dry
NR-NEW (No Result-Not Enough Water)	No result available for this parameter because there was not enough of water available from the borehole
NR-NS (No Result - Not scheduled)	No results available as it was not scheduled for analysis in error


Ammoniacal Nitrogen
Minerex Environmental
RECEIVED: 11/04/2023
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MW5-P1
95A1-D
MW3-P2
MW1-P3
M102PA
MW2-P1
95A1-S
MW5-P2
01JP-S
MW6-P1
MW3-P1
mg/l
0
1
2
3
4
5
6
Oct-03
Mar-04
Sep-04
Mar-05
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Mar-06
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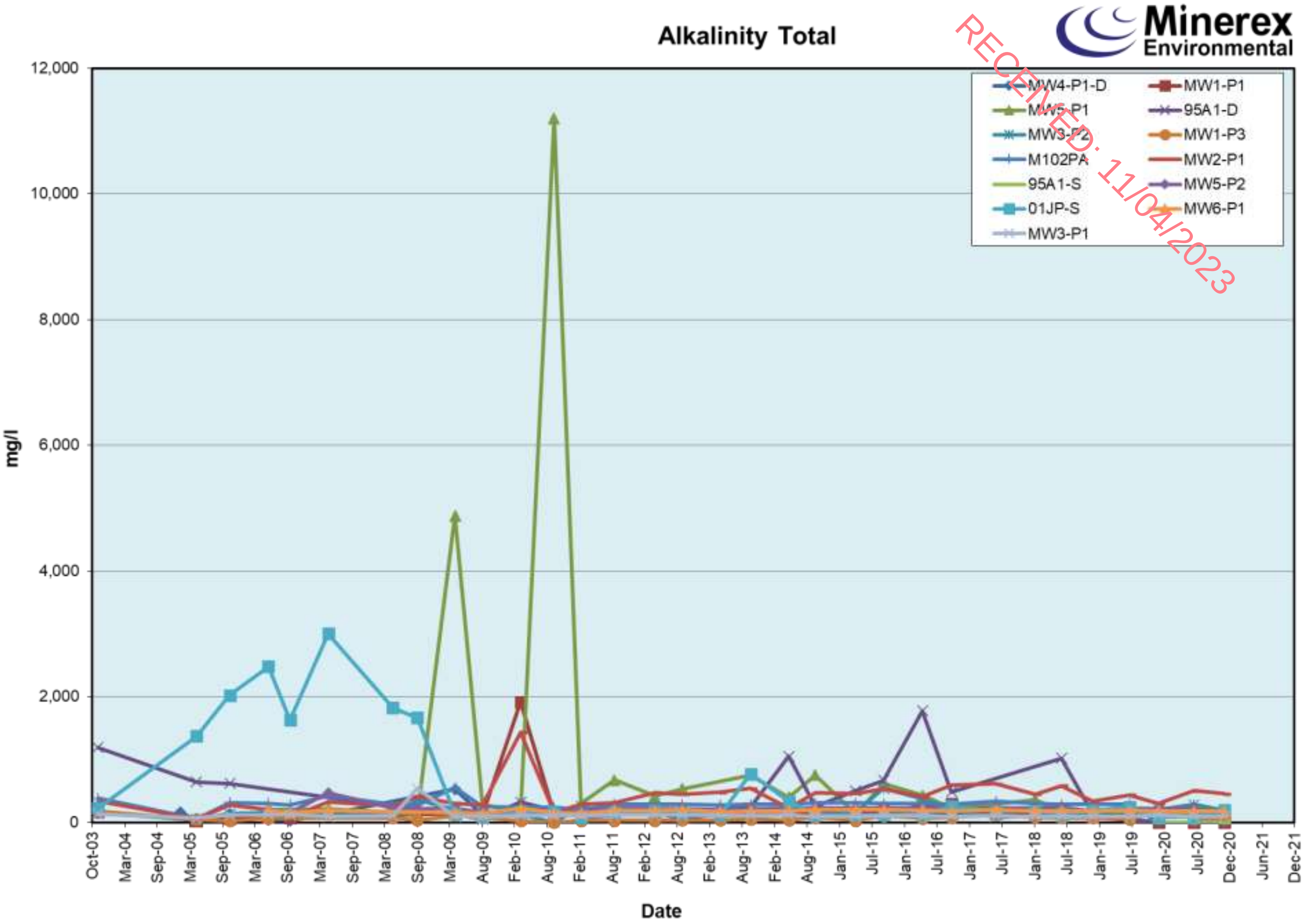
Jun-21
Dec-21
Date


Alkalinity Total
Minerex Environmental
RECEIVED: 11/04/2023
MW4-P1-D
MW1-P1
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95A1-D
MW3-P2
MW1-P3
M102PA
MW2-P1
95A1-S
MW5-P2
01JP-S
MW6-P1
MW3-P1
mg/l
12,000
10,000
8,000
6,000
4,000
2,000
0
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Mar-04
Sep-04
Mar-05
Sep-05
Mar-06
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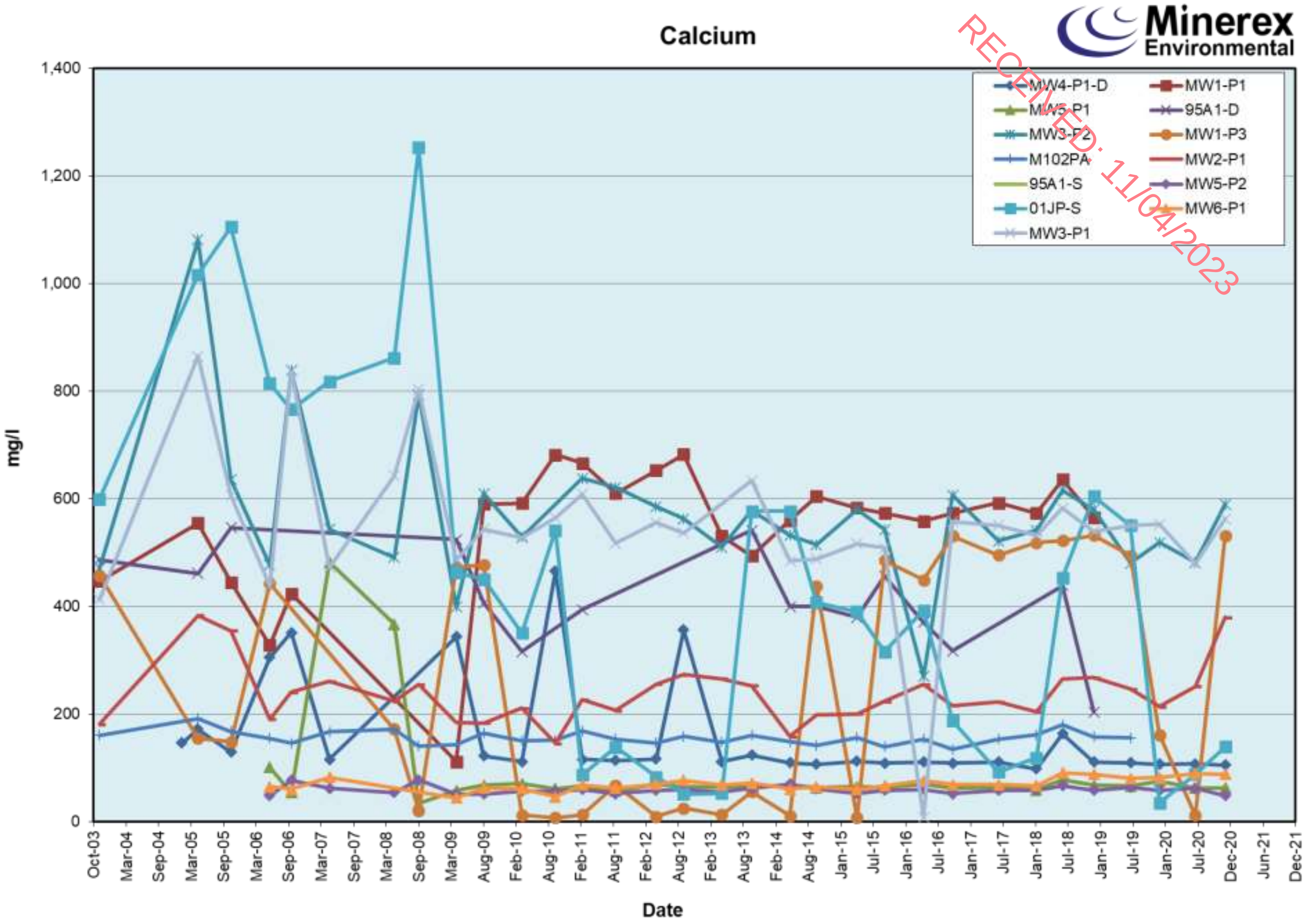
Date


Minerex Environmental
Calcium
RECEIVED: 11/04/2023
MW4-P1-D
MW1-P1
MW5-P1
95A1-D
MW3-P2
MW1-P3
M102PA
MW2-P1
95A1-S
MW5-P2
01JP-S
MW6-P1
MW3-P1
mg/l
1,400
1,200
1,000
800
600
400
200
0
Oct-03
Mar-04
Sep-04
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Sep-05
Mar-06
Sep-06
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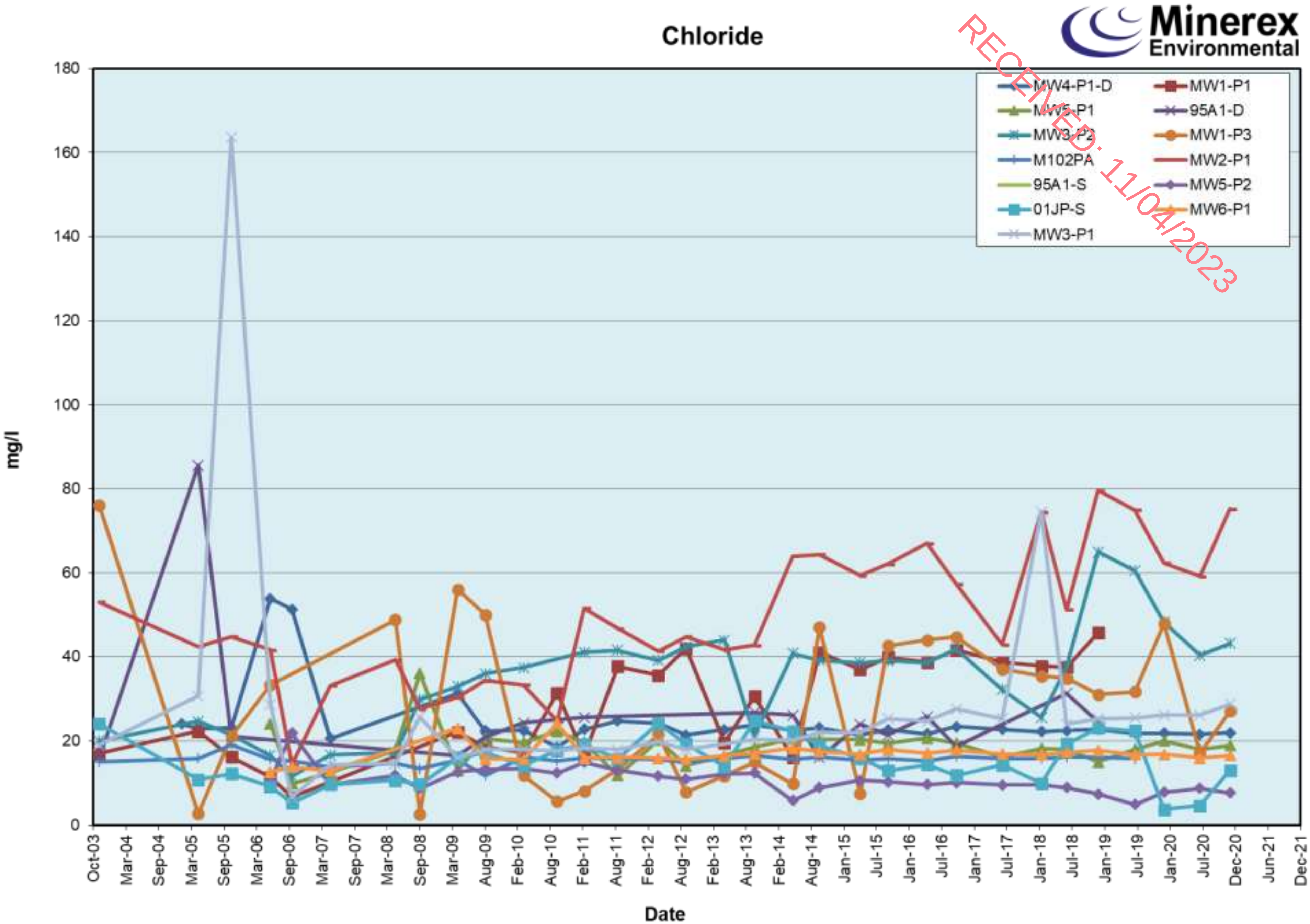

Minerex Environmental
Chloride
RECEIVED: 11/04/2023
MW4-P1-D
MW1-P1
MW5-P1
95A1-D
MW3-P2
MW1-P3
M102PA
MW2-P1
95A1-S
MW5-P2
01JP-S
MW6-P1
MW3-P1
mg/l
0
20
40
60
80
100
120
140
160
180
Oct-03
Mar-04
Sep-04
Mar-05
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Sep-07
Mar-08
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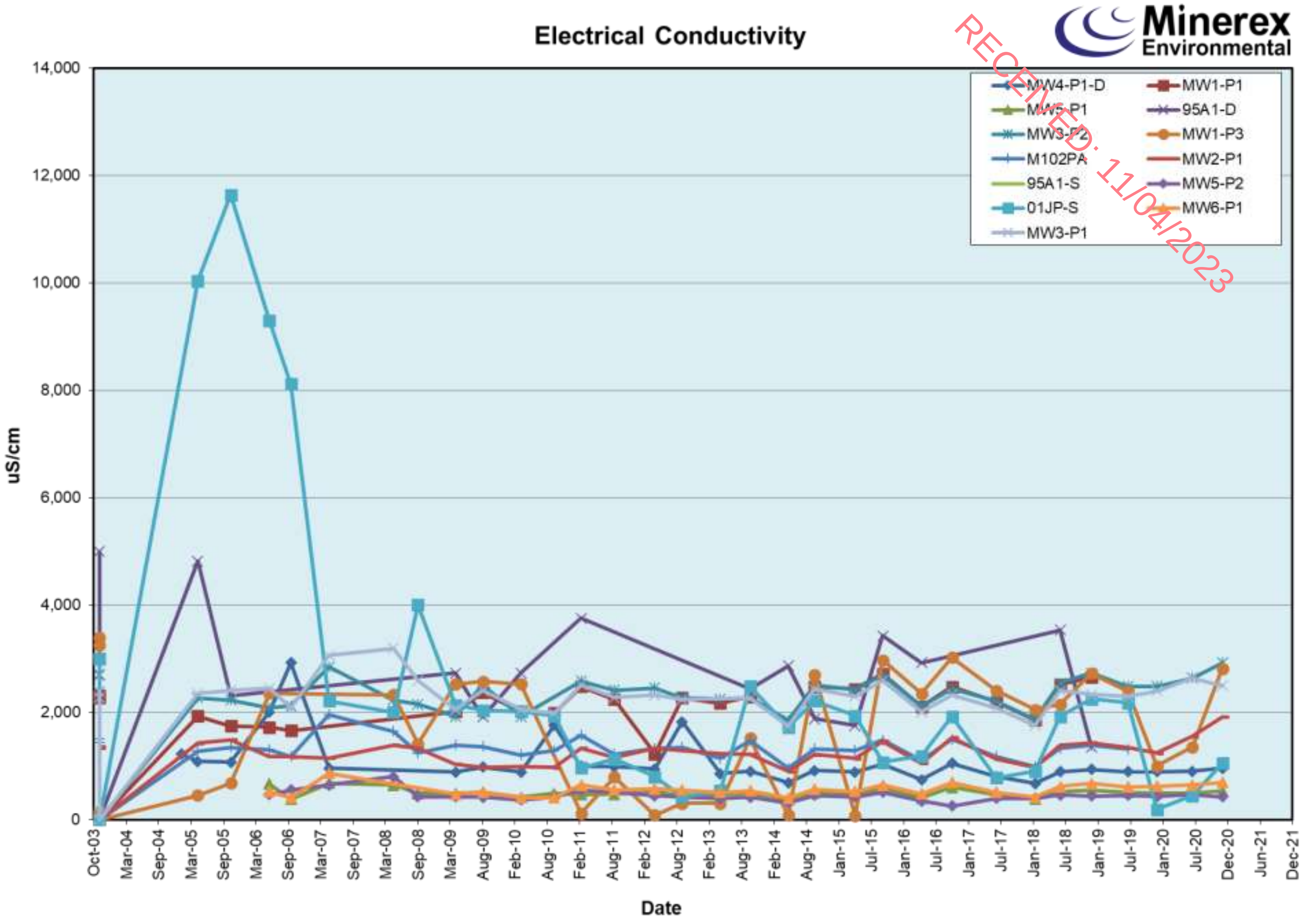
Dec-20
Jun-21
Dec-21
Date


Electrical Conductivity
Minerex Environmental
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
uS/cm
MW4-P1-D
MW1-P1
MW5-P1
95A1-D
MW3-P2
MW1-P3
M102PA
MW2-P1
95A1-S
MW5-P2
01JP-S
MW6-P1
MW3-P1
Oct-03
Mar-04
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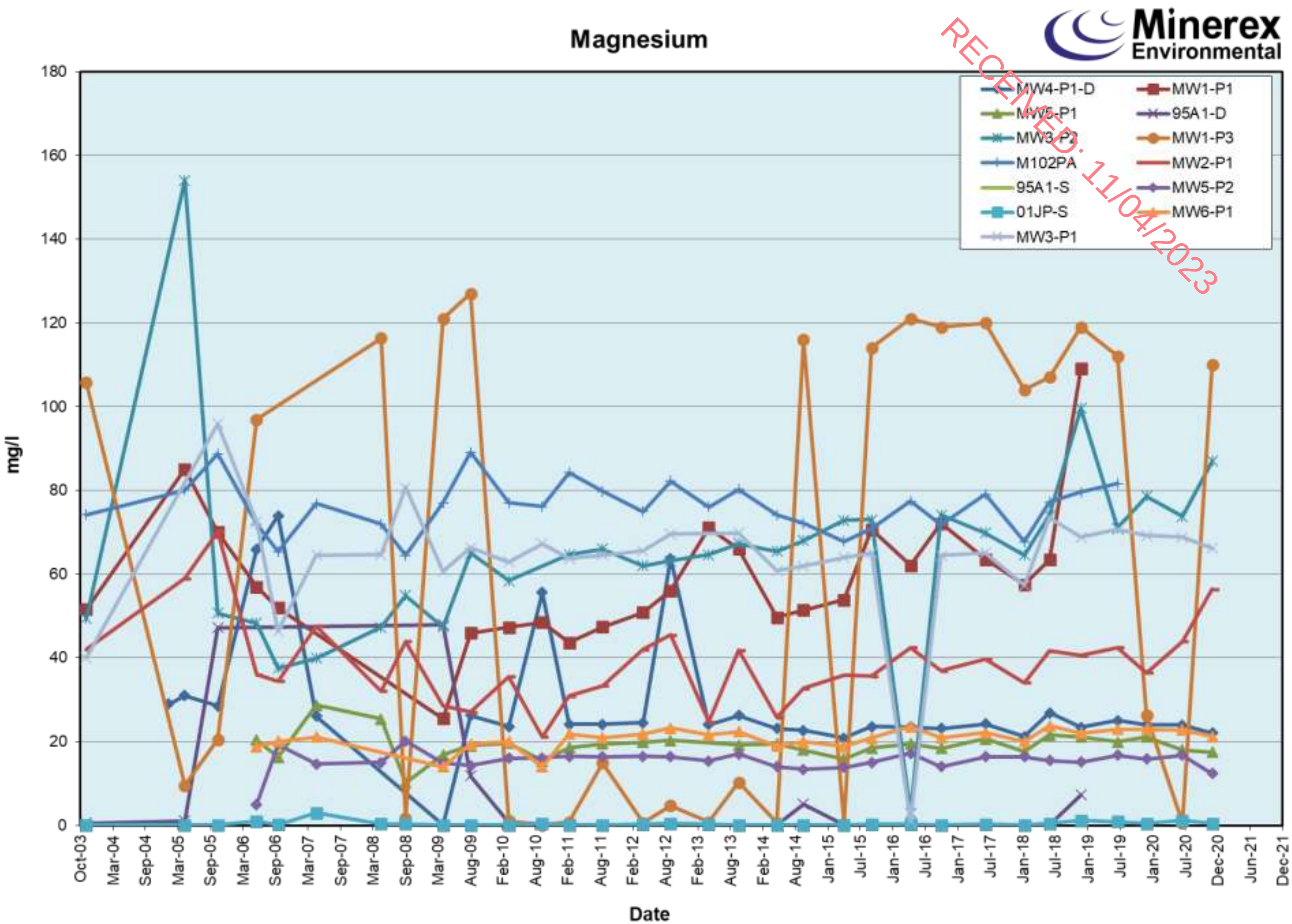
Date
RECEIVED: 11/04/2023


Magnesium
Minerex Environmental
RECEIVED: 11/04/2023
MW4-P1-D
MW1-P1
MW6-P1
95A1-D
MW3-P2
MW1-P3
M102PA
MW2-P1
95A1-S
MW5-P2
01JP-S
MW6-P1
MW3-P1
mg/l
180
160
140
120
100
80
60
40
20
0
Oct-03
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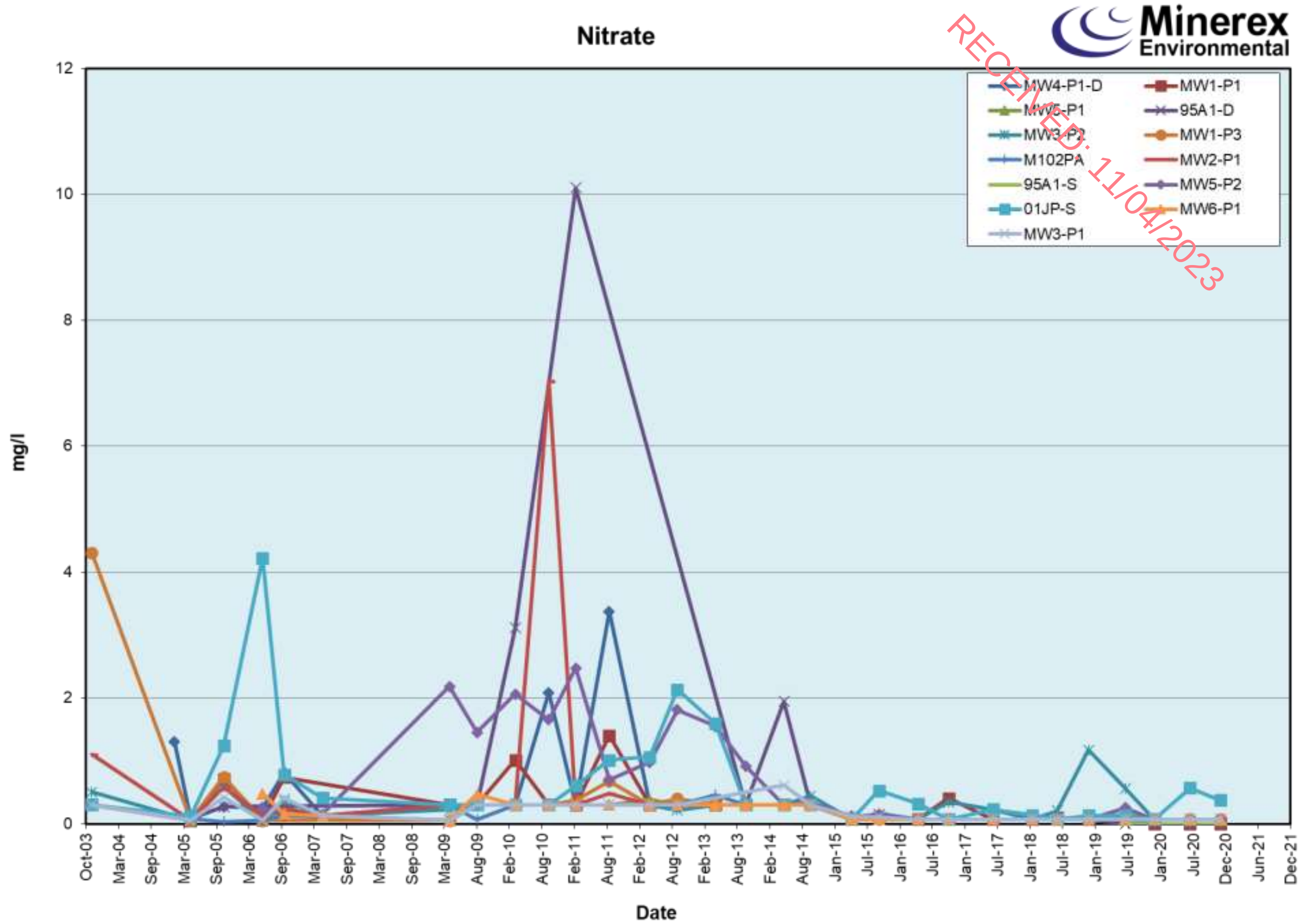
Date



Minerex
Environmental
Nitrate
RECEIVED: 11/04/2023
mg/l
0
2
4
6
8
10
12
MW4-P1-D
MW1-P1
MW5-P1
95A1-D
MW3-P2
MW1-P3
M102PA
MW2-P1
95A1-S
MW5-P2
01JP-S
MW6-P1
MW3-P1
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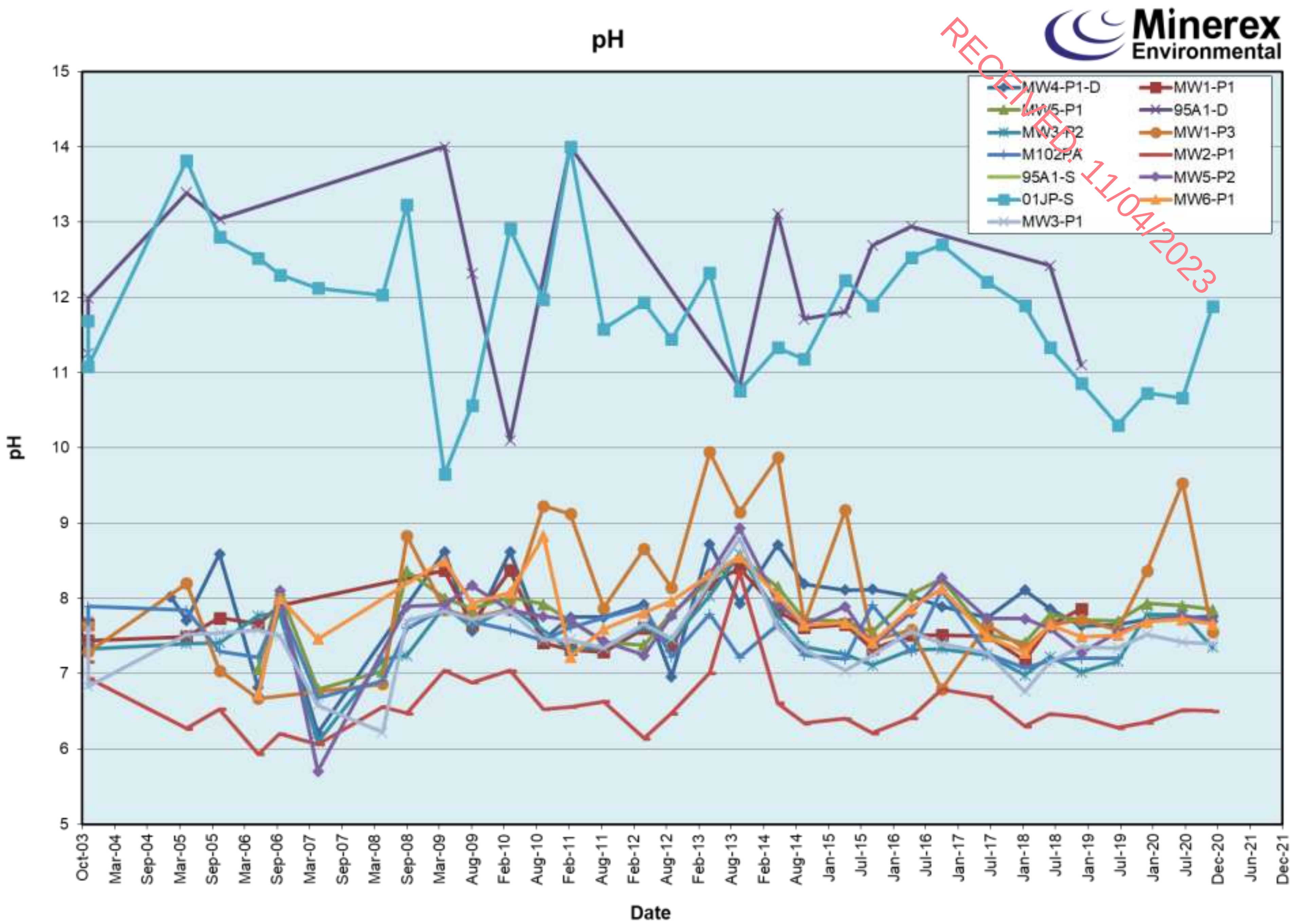
Date



Minerex Environmental
pH
15
14
13
12
11
10
9
8
7
6
5
pH
MW4-P1-D
MW1-P1
MW5-P1
95A1-D
MW3-P2
MW1-P3
M102PA
MW2-P1
95A1-S
MW5-P2
01JP-S
MW6-P1
MW3-P1
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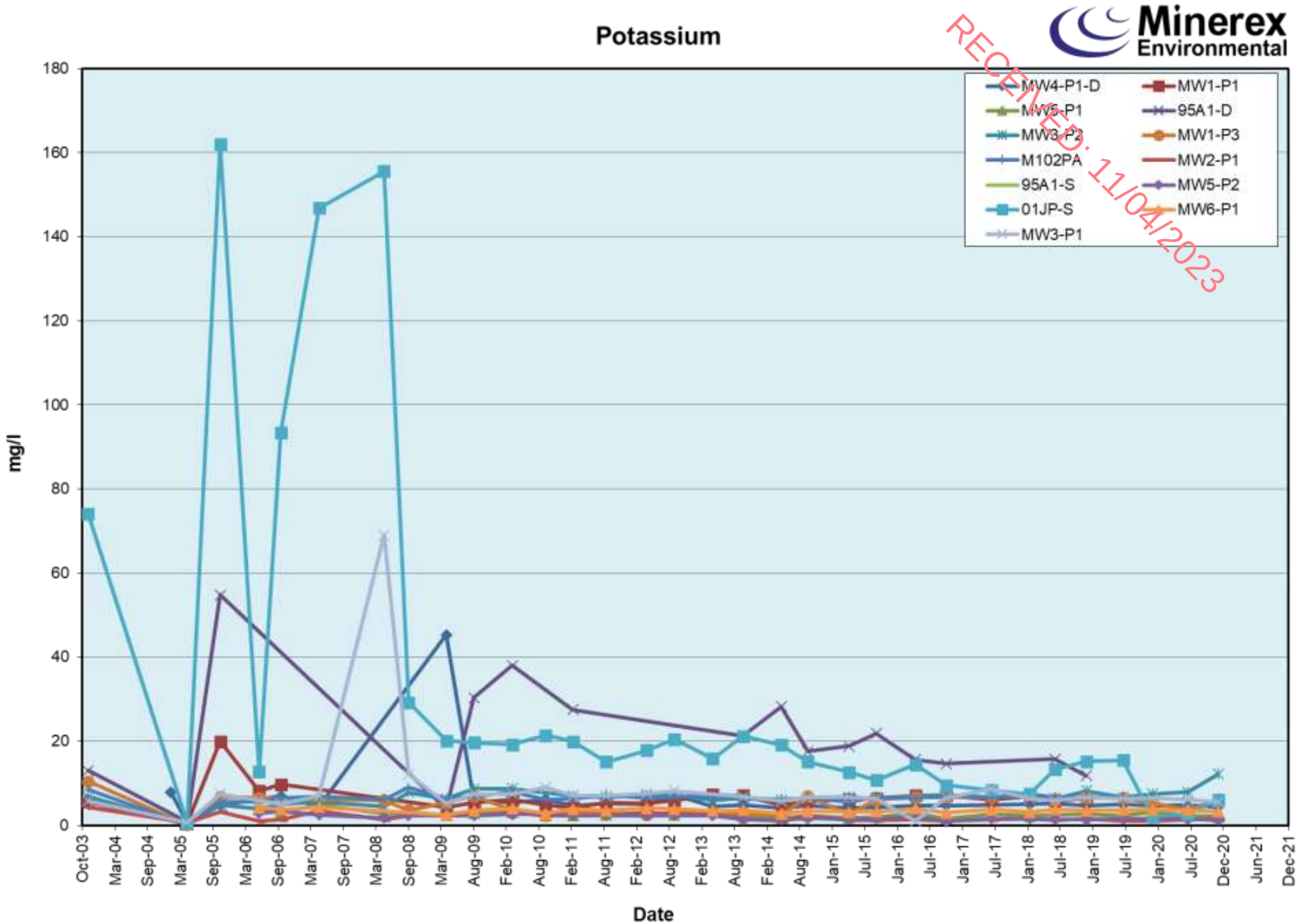
Date
RECEIVED: 11/04/2023


Potassium
Minerex Environmental
RECEIVED: 11/04/2023
mg/l
Date
MW4-P1-D
MW1-P1
MW5-P1
95A1-D
MW3-P2
MW1-P3
M102PA
MW2-P1
95A1-S
MW5-P2
01JP-S
MW6-P1
MW3-P1
0
20
40
60
80
100
120
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160
180
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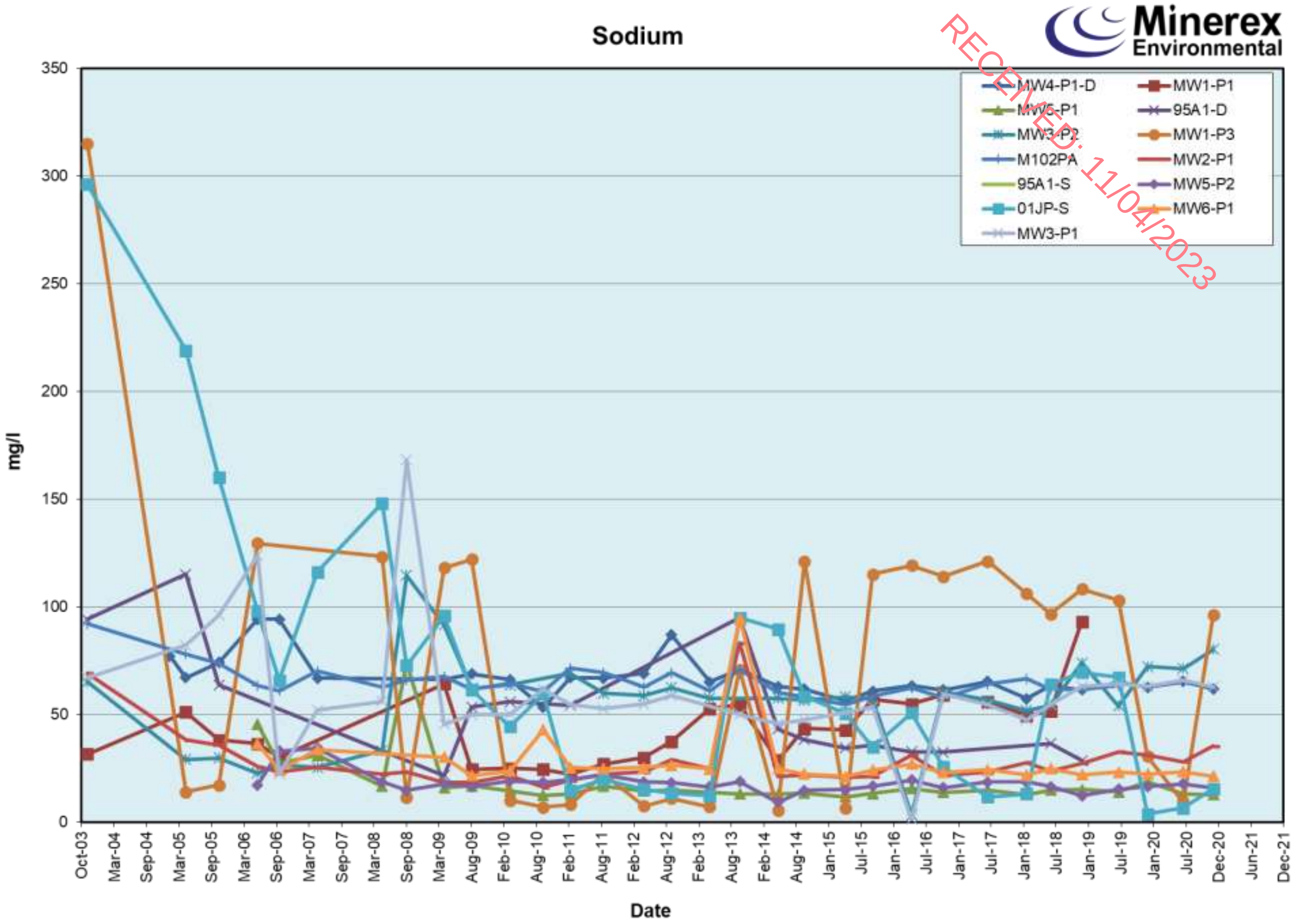
Sodium
Minerex Environmental
RECEIVED: 11/04/2023
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MW1-P1
MW5-P1
95A1-D
MW3-P2
MW1-P3
M102PA
MW2-P1
95A1-S
MW5-P2
01JP-S
MW6-P1
MW3-P1
mg/l
350
300
250
200
150
100
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0
Oct-03
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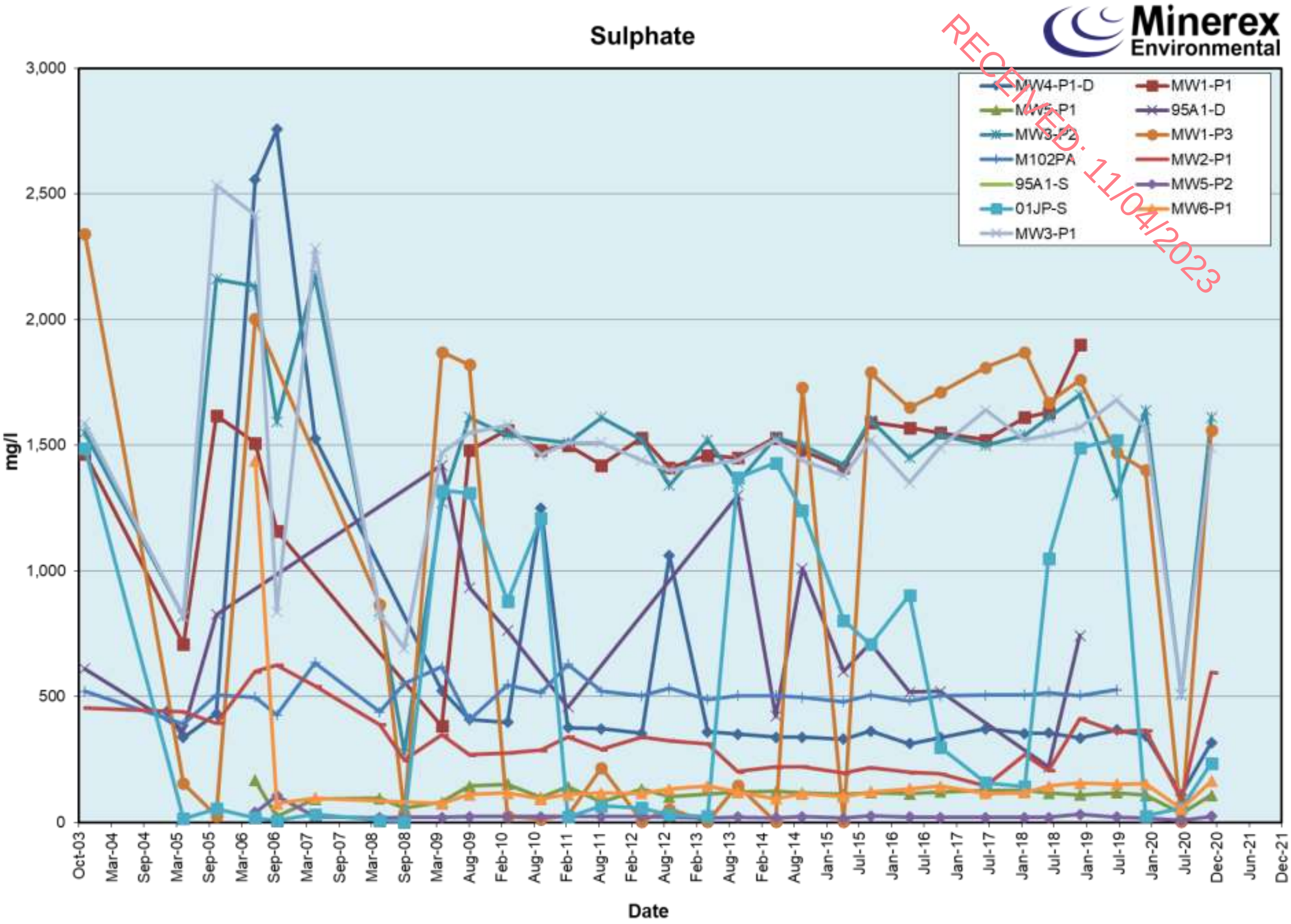
Minerex Environmental
Sulphate
RECEIVED: 11/04/2023
mg/l
3,000
2,500
2,000
1,500
1,000
500
0
MW4-P1-D
MW1-P1
MW5-P1
95A1-D
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MW1-P3
M102PA
MW2-P1
95A1-S
MW5-P2
01JP-S
MW6-P1
MW3-P1
Oct-03
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APPENDIX 8.5
Site Water Balance (2016 - 2021)

SITE WATER BALANCE (2016 - 2021)

Green = Monitored Values, Orange = Derived Values

Month	m³/d														mm/d			mRL
	Recorded MSE-1 discharge to Bursk	Recorded Drummond to Lagoons	Estimated Drummond to MSE-1	Estimated contribution from June 2018 mine fault	Estimated contribution from June 2018 mine fault	Drumgoosat groundwater	Recorded Drumgoosat Well	Additional to Drumgoosat	Estimated Drumgoosat to MSE-1	Knocknacran groundwater	Knocknacran runoff	Estimated Knocknacran to MSE-1	Site runoff to MSE-1	Total Discharge	Precipitation	PET	Effective Ppt	Recorded water level
Dec-16																		966.6
Jan-17	1,776	1,876	1,636	0	0	244	0	241	0	122	18	140	0	1,776	0.0010	0.0003	0.0007	966.4
Feb-17	2,927	1,736	1,736	0	0	259	0	-998	998	130	63	192	0	2,927	0.0028	0.0006	0.0023	965.5
Mar-17	2,480	1,645	1,645	0	0	576	0	-497	497	288	50	338	0	2,480	0.0028	0.0010	0.0018	963.9
Apr-17	1,479	1,921	1,290	0	0	379	0	631	0	189	0	189	0	1,479	0.0003	0.0016	0.0000	961.8
May-17	535	1,608	520	0	0	31	0	1,088	0	15	0	15	0	535	0.0022	0.0026	0.0000	961.6
Jun-17	650	1,611	613	0	0	42	0	998	0	21	16	37	0	650	0.0032	0.0027	0.0006	964.1
Jul-17	589	1,422	563	0	0	31	0	859	0	15	11	26	0	589	0.0029	0.0027	0.0004	966.5
Aug-17	786	1,459	754	0	0	32	0	705	0	16	16	32	0	786	0.0026	0.0021	0.0006	967.8
Sep-17	1,686	1,343	1,343	0	0	15	0	-271	271	7	63	71	0	1,686	0.0037	0.0014	0.0023	969.1
Oct-17	2,569	1,357	1,357	0	0	177	0	-1,058	1,058	89	66	154	0	2,569	0.0031	0.0008	0.0024	968.9
Nov-17	2,210	1,442	1,442	0	0	313	0	-558	558	157	53	210	0	2,210	0.0022	0.0003	0.0019	967.3
Dec-17	2,576	1,864	1,864	0	0	274	0	-513	513	137	61	198	0	2,576	0.0025	0.0003	0.0022	965.6
Jan-18	3,477	2,220	2,255	0	0	234	34	-1,009	975	122	126	248	0	3,477	0.0050	0.0004	0.0046	963.8
Feb-18	3,167	1,972	1,972	0	0	638	0	-1,019	1,019	130	47	176	0	3,167	0.0023	0.0006	0.0017	962.2
Mar-18	2,005	2,228	1,673	0	0	366	0	555	0	288	44	332	0	2,005	0.0025	0.0009	0.0016	961.3
Apr-18	2,169	2,115	1,974	0	0	32	0	141	0	189	6	195	0	2,169	0.0018	0.0017	0.0002	962.0
May-18	1,405	1,788	1,389	0	0	40	0	399	0	15	0	15	0	1,405	0.0012	0.0026	0.0000	962.8
Jun-18	600	1,991	579	0	0	32	0	1,412	0	21	0	21	0	600	0.0000	0.0035	0.0000	964.4
Jul-18	245	7,017	230	0	6,787	32	0	6,787	0	15	0	15	0	245	0.0014	0.0031	0.0000	967.7
Aug-18	92	8,311	64	0	8,246	14	0	8,246	0	16	11	28	0	92	0.0025	0.0022	0.0004	985.4
Sep-18	729	7,226	718	0	6,508	183	0	6,508	0	7	4	11	0	729	0.0017	0.0016	0.0001	989.9
Oct-18	5,817	6,411	1,357	4,363	0	303	59	691	0	89	8	97	0	1,453	0.0011	0.0009	0.0003	995.8
Nov-18	6,319	5,303	1,442	4,613	0	283	137	0	0	157	107	263	0	1,706	0.0044	0.0005	0.0039	995.2
Dec-18	5,928	4,843	1,864	3,845	0	234	144	0	0	137	83	219	0	2,083	0.0034	0.0004	0.0030	994.1
Jan-19	4,174	4,136	2,220	1,818	0	576	112	98	0	122	14	136	0	2,357	0.0009	0.0004	0.0005	993.3
Feb-19	4,801	4,446	1,972	2,666	0	406	124	0	0	130	33	163	0	2,135	0.0019	0.0007	0.0012	992.4
Mar-19	5,963	4,750	2,228	3,337	0	31	131	0	0	288	110	398	0	2,626	0.0051	0.0011	0.0040	991.8
Apr-19	4,465	4,013	2,115	2,133	0	42	884	0	0	189	27	216	0	2,331	0.0026	0.0017	0.0010	991.2
May-19	4,095	3,901	1,788	2,291	0	31	1,292	0	0	15	0	15	0	1,803	0.0013	0.0023	0.0000	990.6
Jun-19	3,407	3,449	1,611	1,747	0	34	399	91	0	21	28	49	0	1,660	0.0035	0.0026	0.0010	990.0
Jul-19	3,222	3,440	1,422	1,779	0	14	449	239	0	15	6	21	0	1,443	0.0030	0.0029	0.0002	990.2
Aug-19	4,739	3,663	1,459	3,172	0	177	1,171	0	0	16	92	108	0	1,567	0.0056	0.0024	0.0033	990.1
Sep-19	3,912	3,968	1,343	2,466	0	313	588	158	0	7	95	103	0	1,446	0.0050	0.0016	0.0035	989.4
Oct-19	4,433	3,661	4,270	0	0	274	961	0	0	89	75	164	0	4,433	0.0035	0.0008	0.0027	988.4
Nov-19	5,653	53	5,303	70	0	242	898	0	0	157	123	280	0	5,583	0.0048	0.0004	0.0045	986.7
Dec-19	4,714	0	4,578	0	0	576	544	0	0	137	0	137	0	4,714	0.0000	0.0003	0.0000	985.8
Jan-20	4,399	0	4,136	142	0	366	798	0	0	122	0	122	0	4,258	0.0020	0.0170	0.0000	986.8
Feb-20	5,998	1,875	4,293	1,375	0	33	786	0	0	125	204	329	0	4,622	0.0079	0.0005	0.0074	987.1
Mar-20	6,446	3,814	4,750	1,368	0	40	865	0	0	288	40	328	0	5,078	0.0021	0.0007	0.0014	985.9
Apr-20	3,224	3,781	3,035	0	0	32	315	746	0	189	0	189	0	3,224	0.0006	0.0013	0.0000	985.0
May-20	2,885	3,197	2,870	0	0	32	193	327	0	15	0	15	0	2,885	0.0006	0.0020	0.0000	985.1
Jun-20	2,681	3,028	1,991	669	0	15	324	368	0	21	0	21	0	2,012	0.0031	0.0032	0.0000	984.8
Jul-20	2,601	2,230	2,543	0	0	177	213	0	0	15	43	59	0	2,601	0.0039	0.0024	0.0016	985.0
Aug-20	3,003	2,188	2,942	0	0	303	243	0	0	16	45	61	0	3,003	0.0038	0.0023	0.0016	985.0
Sep-20	2,745	2,878	2,712	0	0	283	300	166	0	7	26	33	0	2,745	0.0028	0.0020	0.0009	985.0
Oct-20	3,148	2,815	2,995	0	0	234	456	0	0	89	64	152	0	3,148	0.0037	0.0015	0.0023	985.0
Nov-20	4,299	2,806	53	4,029	0	595	1,152	0	0	157	60	217	0	270	0.0030	0.0008	0.0022	983.1
Dec-20	4,710	2,404	0	4,472	0	366	1,095	0	0	137	101	238	0	238	0.0040	0.0004	0.0037	981.5
Jan-21	5,123	3,225	0	4,877	0	31	1,437	0	0	122	124	246	0	246	0.0047	0.0002	0.0045	980.1
Feb-21	6,592	3,262	1,942	4,520	0	45	1,193	0	0	130	0	130	0	2,071	0.0036	0.0189	0.0000	979.2
Mar-21	4,988	1,524	3,814	807	0	31	1,174	0	0	288	80	368	0	4,181	0.0031	0.0002	0.0029	977.9
Apr-21	3,428	2,476	3,222	0	0	34	786	0	0	189	17	207	0	3,428	0.0013	0.0007	0.0006	976.8
May-21	3,375	794	3,197	154	0	14	515	0	0	15	9	24	0	3,221	0.0013	0.0011	0.0003	976.4
Jun-21	1,552	674	1,512	0	0	183	298	0	0	21	20	41	0	1,552	0.0024	0.0018	0.0007	976.3
Jul-21	1,499	333	1,469	0	0	303	298	0	0	15	14	30	0	1,499	0.0028	0.0024	0.0005	976.2
Aug-21	174	327	133	0	0	274	323	195	0	16	25	42	0	174	0.0036	0.0028	0.0009	976.2

APPENDIX 8.6
Inrush Inflow SOP (Standard Operating Procedure) for Underground Mine Workings

OPERATIONS
MINING – SAFE WORK PROCEDURE

Subject	**Inrush / Inflow Identification**			
Owner	**B. Plunkett**	**Document No:**		
Author	**T. O'Reilly**	**Rev:2**	**Knocknacran**	
Date of Issue:	**11/10/2022**		**Drummond**	✓

Inflow / Inrush Identification

Introduction
This procedure has been compiled from Drummond Mine's routine room & pillar mining activities, empirical water intersection while mining, survey data and geological reports since it began in 2006.

For a detailed Hydrological report refer to UPDATED HYDROGEOLOGY ASSESSMENT OF THE GYPROC MINING DISTRICT, Piteau, May 2022.

In Drummond Mine, water is the primary risk of inflow or inrush. To date no gas inflows/ inrushes have been recorded (gas readings taken every shift). However, this procedure will take into account both types of inflow/ inrush.

Water/ gas may enter into the Drummond Underground Mine through natural conduits surrounding the gypsum, such as:

1. Open Faults/ Joints/ bedding planes.
2. Broken roof beam (mining induced).

The sources of water are likely to be from:

1. The watertable.
2. Water bearing dolerite.
3. Undulating (Karstified) gypsum deposit surface (creating pockets of water).
4. Previous Mining in the area south of Drummond Mine (Cormey Mine).

Identify risk zones (see Appendix 1: Drawing 4318c-126-22)
A water inrush in an underground mine is a serious hazard and all reasonable precautions must be taken to prevent this occurrence. Periodical flooding may occur when the drift headings intersect water with or without pressure, which has accumulated adjacent to faults or other discontinuities.

Due to the shallow nature of Drummond Mine (<200m below surface) all water intersections are of Low pressure.

The attached Inrush/ inflow risk map identifies general areas of risk from the criteria used below: (Note: Areas that are identified of higher risk than surrounding lower risk areas; then a separate Mining Risk Assessment will take place before any mining continues in that area).

a) 40m or less from surface:
   a. For potential surface water ingress.
b) Significant rolls or faults:
   a. Allowing water in from overhead water sources.
c) Overlying dolerite:
   a. Water bearing rock.
d) Thickness of Roof Beam:

a. Risk of roof beam breach.

Protection of mining personnel

Inflow and inrush risks are geographically spread throughout Drummond Mine. For this reason, to avoid intersecting water due to the above risk zones, a probe drilling procedure is implemented to minimize the potential for mining into an uncontrolled water inflow/ inrush. Probe drilling of all underground faces is carried out as set out in DTM 25 - Probe Drilling Procedure (Q-Pulse).

Also, where possible, mine workings are kept free from water to allow for safe and efficient working as water may affect the rock strength and stability. This is carried out by installing a pumping system in a temporary or permanent sump at or near the point of inflow.

Control of risks to mining personnel

To control the risk to underground personnel the probe hole procedure must be adhered to. Additionally, permanent inflow coming into the underground workings is collected into underground water sumps and pumped to surface.

Sump sizes depend on the water inflow. The sumps are fenced / guarded to prevent drowning of personnel moving close to the sumps or working on the pumps. Pumping is monitored and the pumped water volumes correlate to seasonal rainfall.

In the South West of Drummond Underground Mine, development is restricted (see planning boundary – Drawing No. 4318a-126-19, Appendix 1) to allow for the presence of Cormey Mine (known to be flooded).

When the mine workings approach the boundaries such as the Drummond Mine inflow location or approaching the planning boundary, all workings will stop. No workings will breach the high risk inflow areas until a risk assessment has been carried out by a competent person and an action plan has been formulated clearly outlining what steps must be taken to prevent mine safely in that area.

In the event of an inrush, evacuation procedures as set out in DTM 01b (Q-Pulse) will be followed incorporating the following:

- Withdrawal of all personnel from Drummond Underground Mine (notification of all personnel via two-way radio system and through the release of 'Stench Gas' (DTM 01b, B2, 1) into the Mine Workings.

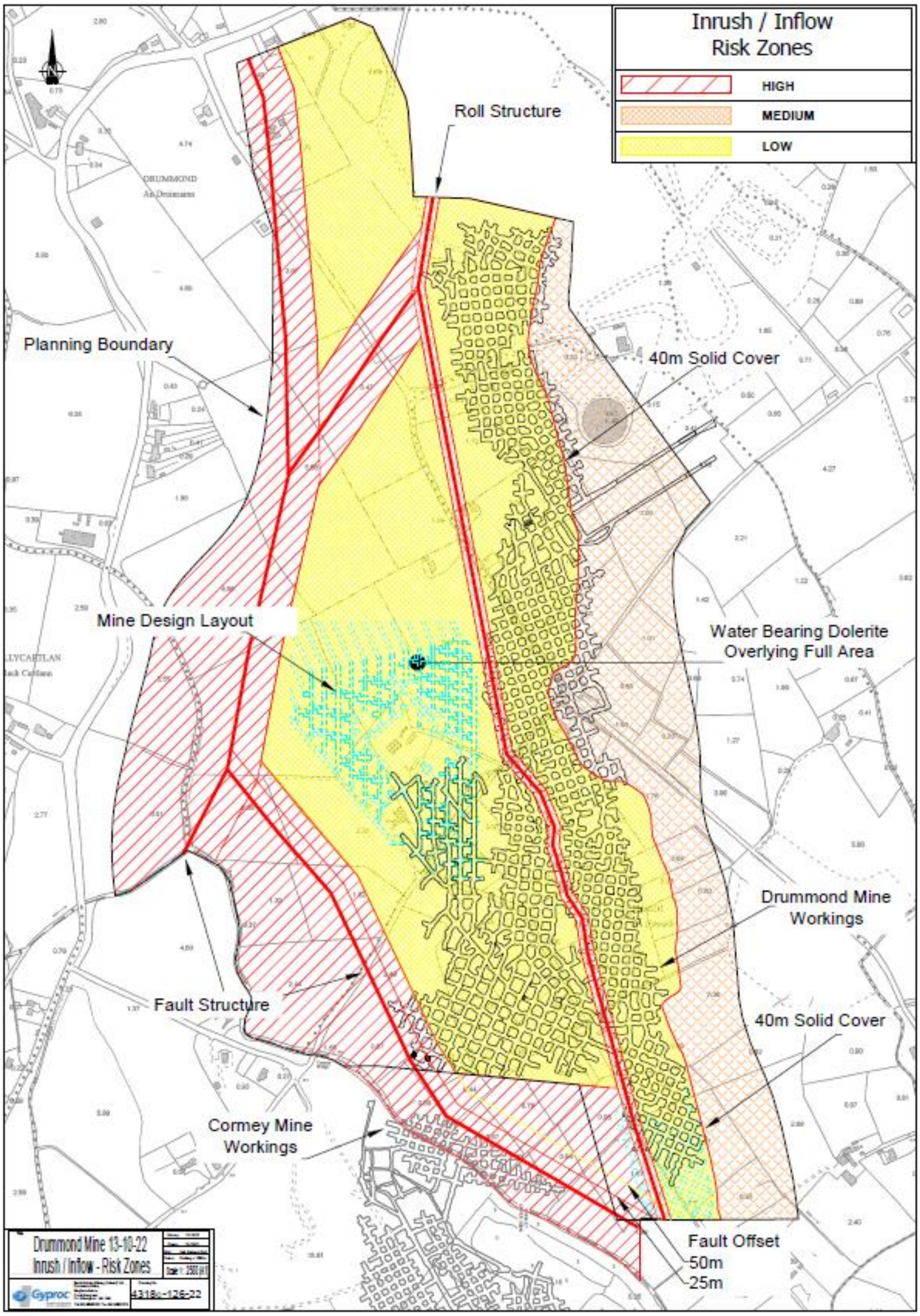
Risk Update

This risk identification will be updated annually as part of the risk register review for Drummond Mine.

Appendix 2 summaries the Control measures and incident response in event of an inflow or an inrush.

End

Appendix 1.

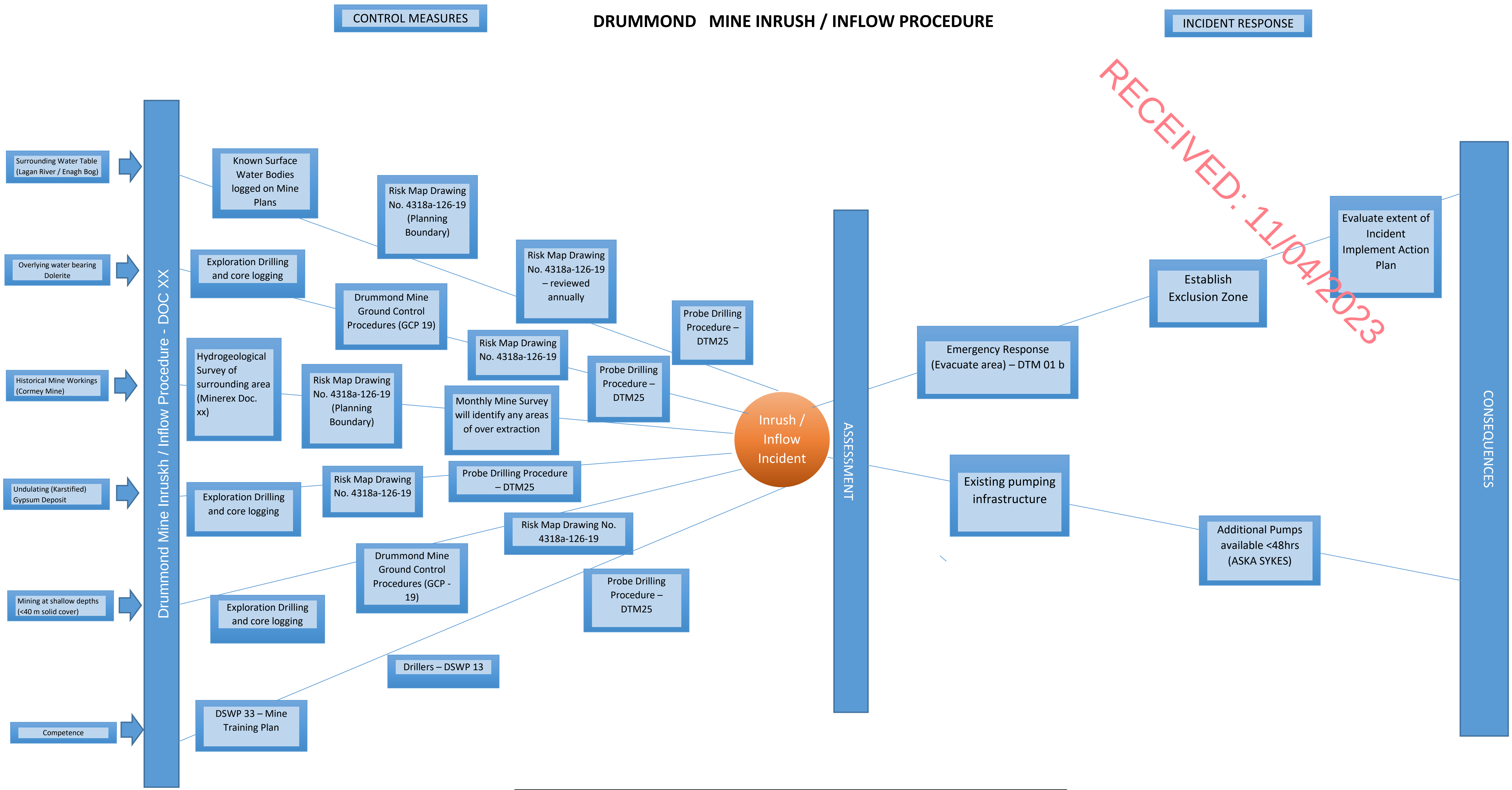


Inrush / Inflow Risk Zones
HIGH
MEDIUM
LOW
Roll Structure
Planning Boundary
40m Solid Cover
Mine Design Layout
Water Bearing Dolerite Overlying Full Area
Drummond Mine Workings
Fault Structure
40m Solid Cover
Cormey Mine Workings
Fault Offset
50m
25m
Drummond Mine 13-10-22
Inrush / Inflow - Risk Zones

Appendix 2 Bow Tie Risk Assessment

Attached on separate document

DRUMMOND MINE INRUSH / INFLOW PROCEDURE



Appendix 2. Drummond Mine Inrush/ Inflow Bowtie assessment summary

APPENDIX 8.7
Knocknacran West Pit Lake Model and Restoration Plan, Piteau, December 2021

PITEAU ASSOCIATES
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Knocknacran West Pit Lake Model and Restoration Plan

1. INTRODUCTION

This report provides an assessment of the future hydrogeology of the Knocknacran West Open-Cast Mine at the time of completion of mining and during the closure period. The study is based on mine planning information as of July 2021. Figure 1 shows the proposed development area of Knocknacran West.

Figure 1: Proposed Development Area - Knocknacran West Project (outlined on red)

Restoration of the open-cast (pit) includes:

- Creation of a water body in the final void space at Knocknacran West.
- Routing of seasonal discharge from the restored pit back to the original Corduff Stream.
- Restoration of the Knocknacran Open-Cast Mine area to close to original ground level.
- Restoration of areas that remain above the final water level in the Knocknacran West Open-Cast Mine.

2. SOURCES OF WATER THAT WILL ENTER THE FINAL OPEN-CAST VOID

Upon cessation of mining and placement of backfill material (stripped overburden and interburden), the pump in the Knocknacran West open-cast will be shut down and the water levels within the final void will start to rise. The sources of water that will inflow to the final void will be as follows:

- Rainfall onto the walls of the open-cast which runs off into the developing water body. Runoff from the sides of the open-cast will be the main source of water initially; but will reduce with time as the sides slopes gradually become submerged.
- Direct incident rainfall onto the open water body, which will gradually increase with time as the area of open water increases.
- Surface water runoff that enters the open-cast from the marginal area. This is assumed to be minor since a berm will be placed around the crest of the open-cast.
- Minor bedrock groundwater from the gypsum strata and dolerite that surround the pit area. Groundwater inflows to the Drumgoosat underground workings were low. Groundwater inflow to the open-cast is expected to be even lower than the water pumped from the Drumgoosat underground workings.
- Minor groundwater from the superficial deposits exposed within the upper side slopes of the open-cast which is also expected to be very low because the superficial deposits consist mostly of low permeability boulder clay and there are no known sand and gravels lenses in the local area.

The level of the water body in the Knocknacran West open-cast is expected to rise slowly with time to a final level of between ca. 38 and 39 m OD, when the lake will overflow into the original Corduff Stream on the northeastern rim of the excavation. The final surface area of the open water body will be about 26 ha.

Predicted water inflows to the final Knocknacran West open-cast excavation are summarized in Tables 1 and 2. When predicting the inflows, the following assumptions have been made:

- Runoff from rainfall onto the side slopes of the open-cast is predicted to decrease from an annual average of about 350 m^3/d upon shut down of the pumps, to an annual average of about 150 m^3/d when the level of the open water body has reached its final (stable) elevation. The annual average runoff has been calculated using the exposed area of the slopes at any given time and the mean monthly rainfall shown in Table 3. It is assumed that, on average throughout the year, 40% of the rainfall will be shed from the slopes and enter the water body. The relatively high runoff coefficient for the rainfall that reaches the open-cast mine floor is partly because of the drainage system on the side slopes of the open-cast that will be installed concurrently with mining. The balance of the rainfall will be taken up by plants growing on the side slopes or evaporate from the benches in the open-cast. Seasonally, the runoff will vary from zero during dry summer months to an average of about 230 m^3/d in the autumn and winter months. Seasonal variations in the runoff coefficient have not been factored into the current analysis.

- Surface water runoff from the reclaimed backfill surface surrounding the open water will permanently enter the water body. The average flow rate from this area is predicted to be about 50 m^3/d, again varying seasonally. For estimating the flow rates, the mean monthly rainfall shown in Table 3 has been assumed throughout the entire time period. It is assumed that, on average, about 20% of the rainfall onto the backfill area will reach the water body.

- The rate of rainfall contribution to the water body has been calculated using the mean monthly values shown in Table 3 and the month-by-month surface area of the open water. It has been assumed that 100% of the incident precipitation contributes to the open water surface.

- Groundwater inflows will vary seasonally between about 10 and 300 m^3/d, with an average inflow rate of about 100 m^3/d. Some of this water will enter the workings from the gypsum strata; some will enter from the superficial deposits. The predicted rate of groundwater inflow is less that the reported groundwater inflow during operation of the Drumgoosat Underground Mine (which was reported to vary seasonally between 20 m^3/d in September to 870 m^3/d in March). The reasons for this are: (i) any groundwater inflow from the south is already cut off by the low permeability backfill material (i.e. previously stripped interburden – low permeability mudstone) placed in the existing Knocknacran open-cast, (ii) any groundwater inflow from the north will also be cut off by the placement of low permeability backfill material within the planned Knocknacran West open-cast, (iii) there will be limited on-going groundwater recharge because the recharge area will largely have been removed by the open-cast, and (iv) there will be limited groundwater inflow from the east or west because of the presence of faulting and stratigraphical offsets to the gypsum strata in those directions.

Table 1: Predicted water balance of the Knocknacran West water body in early time following shut down of the pumps

	Groundwater Inflow (m^3/d)	Pit wall Runoff (m^3/d)	Backfill Runoff (m^3/d)	Incident Rainfall (m^3/d)	Evaporation (m^3/d)
Average	100	350	50	140	65
Min	10	0	0	0	0
Max	300	565	100	265	150

Table 2: Predicted water inflows to the Knocknacran West water body once the water level has reached its final elevation (38-39 m OD)

	Groundwater Inflow (m^3/d)	Pit wall Runoff (m^3/d)	Backfill Runoff (m^3/d)	Incident Rainfall (m^3/d)	Evaporation (m^3/d)
Average	100	155	50	245	245
Min	10	0	0	390	55
Max	300	250	100	910	500

Table 3: Mean monthly rainfall and potential evaporation used in the inflow model

Month	Precipitation (mm/month)	Potential Evapotranspiration (mm/month)
January	70	11
February	66	18
March	107	32
April	47	50
May	48	78
June	67	89
July	75	90
August	78	69
September	70	46
October	66	25
November	99	13
December	91	10
Total	**883**	**531**

3. WATER LOSSES FROM THE WATER BODY WITHIN THE FINAL OPEN-CAST

Losses from the impounded water body in the Knocknacran West open-cast will occur because of evaporation from the surface of the water and due to surface outflow once the level of the water body reaches its lowest point (spill point) on the northeastern rim of the open-cast.

The rate of open water evaporation has been calculated using the mean monthly potential evaporation shown in Table 3 and applying a coefficient of 0.65 to account for the scale factor between a small evaporation pan and a large surface water body. The predicted evaporation rates are listed in Tables 1 and 2.

The inflow model (Section 4) has been used to calculate the rate of surface water outflows once the level of the water body reaches the lowest point on the crest of the open-cast pit rim.

4. PIT LAKE MODEL

A pit lake model has been developed for the Knocknacran West open-cast using the Goldsim modelling software code. The Goldsim programme is a dynamic simulation software that allows hierarchical modelling of a natural environment by adding elements that represent data, equations, processes or events, and linking them together into graphical representations.

The Goldsim code is commonly used for developing water filling simulations in mining voids in a variety of environments worldwide. Inputs can be defined as distributions and the entire system simulated a large number of times to provide probabilistic outputs. The software incorporates a number of computational features to facilitate probabilistic simulation of complex systems, including tools for generating and correlating time series plots, such as changes in water level with time.

The inflow model uses a monthly timestep and incorporates the input and output variables to simulate rise in water level in the final open-cast. The following input elements are incorporated into the modelling code:

- A stage-area relationship for the final open-cast between 3 m OD (the final planned depth of mining) and 38-39 m OD (the lowest point on the crest of the final open-cast). The stage-area includes the mined void and incorporates the planned backfill areas.
- Monthly predictions of all inflow variables described in Section 2, incorporating the flow rate and the contributing area based on the stage-area relationship.
- Monthly evaporation outflow, incorporating the open water evaporation rate and the contributing area based on the stage-area relationship.
- A stage-volume relationship for the final open-cast between 3 m OD (the final planned depth of mining) and 38-39 m OD (the lowest point on the crest of the final open-cast). The stage-volume includes the mined void and incorporates the planned backfill.

The model calculates the following output variables:

- The water balance of the water body for each monthly time step.
- The rise (or fall) in water level each monthly time step based on the water balance and the stage-volume relationship.
- The average rate of monthly outflow from the open-cast once the water level has risen to the outflow point, based on the water balance.

Groundwater levels in the gypsum strata that surround the final open-cast will rise at approximately the same rate as the water body within the final open-cast workings. Calculations of the void space of the workings indicate the amount of groundwater storage is small and will not materially affect the rate of rise in the water level in the open-cast.

The presence of low permeability backfill material immediately to the north and south of the Knocknacran West workings will isolate the open water body from much of the surrounding groundwater system. As a result, it is considered likely that much of the replenishment of local groundwater storage will already have occurred by the time mining has been completed in the Knocknacran West open-cast.

5. SENSITIVITY ANALYSIS

The model was used to test the sensitivity of the hydrogeological system to a range of input variables, as follows:

- Base case predictions (Case 1): as described in Section 2.
- Higher runoff and lower groundwater inflow (Case 2): This case assumes that, compared to the base case, the groundwater inflows are halved, runoff from the pit slopes increases from 40% to 50%, direct precipitation to the lake surface is 20% higher and evaporation reduces by 5%. Such runoff conditions may occur if all the rainfall were to occur in concentrated periods, as was observed in 2020.
- Lower runoff and higher groundwater flow (Case 3): Compared to the base case, this case assumes that the groundwater inflows are two times higher, runoff from pit walls is 20% lower, precipitation is the same and evaporation is 5% higher.

6. PREDICTED INFLOW RATES

Predicted inflow rates to the final Knocknacran West open-cast for Case 1 are shown in Figure 2. The rate of groundwater inflow is assumed to be steady over each year of the model period, varying seasonally. Groundwater inflows will be minor and are not expected to be head-dependant. The rate of runoff from the reclaimed slopes is observed to decrease with time as the level of the water body gradually rises and submerges the slopes. The rate of runoff from the restored backfill area surrounding the open-cast is included in the runoff term and is assumed to remain steady over the model period (but also varies seasonally). Conversely, the component of incident rainfall onto the open water surface is observed to increase with time as the surface area of open water gradually increases.

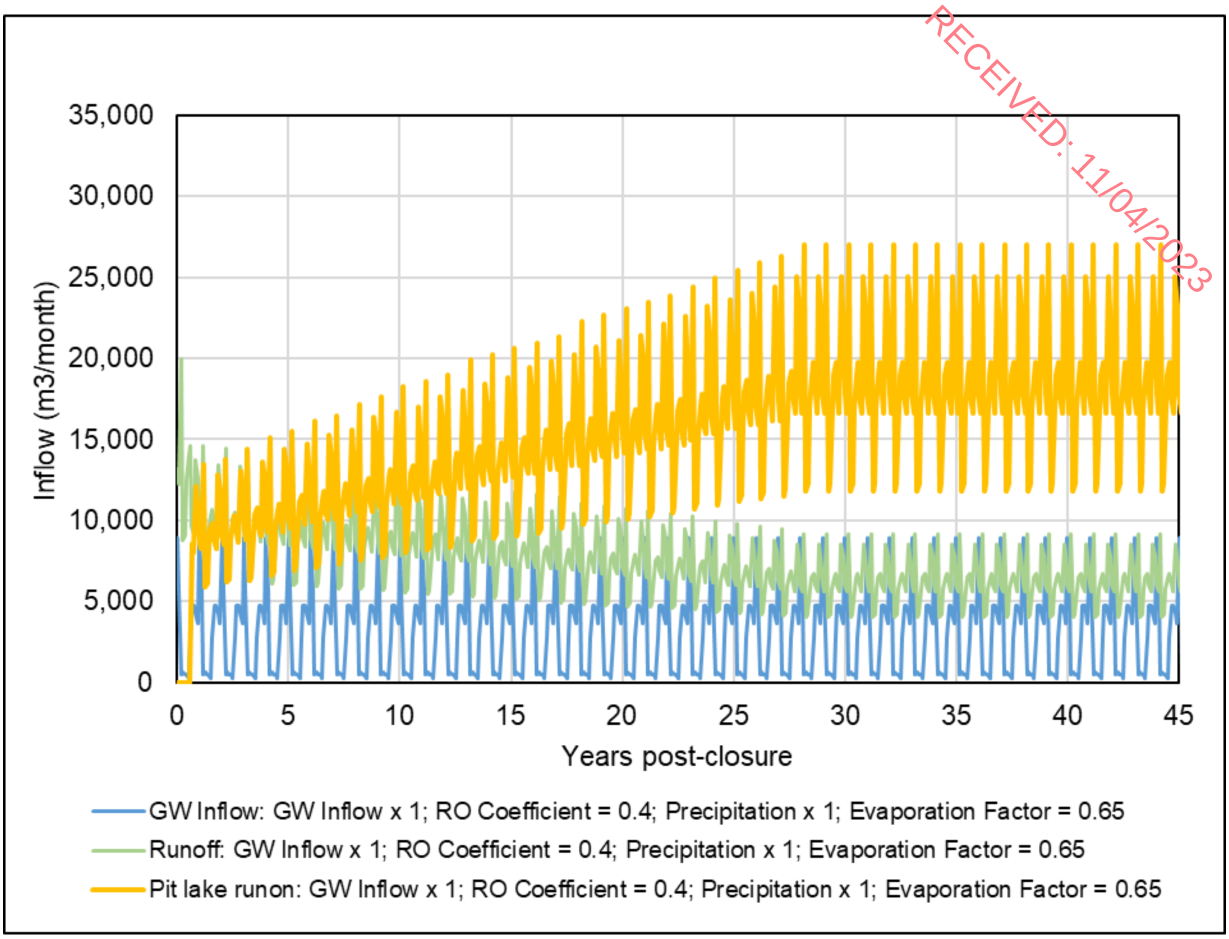

Figure 2: Predicted inflows vs time to the final Knocknacran West open-cast

7. PREDICTED RISE IN WATER LEVEL

The model has been used to predict the rise in water level within the Knocknacran West open-cast following cessation of mining (Figure 3). The water rises at a progressively slower rate with time as the stage-area of the void increases. For Case 1, the rising water level is predicted to reach the overflow point (ca. 38-39 m OD) after about 27 years. The runoff sensitivity cases show a relatively small variation assuming similar rainfall patterns to Table 3.

The filling model shows the seasonal increase and decrease in the rate of water level rise as a result of the seasonal variation in rainfall and evaporation rates. In reality, the seasonal variation may be slightly more than simulated because the runoff coefficient would also vary seasonally.

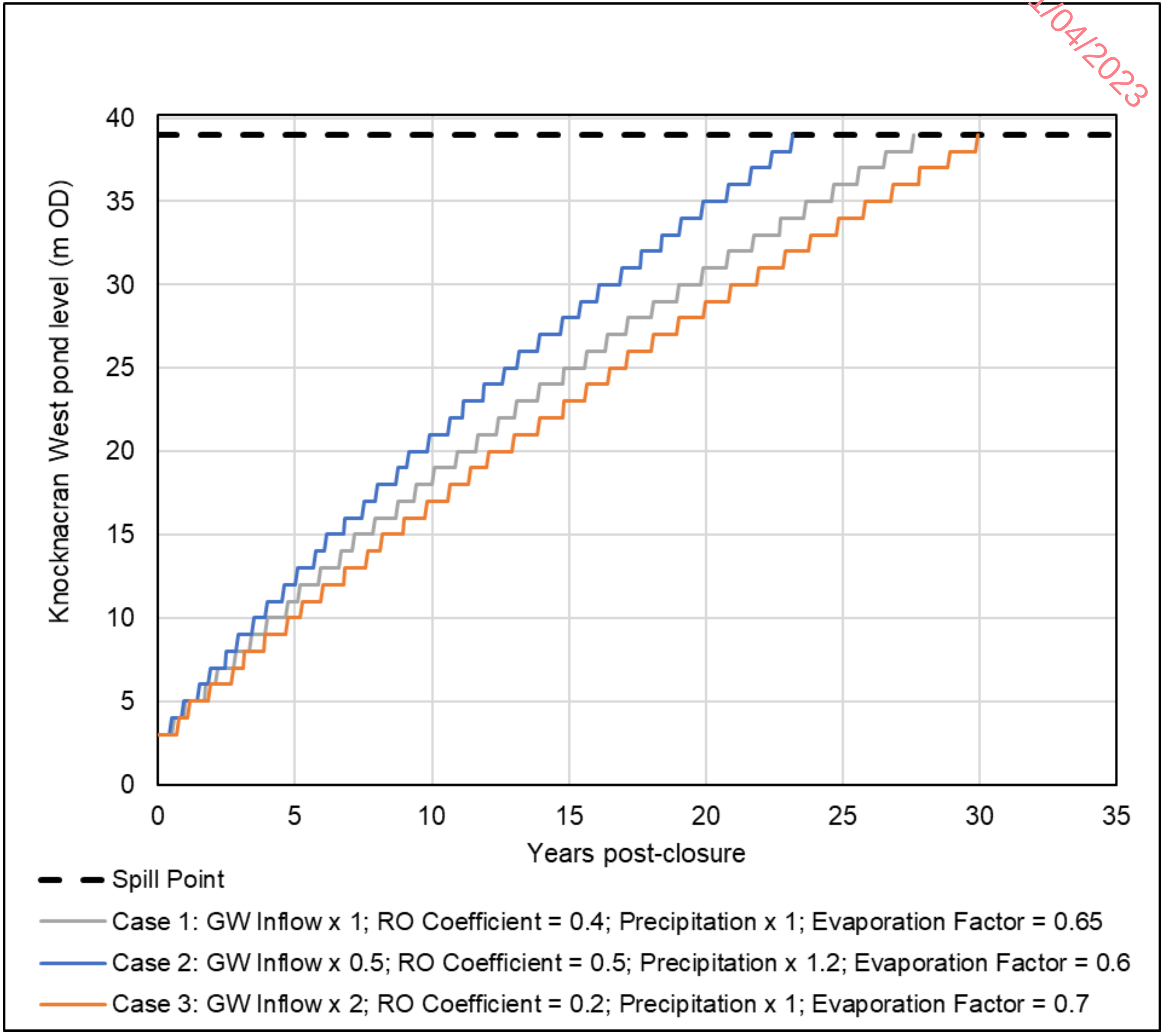

Figure 3: Predicted rise in water level vs time to the final Knocknacran West open-cast

8. FINAL WATER BODY

The model shows that the water level in the open-cast will rise to the level of the lowest point on the northeastern rim of the proposed Knocknacran West open-cast excavation. Figure 4 shows a map and cross sections of the final water body. The final water level will be about 38-39 m OD. The final water body will be about 36 m deep, 500 m in width, and 760 m in length.

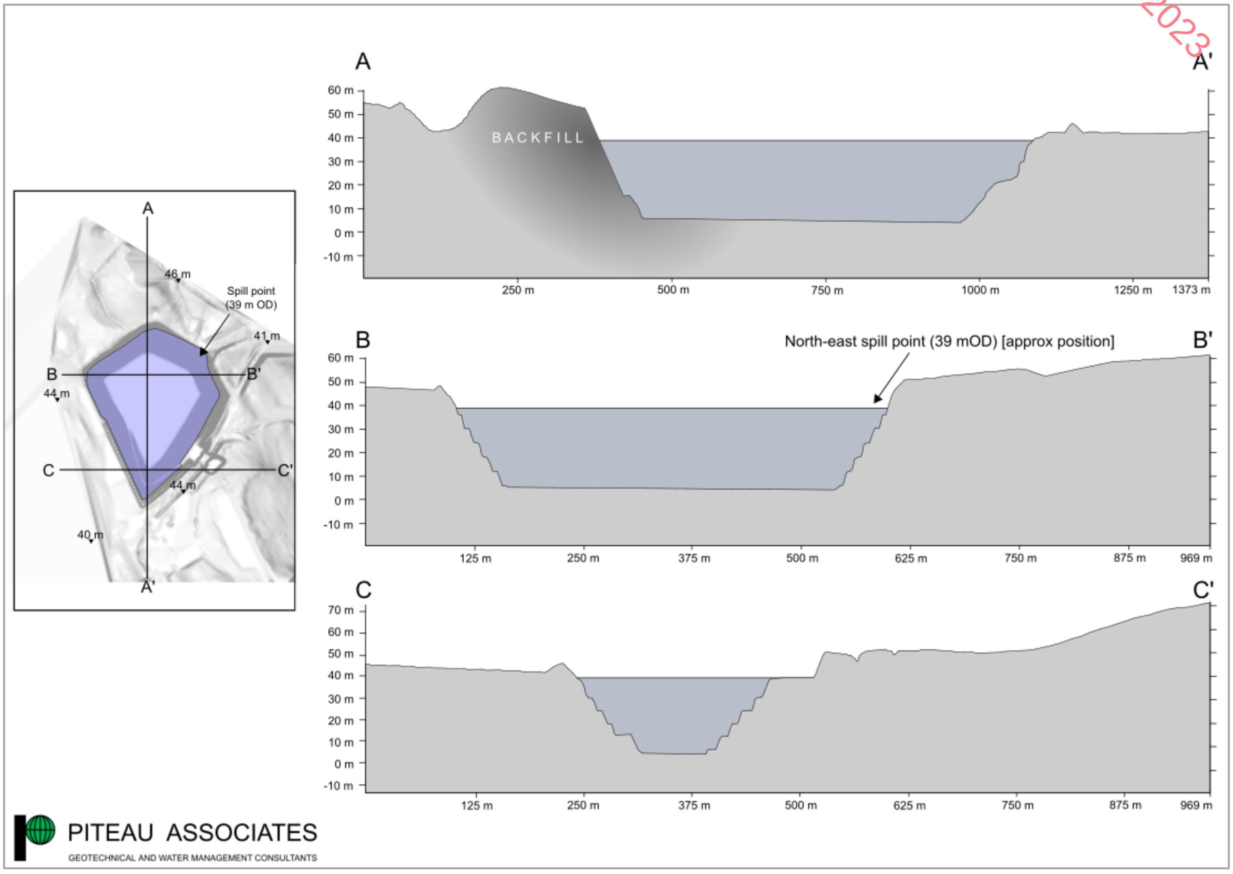

Figure 4: Map and cross sections showing the final water body including the proposed mining area and planned backfill

The water body will create an outflow at the northeastern rim of the open-cast to the original Corduff Stream, which rises naturally in the area above the Drumgoosat Mine. The Corduff Stream flows north towards Lough Fea (Figure 5).

The average annual outflow is predicted to be within the range 500-700 m^3/d, varying seasonally from zero in the summer, to over 1,000 m^3/d in the winter months.

Figure 5: Final Knocknacran West pit lake with discharge from the eastern pit rim to the original Corduff Stream

9. MODELLED PIT LAKE WATER CHEMISTRY

9.1 Inflow Sources & Chemistry

In order to predict the quality of the impounded water body, each of the inflow sources has been assigned a "type" chemistry, with the mixing ratios varied with time according to the contributing inflow rates in the model. The following water chemistry assumptions have been made:

- The initial runoff from rainfall onto the side slopes of the open-cast is assumed to have a chemistry similar to the sample of the current Knocknacran sump water taken on 11 March 2020 (Table 4). The water has relatively high levels of calcium and sulphate indicating it has contacted gypsum material as it flowed down the open-cast slopes into the sump. Alkalinity is high (300 mg/l) as would be expected. The water contains dissolved iron which is likely to be in solid (colloidal) form and would be expected to reduce within a permanent open water body. Low level detections of zinc and nickel are also reported. The reported value of nitrate is low.

- With time, as the water level rises within the open-cast, a decreasing proportion of the runoff will contact the side slopes. Additionally, the water will be directed towards the water body in constructed channels across and down the mining benches using the system to protect the benches from erosion during active mining (Figure 6). The runoff water quality is therefore expected to improve with time as the level of the water body rises. The final runoff is assumed to have solute concentrations that are similar to superficial groundwater, with values shown in Table 4.
- Runoff water from the restored backfill surrounding the open-cast void is also assumed to have a similar quality to superficial groundwater.
- The rainfall contribution to the water body is assumed to have zero chemical mass.
- Initial groundwater inflows to the final void are assumed to be mostly from the gypsum strata and are assumed to have a water chemistry similar to well M102PA. With time, the proportion of groundwater inflow from the superficial deposits will increase, and the final water quality is assumed to be similar to MW5P2. In the model, the groundwater chemistry has been varied from 100% gypsum groundwater in early time to 100% superficial water when the water body reaches the overflow point on the crest of the open-cast.
- Evaporation from the lake surface is assumed to remove water volume but no chemical mass.

Table 4: Type chemistry of the inflow water sources

	Groundwater (mg/L)	Pit Wall Runoff (mg/L)	Alluvial inflow (mg/L)
Sodium	65	65	18
Potassium	8	5	3
Calcium	175	368	50
Magnesium	75	45	18
Chloride	16	16	10
Sulphate	500	973	10
Nitrate	0.5	0.7	1
Phosphate	0.12	0.12	0.01
Alkalinity	300	300	250
Aluminium	0.24	0.24	0.02
Zinc	0.04	0.04	0.04
Iron	0.29	0.29	0.01
Lead	0.0005	0.0005	0.0005
Manganese	0.099	0.099	0.099
Nickel	0.028	0.028	0.028
Tin	0.0005	0.0005	0.0005
Copper	0.001	0.001	0.001
Value derived from other source term			
Estimated			
Value is half of detection limit			

Figure 6: Drainage system of the pit slopes which will help reduce the contact of surface water runoff with gypsum materials once the level of the impounded water body rises

9.2 Chemistry of the Water Body

The water chemistry of the impounded water body has been predicted using the Goldsim model. For each monthly timestep, the mass of each constituent entering the lake has been determined using the chemistry of the water sources (Table 4) and the volume of inflow (Figure 3). The influent waters are mixed in Goldsim in proportion to the magnitude of their inflow during each monthly timestep.

The model has been run for 100 years following shut down of the pumps. In the model, the water body is assumed to fully mix laterally and vertically, which is a reasonable assumption given the ambient weather conditions at the site.

The resulting water chemistry is shown in Table 6 for Year 10 and the point where outflow occurs from the pit rim. The model results for nitrate, sulphate and chloride are shown in Figures, 7, 8 and 9, respectively. When the water body starts to outflow at the northeastern rim of the pit, the total dissolved solids (TDS) concentration is predicted to be ca. 400-550 mg/l. Sulfate values are predicted to be about 149 mg/l, with calcium about 73 mg/l. The water is predicted to have a near-neutral to slightly alkaline pH. It should be noted that outflow will mostly occur during the months of October to March, when flows in surrounding ditches and streams are also high.

Table 6: Predicted quality of the impounded water at Year 10 and the time that the water overflows the crest of the open-cast (38-39 m OD)

Parameter	Standard (mg/L)	Concentration at 10 years post-closure (mg/L)	Concentration at the time of overflow (mg/L)
Potassium	-	3.2	2.4
Sodium	-	30.4	19.5
Calcium	-	132.1	73.0
Magnesium	-	26.6	18.3
Chloride	-	9.0	7.0
Sulphate	-	321.0	148.9
Nitrate	25	0.52	0.50
Phosphate	0.065	0.05	0.03
Alkalinity	-	185.7	154.7
Aluminium	-	0.1	0.05
Zinc	-	0.027	0.023
Iron	-	0.12	0.06
Lead	0.008	0.0003	0.0003
Manganese	-	0.07	0.06
Nickel	0.0047	0.019	0.016
Tin	-	0.00033	0.00029
Copper	0.02	0.0007	0.0006

The model has been purposely set up using a conservative approach; without the benefit of thermodynamic chemical reactions which would cause parameters to be removed from the lake waters as solid phase, thus improving the actual chemistry of the water body. It is also possible that some permanent stratification of the deeper parts of the water body would occur, with higher TDS water accumulating in the bottom of the water body, leaving better quality, lower TDS water near to the surface. Both these factors would act to improve the near surface water quality of the water body.

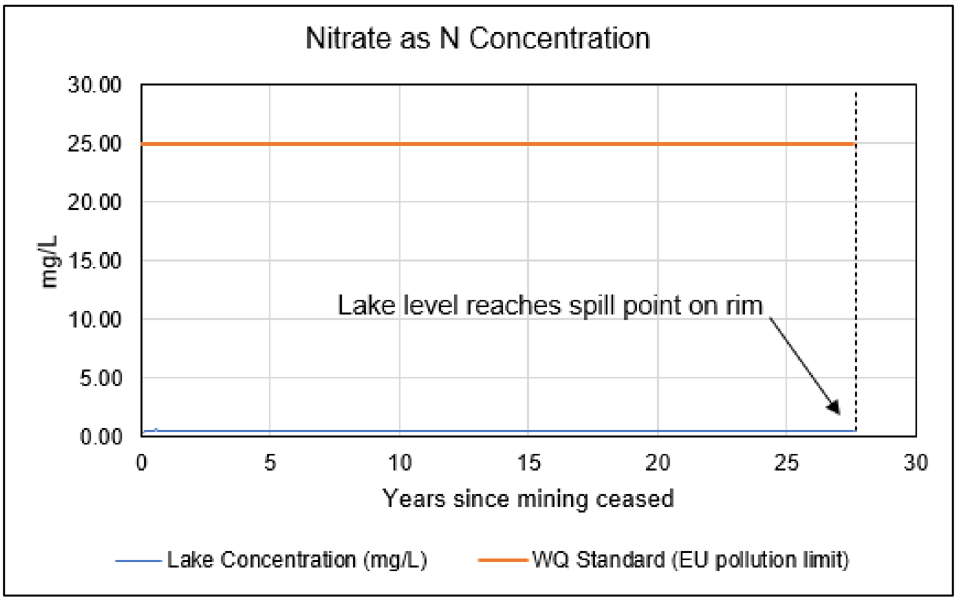

Figure 7: Modelled nitrate values in the Knocknacran West pit lake

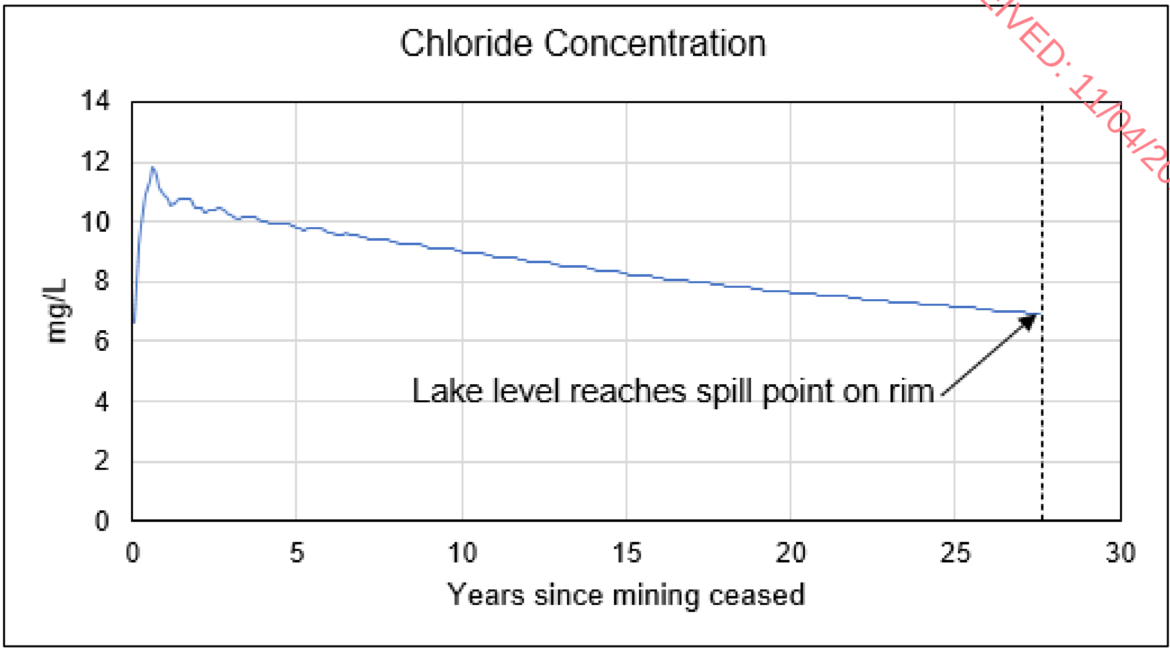

Figure 8: Modelled chloride values in the Knocknacran West pit lake

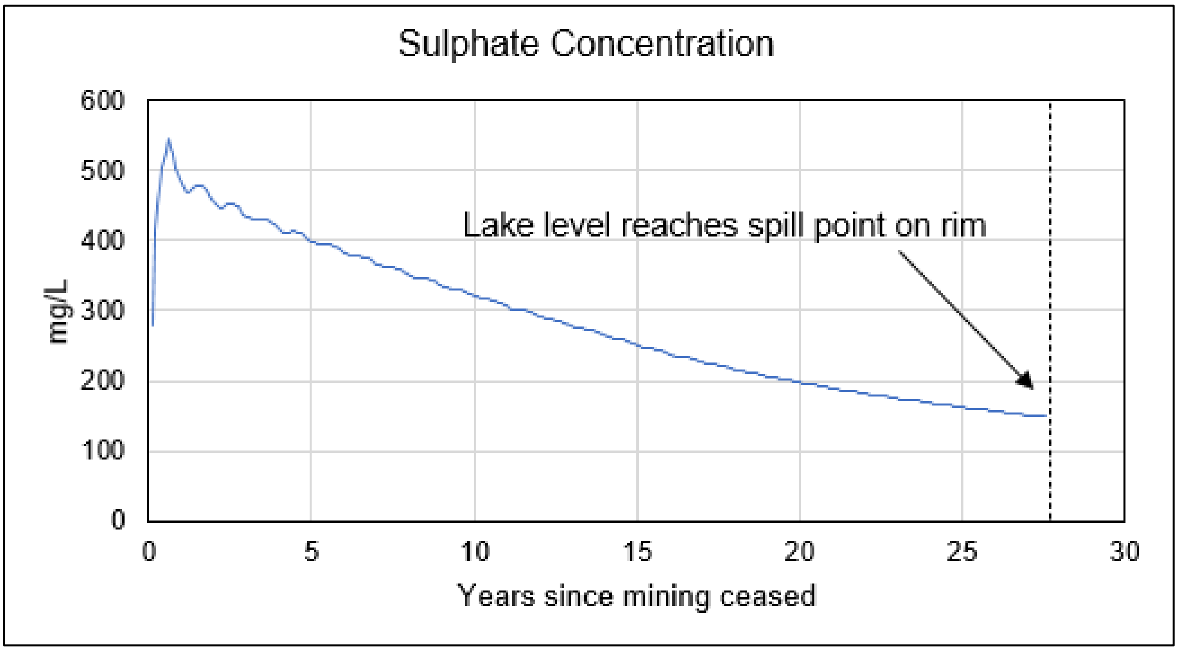

Figure 9: Modelled sulphate values in the Knocknacran West pit lake

APPENDIX 8.8
Hydrogeology Study of the Drumgoosat Workings, Piteau, May 2021

PITEAU ASSOCIATES
Geotechnical and Water Management Consultants

HYDROGEOLOGY STUDY OF DRUMGOOSAT UNDERGROUND WORKINGS

Prepared for

SAINT-GOBAIN MINING IRELAND (LTD.)

May 2021

PROJECT 4238-R4v1

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RECORD OF AMENDMENTS

This report has been issued and amended as follows:

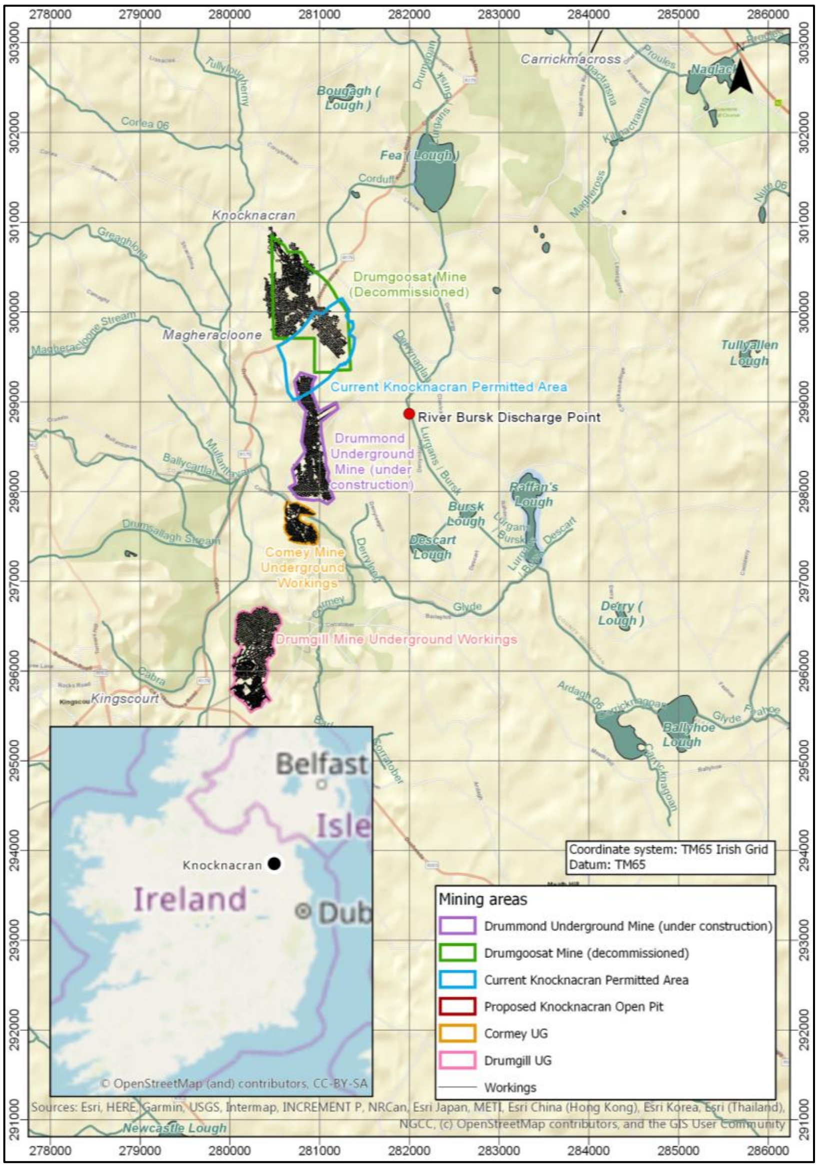
Issue	Description	Date	Prepared by	Approved by
v1	Draft	27-February 2021	Martin Williams and Lara Belton	Geoff Beale
v2	Second draft	28-May 2021	Martin Williams and Lara Belton	Geoff Beale

1. INTRODUCTION

1.1 BACKGROUND

This report provides a study of the Drumgoosat underground workings in the Kingscourt Gypsum mining district, Co Monaghan. The report draws on the available data for the mine area and surrounding district, including old mine planning information, groundwater, water quality and recent investigation drilling. The general location of the mining area is shown in Figure 1.1.

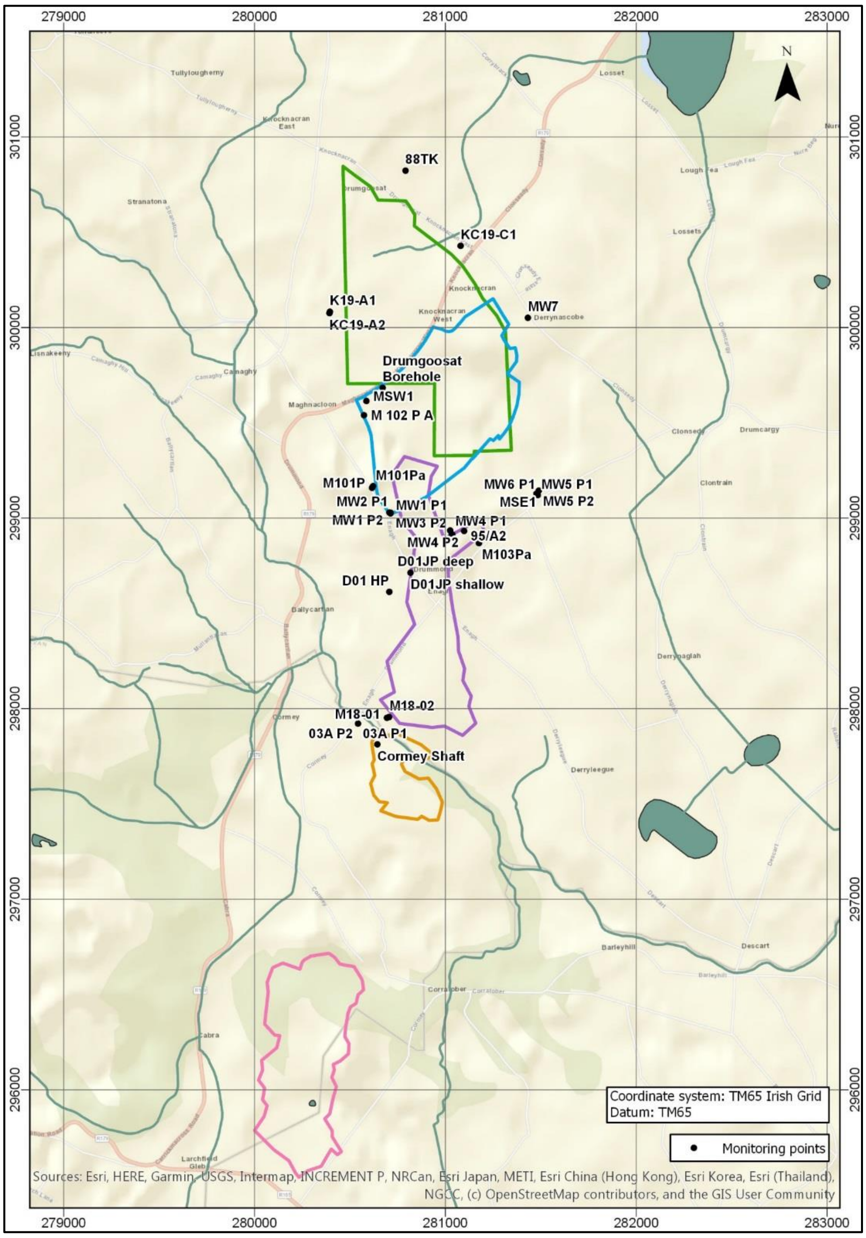
Figure 1.1: Map of the Kingscourt Gypsum mining district showing the location of the Drumgoosat mining area (outlined in green)



The specific goal of the study is to assess whether on-going dissolution of gypsum may have the potential to influence the long-term stability of the workings. The report has been prepared by Piteau Associates for Saint-Gobain Mining Ireland (Ltd.).

Underground mining operations at Drumgoosat terminated more than three decades ago, since when the mine workings have received natural groundwater recharge which has been pumped out by the Drumgoosat dewatering borehole (Figure 1.2). The mine was operational between 1963 and 1989. It is up to 100 mbgl and has an aerial extent of around 1,700 m × 800 m (80 ha). The estimated open space within the workings is of the order of 800,000 m^3. Structural support is provided by pillars left in place within the gypsum beds during mining.

Figure 1.2: Location of Drumgoosat dewatering borehole



A large subsidence event above the mining area occurred on 23rd/24th September 2018 which has been well studied and documented. Subsequent minor events occurred during 2019 and 2020. The northeast part of the Knocknacran open cast is underlain (and quarries into) the southern-most area of the old Drumgoosat workings.

1.2 SCOPE

The study includes all available geology, groundwater and surface water information for the area, including the information contained in reports by Minerex (2014 and 2019), SLR (2019), SGMI (2019), SRK (multiple dates) and Piteau Associates (2019 and 2020).

The work has been carried out as follows:

- Evaluation of available hydrogeology information to assess the seepage paths for water entering the Drumgoosat workings, including: (i) rapid infiltration from the surface, (ii) percolation from the overburden deposits, (iii) percolation from the intrusive sills, and (iv) lateral groundwater flow in the Kingscourt gypsum strata. A discussion of the groundwater inflows is included in Section 2.

- Construction of a groundwater flow model to quantify the rate of recharge to the workings as the basis for calculating the potential rate of gypsum dissolution. The groundwater flow model is described in Section 3.

- Assessment of the available water chemistry data, to develop a “type chemistry” for the inflowing water to the workings and development of a thermodynamic model using the PHREEQC code to assess the saturation state of underground waters, and calibration of the model to Calcium (Ca) and Magnesium (Mg) concentrations in the pumped discharge water. The water chemistry model is described in Section 4.

- Evaluation of all sources of information to develop conclusions of the study and recommendations for future planning. This is described in Section 5.

2. HYDROGEOLOGY

2.1 CLIMATE

An analysis of the available climatological data has been carried out to support groundwater recharge estimates to the workings. Climate records from the region between 1990 and 2019 show an annual average precipitation rate of 955 mm. Dunsany synoptic station (45 km south of the site) has an annual average potential evapotranspiration rate of 515 mm (2016 to 2019). Table 2.1 presents the monthly mean values for precipitation and evaporation.

Table 2.1: Monthly mean precipitation and potential evapotranspiration

Month	Precipitation (mm/mon)	Potential Evapotranspiration (mm/mon)
January	94.9	11.3
February	74.9	17.7
March	72.8	32.3
April	66.1	49.2
May	64.4	78.1
June	67.9	84.9
July	73.3	87.1
August	77.3	67.3
September	64.4	45.6
October	96.5	25.2
November	98.8	9.1
December	103.6	9.4
Total	**954.9**	**514.5**

As is typical in Ireland, the wettest months coincide with the months of lowest potential evapotranspiration (October to January). The driest months with highest potential evapotranspiration are May and June. Most of the recharge is expected to occur in late winter or spring although, in recent years, high summer rainfall is also seen to produce discrete recharge events.

2.2 TOPOGRAPHY AND SURFACE WATER

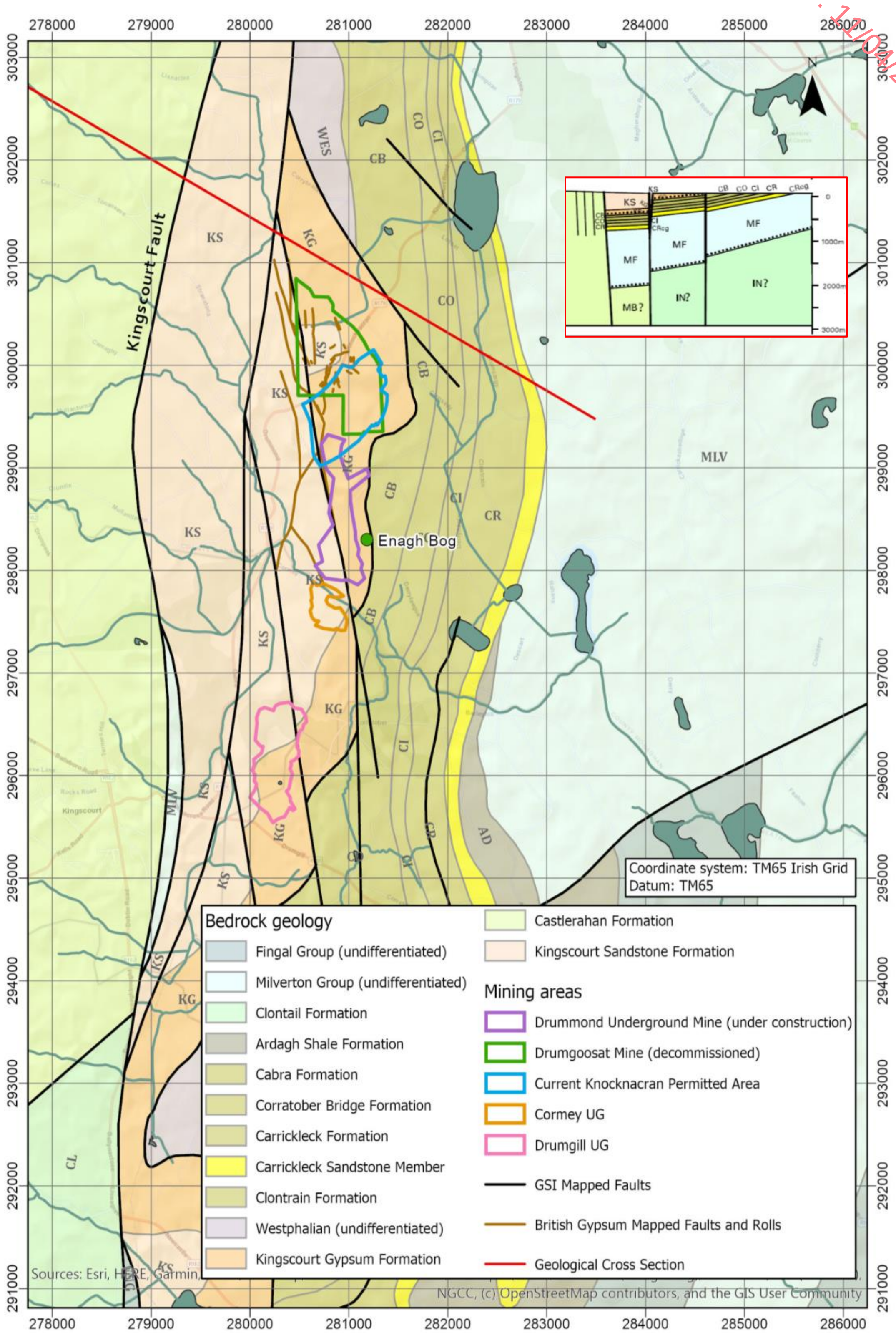
Figure 1.1 shows the general area of the Kingscourt Gypsum mining district. The area has a gently undulating topography with a general fall from west to east. The area of the site has an elevation of between 40 and 50 maODM (metres above Ordnance datum, Malin) which is also typical of the area to the east.

The Corduff Stream rises in the area above the Drumgoosat mine and flows north to Lough Fea, about 2 km northeast of site (Figure 1.12). Lough Fea is part of the River Bursk catchment. The Bursk flows south into Bursk Lough, then Rahans Lough, and then into the River Lagan. Bursk Lough is also fed by Descart Lough.

2.3 STRATIGRAPHY

All gypsum mining areas are located on the Kingscourt Outlier, a half-graben structure formed of Carboniferous and Permo-Triassic rocks. The geology of the district has a strong north-south strike, as illustrated in Figure 2.1. The gypsum deposits occur within the north-south striking Permian-age Kingscourt Gypsum Formation, which consists of bedded mudstone with gypsum and anhydrite, and is approximately 1.2 km wide and 12 km long.

Figure 2.1 District bedrock geology (with half-graben cross section (after GSI; outline of the Drumgoosat mining area shown in green)



The Kingscourt Gypsum sequence subcrops along the eastern margins of the half graben. The strata occur in a series of open folds, with a general dip to the west at between 10° and 30° towards the Kingscourt Fault. The Kingscourt Fault forms the western boundary of the Kingscourt Gypsum sequence. To the west of the Kingscourt Gypsum sequence, the Castlerahan Formation outcrops to the west of the Kingscourt Fault.

Error! Reference source not found.2 is a west-east cross section through the Drumgoosat workings. Figure 2.3 is a northwest-southeast cross section through the northern part of the workings. The mining sequence includes five primary stratigraphic units plus subsequent intrusive rocks (sills), as follows:

- Lower Mudstone
  - Transitional mudstone which grades upward into the Lower Gypsum.
  - Occurs below the floor of the Drumgoosat workings and was exposed underground in the lower areas of the mine, at the base of the Lower Seam
- Lower Gypsum
  - Gypsum and anhydrite bed up to 35 m in thickness, mined by Drumgoosat, Knocknacran and Drummond mines
  - Above the transition zone with the Lower Mudstone, it comprises a thickly bedded, high quality white to grey nodular gypsum
  - Transitions upwards into good quality, light brown laminated gypsum with rhythmic banding, which gradually changes to creamy pink or red further up the succession.
  - The laminated beds are, in turn, overlain by banded magnesium-rich gypsum layers which can be high in carbonates and show signs of being leached by groundwater.
  - Massive white gypsum is the upper-most section of the Lower Gypsum unit.
- Middle Mudstone
  - Forms much of the interburden in the between the upper and lower levels of the Drumgoosat workings
  - Varies between 6 and 12 m thick and separates the Upper and Lower Gypsum units
  - Consists of reddish, micaceous, plastic mudstones, with frequent green reduction spots and laminations near the base.
- Upper Gypsum
  - Massive, fine grained, grey-brown to red pure gypsum. Mined by Drumgoosat and Knocknacran, but not by Drummond. In Drumgoosat, most of the upper seam mining occurred on in the western area where the seam is thicker.
  - Typically red in colour, and ranges in thickness between 6 and 10 m (thinner than the lower bed).

- <u>Upper Mudstone</u>
    - Moving upward in the sequence from the massive red gypsum is inter-banded gypsum and red siltstone, coarse gypsum and finally massive gypsum containing very pure and fine-grained grey or cream laminated mineral.
    - The sequence is between 26 and 36 m in thickness and occurs above the roof of the Drumgoosat workings.
- <u>Dolerite and basalt sills</u>
    - The gypsum sequence includes interbedded dolerite and basalt sills which have been variably altered during intrusion, making them: (i) susceptible to weathering, and (ii) incompetent in places.
    - A fine grained dolerite occurs mostly between the Upper and Lower Gypsum units. In the Middle Mudstone, the intrusion reaches a maximum thickness of 60 m. It has undergone extensive near-surface lateritic weathering and hydrothermal alteration. It is weathered to a fine grained sand in places.
    - A dolerite sill occurs mostly to the east of the Kingscourt Gypsum sequence and thins towards the west, with the dip of the gypsum beds.
    - There is also a secondary intrusion (8 m in thickness) that is typically confined to the Lower Mudstone.

To the east of the Kingscourt Gypsum, a sequence of Namurian sandstones outcrops, again with a north-south strike. The sequence includes the Cabra Formation, Corratober Bridge Formation, Clontrain Formation and Carrickleck Formation. This sequence also underlies the Kingscourt Gypsum. The formations comprise Namurian-age (Carboniferous) sandstones and interbedded shales. These are poorly cemented and typically weathered. This tends to result in increased permeability. Observations during mining and subsequent monitoring have shown that the Namurian sandstones are not a factor in the local Drumgoosat hydrogeology.

Figure 2.2: West-east cross section through the Drumgoosat mine workings

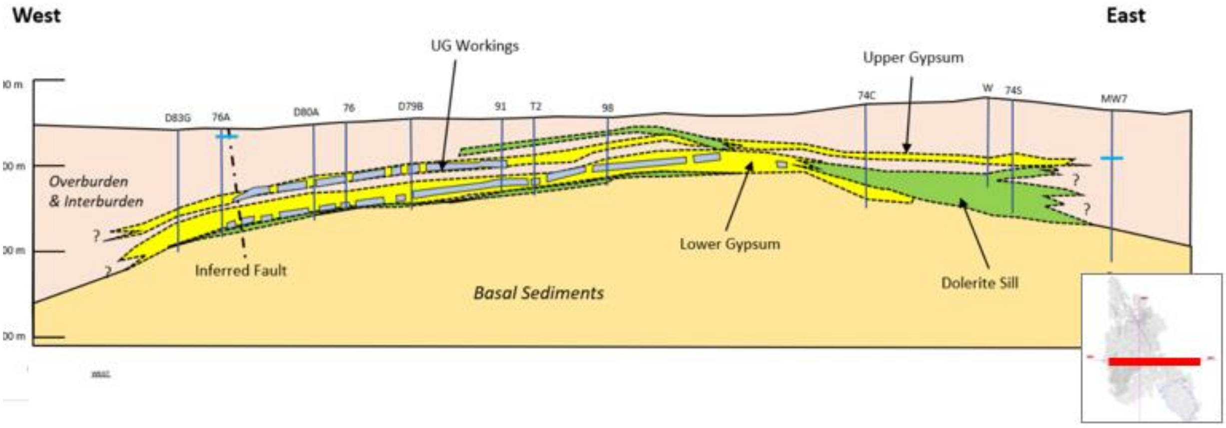
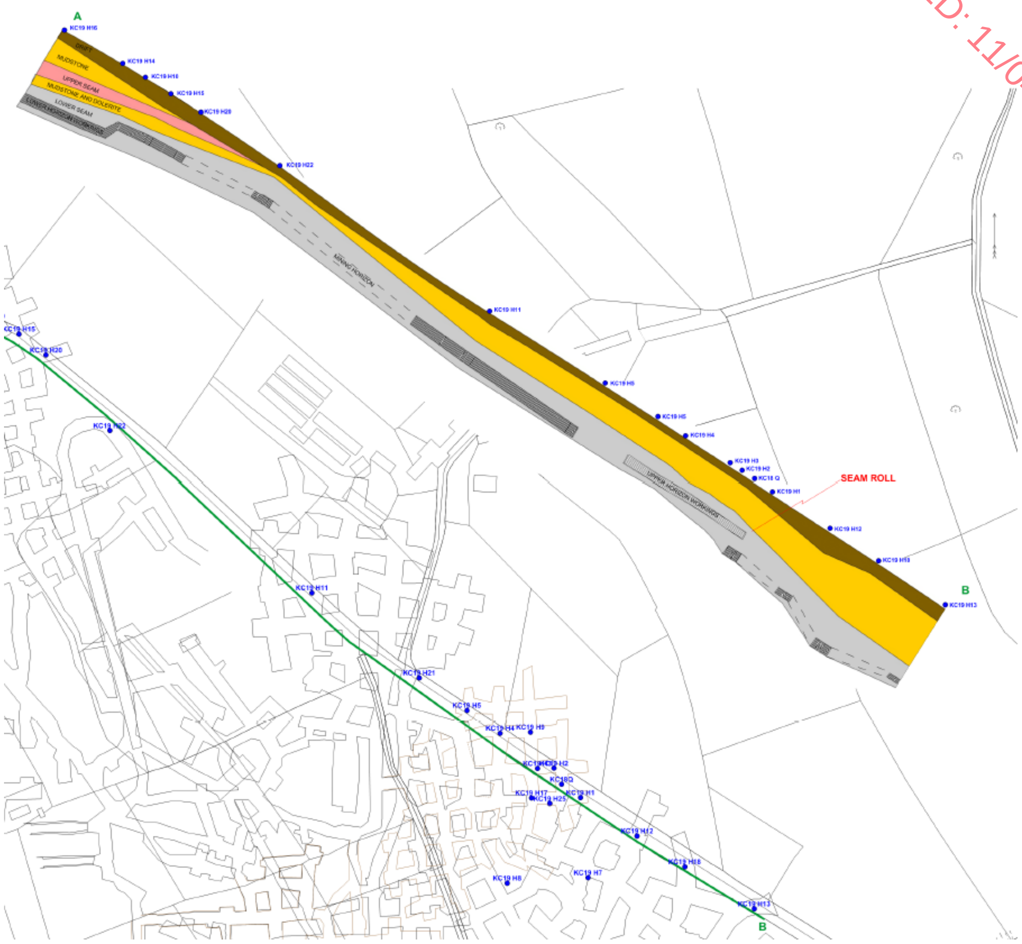


Figure 2.3: Northwest-southeast cross section through the northern part of the Drumgoosat mine workings



2.4 GEOLOGICAL STRUCTURE

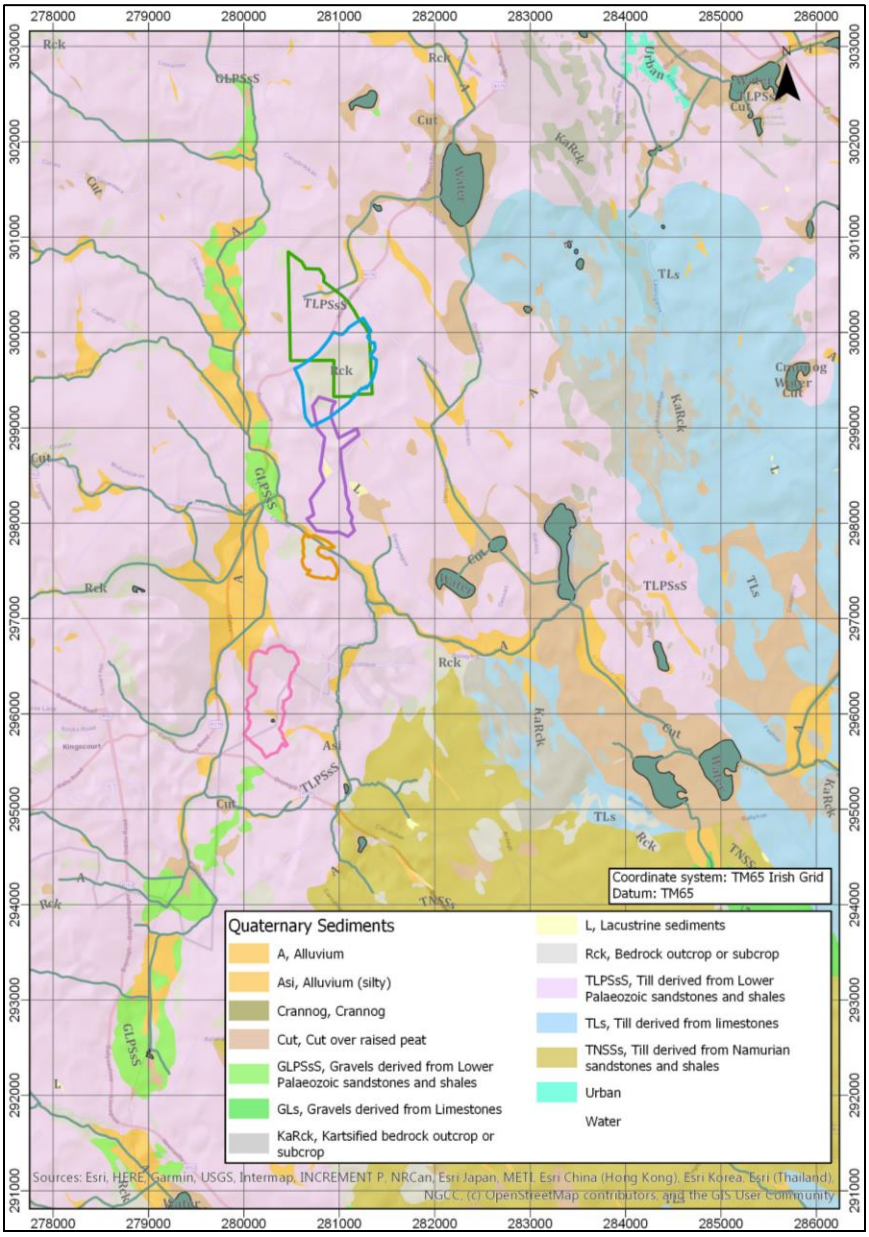
The dominant structural trend in the area is north to south, consistent with the strike of the main stratigraphical units, including the gypsum seams. The Kingscourt Fault is located about 1.5 km to the west and makes up the western boundary of the Kingscourt Gypsum sequence. Several other major faults in the sequence also trend north-south but have opposite throws (up to approximately 150 m) which, in combination, form graben-like structures. Roll and fault information for the Drumgoosat area also shows structures primarily following the north-south orientation, although some rolls are orientated in a northeast-southwest direction. The shaley units within the gypsum exhibit well developed bedding, with a regional bedding trend between 10° and 30° to the west.

Local mapping by British Gypsum also shows a set of north-south striking faults, corresponding with the major structural orientations of the area. Palaeokarst surfaces are evident on the surfaces of the gypsum beds, particularly the Upper Gypsum horizon, with post-depositional solution evident where the existing Knocknacran open cast mine has exposed the strata in the up-dip area to the east.

2.5 SUPERFICAL DEPOSITS

The Drumgoosat workings are overlain by till derived from the Lower Palaeozoic sandstones and shales (Figure 2.4). The average overburden thickness in the Kingscourt mining district is about 13 m. In the area of Drumgoosat, the available logs indicate the thickness may range between 8 and 33 m.

Figure 2.4: Overburden thickness in the Kingscourt mining district (after GSI)



The till layers are traversed by glaciofluvial sand and gravel deposits that mostly follow the channels of local watercourses. These deposits are notable along the course of the Magheracloone Stream, running north to south along the western border of the site. Some areas of peat are also present in topographic lows, along with some minor pockets of lacustrine sediments throughout the area.

2.6 PUMPING RECORDS

Scanned copies of hand-written pumping hour records are available from the period when Drumgoosat was being mined. The record was not continuous but included dates between 1981 and 1992. 1991 provided the best record and had pump capacity estimates so flows could be derived from the pumping hours record. It showed that a total of 92,691 m^3 was pumped from Drumgoosat between 9th January and 5th December 1991, giving an average flow of 281 m^3/day (about 3 L/s). Pumped flows were strongly seasonal ranging from 20 m^3/day in September to 870 m^3/day in March. This reflects the normal seasonal recharge pattern.

The Drumgoosat dewatering borehole is located at the south end of the workings. Pumping data are available for 2018 and 2019. Figure 2.5 shows the flow fluctuates between 0 and 1,400 m^3/d, depending on the pumping cycle. Table 2.2 provides a summary of the flow records. Recent flows have averaged about 200 m^3/day (2.3 L/s; 6,000 m^3/month).

Table 2.2: Estimated groundwater inflows to Drumgoosat workings and Knocknacran open cast

Month	1991 Drumgoosat pumping record (m^3/month)	Estimated current Drumgoosat groundwater inflow (m^3/month)	Estimated current Knocknacran groundwater inflow (m^3/month)
January	11 351	7 567	3 784
February	10 885	7 257	3 628
March	26 786	17 857	8 929
April	17 037	11 358	5 679
May	1 437	958	479
June	1 879	1 253	626
July	1 426	950	475
August	1 511	1 007	504
September	672	448	224
October	8 240	5 494	2 747
November	14 101	9 401	4 700
December	12 726	8 484	4 242
Total (m^3/year)	**108 049**	**72 033**	**36 016**
Average (m^3/month)	**9,004**	**6,003**	**3,001**
Average (m^3/day)	**300**	**200**	**100**

Downhole water level measurements in the Drumgoosat dewatering well are shown in Figure 2.6. Up to the time of the June 2018 Drummond mine inflow, water levels within the workings were generally maintained at between 960 and 970 maODM. Recent (post 2018) water levels are also maintained at about that level.

Figure 2.5: Pumping records from the Drumgoosat well since 2018

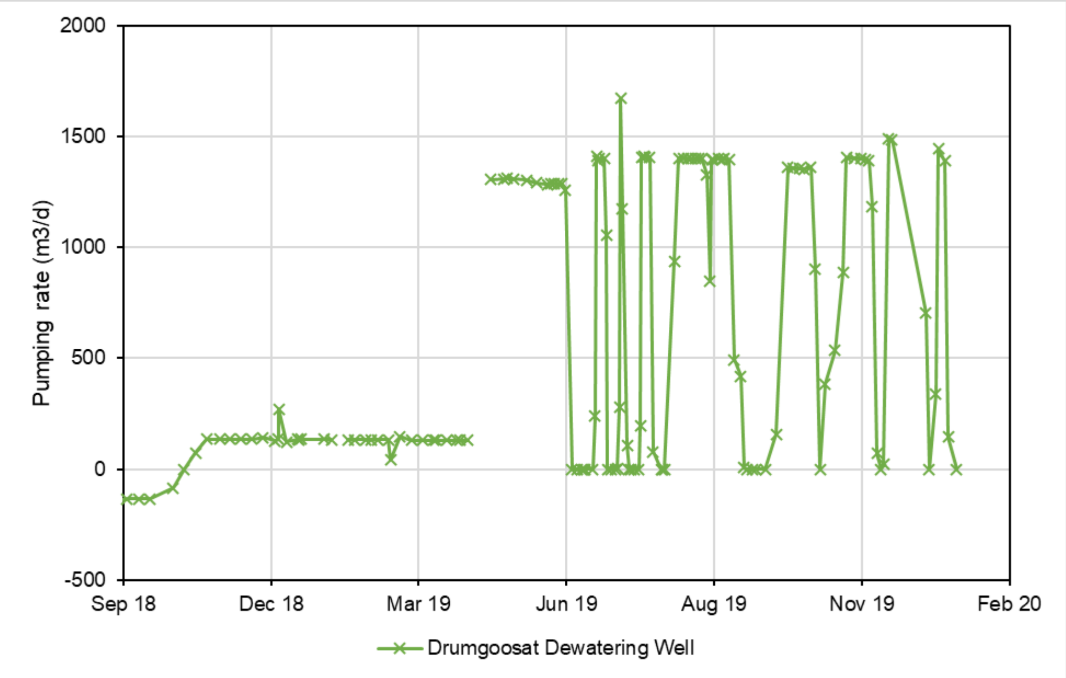


Figure 2.6: Water levels recorded in the Drumgoosat well

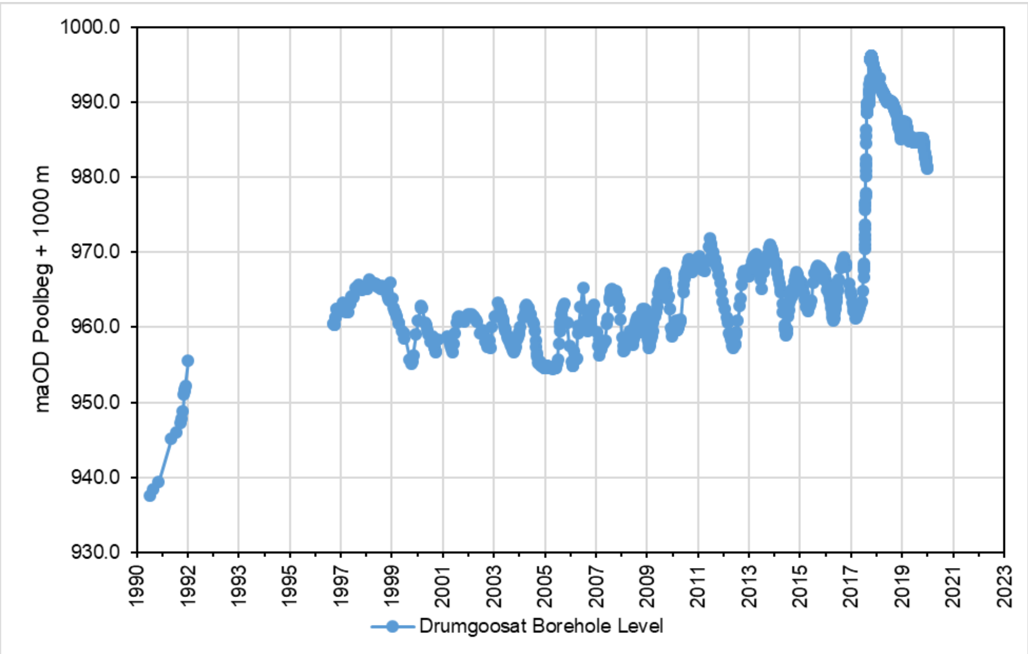


Table 2.2 also shows the estimated groundwater inflows to the Knocknacran open cast. The average inflow is estimated to be about 100 m³/d (1 L/s) indicating the small amount of water that reaches the gypsum strata in the north part of the mining district. The Knocknacran open cast is hydraulically connected to the Drumgoosat underground workings.

2.7 GROUNDWATER RECHARGE

The estimated footprint area of the Drumgoosat working is about 0.8 km². it was previously estimated that the area of hydraulic influence of the Drumgoosat underground is about 1.7 km² based on the geological model (Piteau, 2019). However, as discussed in Section 2.8 below, there is no observed drawdown in the superficial deposits, and the northeast part of the footprint area is drained by the Corduff stream.

Groundwater recharge in the area is mostly derived from infiltration of precipitation and localized runoff into field drains and ditches. Using an annual average precipitation rate of 955 mm and an annual average potential evapotranspiration rate of 515 mm (Section 2.1), and assuming actual evapotranspiration is 95% of potential, the effective rainfall for the area is around 466 mm/yr.

The GSI national groundwater recharge map indicates that natural recharge may locally range between 1 and 800 mm per year (**Error! Reference source not found.**) based on rainfall datasets held by the GSI that include annual rainfall, actual evapotranspiration, soil drainage, subsoil permeability, groundwater vulnerability and bedrock aquifer class. Locally, the GSI map indicates that recharge within the footprint study area is typically 100 to 200 mm/year, which represents about 10 to 20% of mean annual precipitation and 22 to 42% of the effective rainfall. The estimate is considered to be slightly high given the local topography and drainage but is reasonable for planning purposes. It represents a conservative estimate for predicting on-going recharge to the underground mining areas.

Recharge in Ireland primarily occurs between October and March when rainfall exceeds evapotranspiration i.e. when the soil water is at field capacity. From March to October, the opposite is often true when the soil moisture is in deficit. However, in recent years, high summer rainfall has also produced recharge. For the current study, an average recharge rate of 200 mm/year has been assumed based on the discussion above. For a capture area of 0.8 km², the represents a potential recharge rate of 438 m^3/day.

2.8 GROUNDWATER LEVELS

Figure 2.shows hydrographs for the six wells believed to be representative of superficial deposits (mostly till). Locations of the wells are shown on Figure1.2 and 2.8. The observed water levels range between 28 maODM (95 A2) and 50 maODM (MW5 P2). The water elevation typically reflects the topography and the elevation of the well collar. The depth to water in the wells is typically in the range of 0.5 to 2 m.

Figure 2.7: Hydrographs for wells thought to be screened in superficial deposits (till)

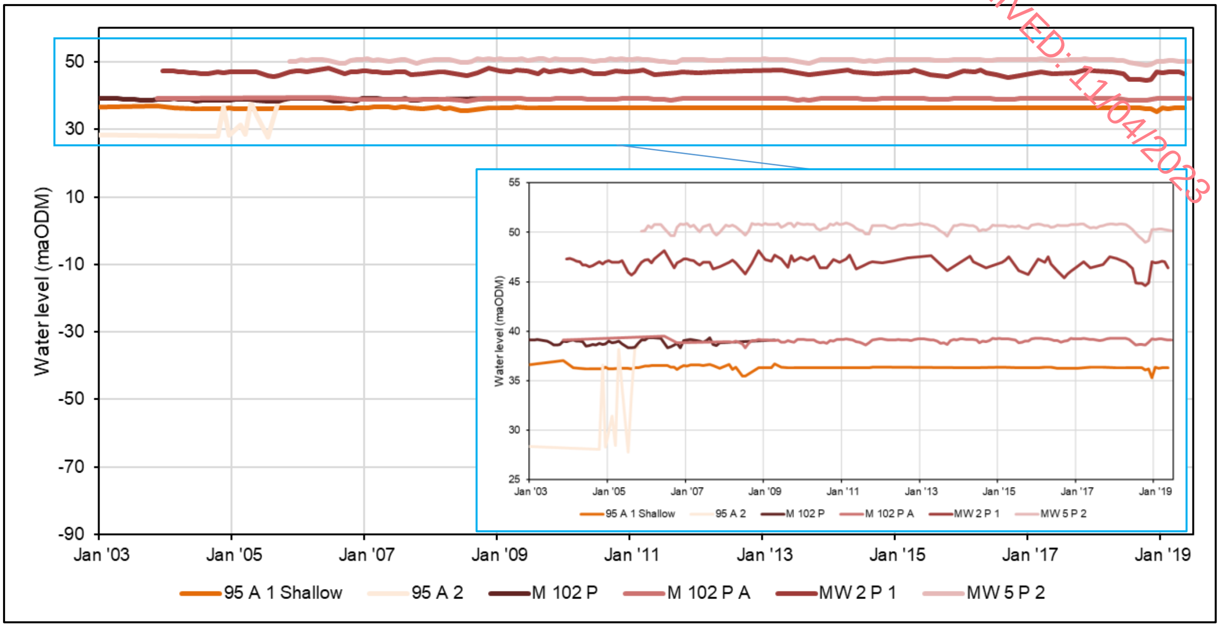
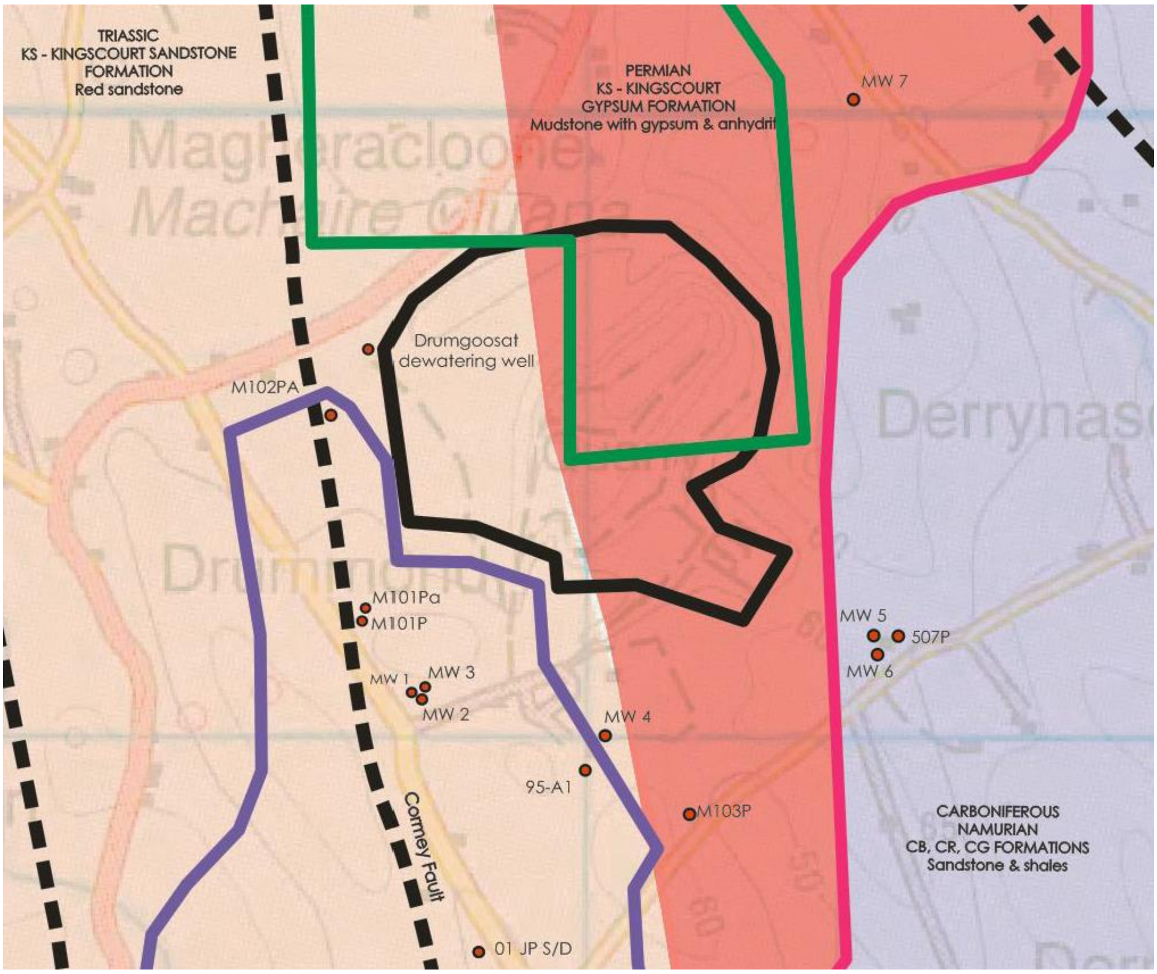


Figure 2.8: Groundwater monitoring well locations around Drumgoosat



All wells show a seasonal fluctuation, except for 95 A 1. The largest seasonal fluctuation is typically seen in MW2 P1, located close to the northern margin of the Drummond underground mining area. This showed a water level reduction of about 3 m during the dry summer of 2018; recovering during the recharge period towards the end of the year. The seasonal variation is due to recharge from October to March (increasing levels) and evapotranspiration between April and September and discharge to local diches or small streams (falling levels).

As is seen in other mining districts in Ireland (and worldwide), the behaviour of water levels in superficial deposits tends to be mostly independent of conditions in the underlying bedrock formation. All superficial observation wells are above or very close to mine workings but there are no declining trends in any of the superficial groundwater monitoring points, which suggests that any leakage from the alluvium to the dewatered underground mining areas would represent only a small part of the near-surface water balance in the superficial deposits. The seasonal fluctuation in MW2 P1 appears to be related to natural climatic cycles. There are no trends that would indicate long term drawdown or changes due to the mining operations.

3. GROUNDWATER MODEL

3.1 GENERAL

A numerical groundwater flow model has been developed for the Drumgoosat workings to help quantify the amount of recharge and the groundwater flow paths in the mining area. The glacial till occurs across the entire model domain. The model includes the underlying gypsum sequence as defined in the geological model. The Upper and Lower Gypsum beds are variably intercalated within or at the base of the mudstone. In the model domain, the gypsum beds dip to the west at 10 to 15^{o} along a strike-length of 650 m or more.

The focus of the model was to help assess groundwater flow pathways and determine how much recharge may enter the workings on an on-going basis. The modelling steps were as follows:

- Construction of the model, to include the existing workings.
- Assignment of boundary conditions (Seepage face; Constant head)
- Assignment of material properties
- Calibration to the available water balance data

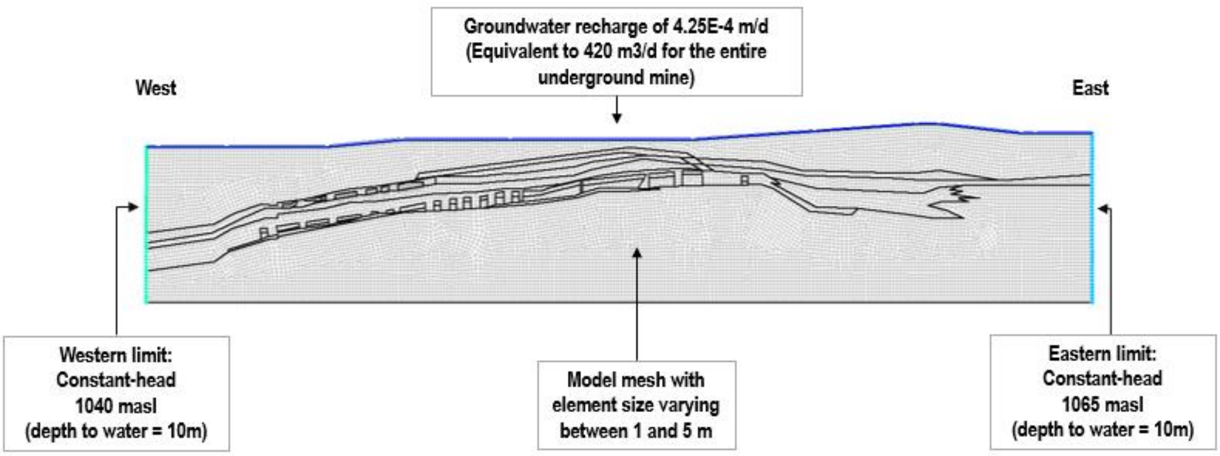
The cross section shown in Figure 2.2 was selected for model development as it provides the most representative geological sequence above the mining area. The model was based on the detailed review of available monitoring data described in Section 2. Calibration of the model was carried out using observed flows from the Drummond well.

3.2 MODEL CONSTRUCTION

The model was constructed in 2D in order to get a representation of the vertical groundwater flow pathways and head gradients. The model uses the SEEP/W code (2018). The software is based on the principle of finite elements and supposes a discretisation of the model for the resolution of flow equations. The discretisation (or 'meshing') consists of subdividing the cross section into smaller elements. The finite element method defines the variation of head within an element by means of interpolation functions. Groundwater heads are calculated at all nodes within the model domain before integrating them into the global matrix. Most of the codes for the numerical modelling of flow and contaminant transport are based on this principle.

For model construction, the meshing of regions was completed with points, lines and polylines. Both the Upper and Lower Seams were discretized in the model geometry. The model was populated with a finite element mesh which defines all stratigraphic and structural features which are considered likely to exert control on groundwater flow, including lithology and structure. Figure 3.1 shows the mesh used within the model grid. The total length of underground workings included in the 2D section is equivalent to 650 m. A multiplication factor of 1,186 was used to extrapolate model results to the entire underground workings.

Figure 3.1: Drumgoosat model grid



3.3 HYDRAULIC PROPERTIES

Matrix hydraulic properties are important inputs for the simulation of infiltration and seepage dynamics. The saturated volumetric water content and saturated hydraulic conductivity are given greater importance over their unsaturated equivalents. Therefore, material properties of the hydrogeological units have been determined for modelling purposes with respect to three fundamental sets of variables:

- Soil moisture retention or suction curves, which express the pore pressure versus water content relationship of any given material, as governed by void volume and matrix suction.
- Volumetric water content describes the capability of a porous material to store water as a function of the matrix pressures. Under unsaturated conditions, the water stored is dependent of the matrix suction which is the difference between pore-air pressure and pore-water pressure. The volumetric water content was defined based on experience on similar geological settings.
- Hydraulic conductivity (K) which refers to the ability of material to conduct water under variably saturated conditions. The maximum hydraulic conductivity of a soil or rock medium is under saturation and decreases in accordance with the suction curve, as the water content falls below saturation.

The saturated hydraulic conductivity values assigned to the hydrogeological units were based on analysis of vertically discretized groundwater level data from three HQ (96 mm diameter drill hole) piezometer holes drilled through the gypsum strata in 2014 in the Enagh Bog area (Minerex, 2014). The data collected from these holes captures the vertical hydraulic layering which is expected in the layered mudstone strata above the historical Drumgoosat workings. Each hole was completed with 23 mm ID (33 mm OD) PVC pipe, with a 6 m perforated interval in the bottom. The base of the perforated interval was positioned immediately above the top of the Lower Gypsum unit; i.e. in weathered dolerite or mudstone. The base of the perforated interval was 59.1 m below ground in KC 14A, 101.0 m below ground in KC 14B, and 31.9 m below ground in KC14C (Minerex, 2014).

The location of the piezometer holes is shown in Figure 3.2. Each borehole was filled with cement bentonite grout up to the base level of the perforated interval. Washed coarse sand was installed opposite the perforated section and to 1 m above the perforated interval in each hole. The borehole annulus from the top of the sand pack up to ground level was filled with cement bentonite grout (Minerex, 2014).

During drilling, the water level each borehole was measured at the start of each daily shift.

Figure 3.3 shows that the measured depth to water typically increased as the depth of the holes increased, illustrating a downward hydraulic gradient. KC 14A and KC 14C were reported to be similar in terms of degree of weathering of dolerite. KC 14B was drilled further downdip exhibited less weathering. It is reported that the drillers had difficulty installing the piezometer pipe in each hole. Following the completion of drilling, standing water levels in each of the completed piezometers were reported as being close to the piezometer base; i.e. just above the top of the Lower Gypsum unit.

Figure 3.2 Location of piezometer holes KC 14A, KC 14B and KC 14C (Minerex, 2014).

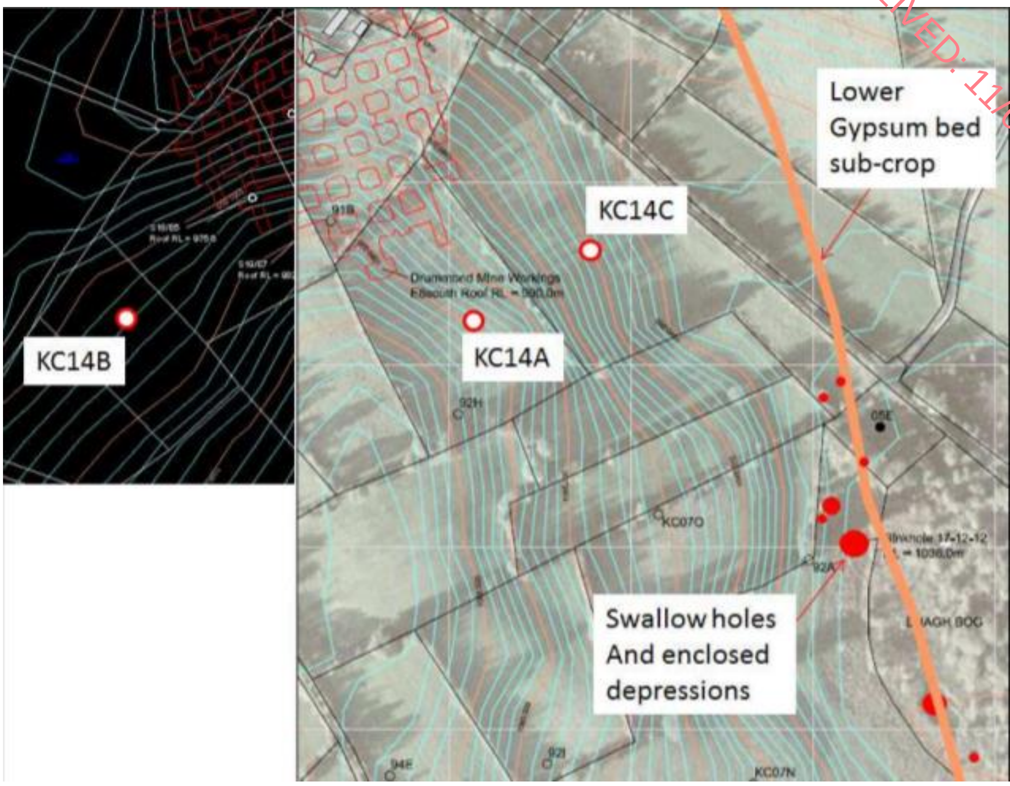
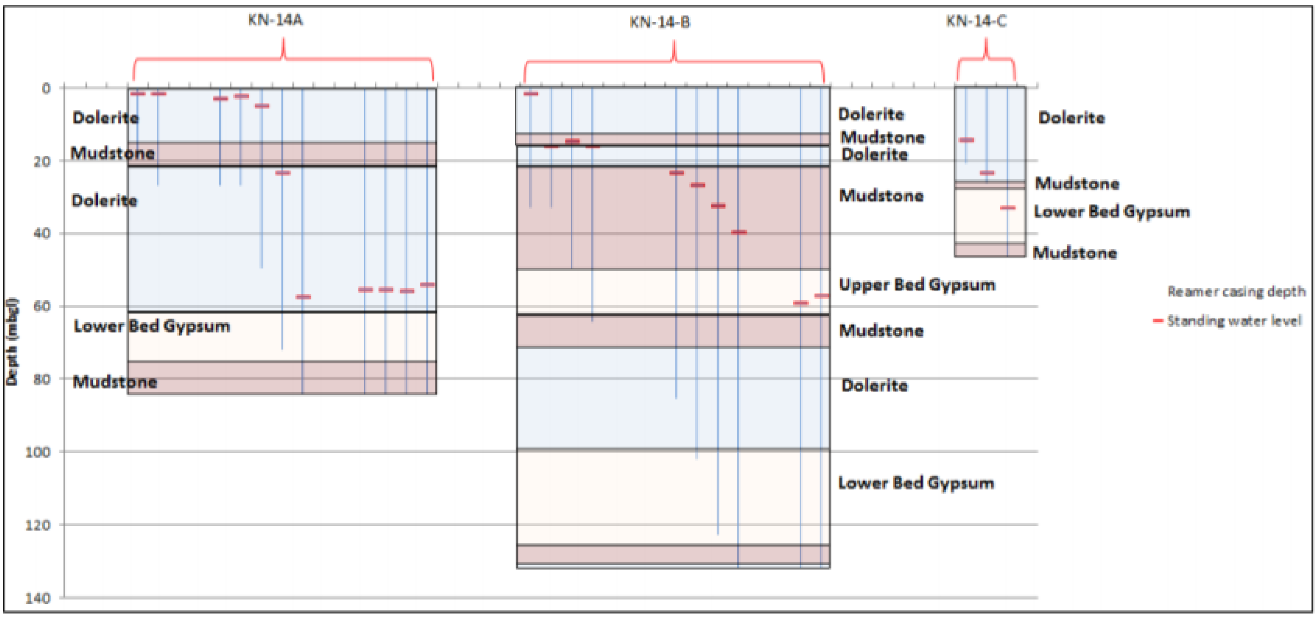


Figure 3.3 Water levels reported during the drilling of piezometer holes KC 14A, KC 14B and KC 14C (Minerex, 2014). In each case, the thin blue line represents the depth of the hole when the water level measurement (in red) was taken



The water level measurements indicate a strongly layered groundwater system with multiple minor perched groundwater zones on individual layers in the gypsum strata and dolerite. Permeability values calculated from testing carried out in the completed piezometers were within the range 10^{-6} to 10^{-7} m/s. These values are low but would allow preferential percolation and slow seepage along individual beds. The values likely represent horizontal permeability (K_h). Values of vertical permeability (K_v) can be expected to be lower.

3.4 BOUNDARY CONDITIONS

Boundary conditions determine where the water enters and leaves the model. They are used to replicate (using mathematical expressions) the state of the physical boundaries which constrain the groundwater system (i.e. sources and/or sinks of water). An important function in SEEP/W is the management of seepage surfaces. Figure 3.1 shows the boundary conditions assigned to the model. The boundary conditions correspond to constant head boundaries. These conditions maintain a hydraulic head representative of groundwater levels at the edges of the model.

Modelled discharge to the underground workings is represented with a 'seepage' boundary condition. This boundary condition is used because neither H (head) nor q (flux) are known at the location of each node. A seepage face will only allow outflow from the model equal the amount of water arriving at the location of the discharge point.

The top of the model is assigned with a Unit-Flux (or 2nd kind) boundary condition. Precipitation data for the model domain area were applied to generate initial estimates of recharge. Total recharge was calculated on this basis to be of the order of 420 m^3/day which is of the same order (about 25% higher) than the estimate based on the GSI maps and is consistent with the calculated value described in Section 2.7 (above).

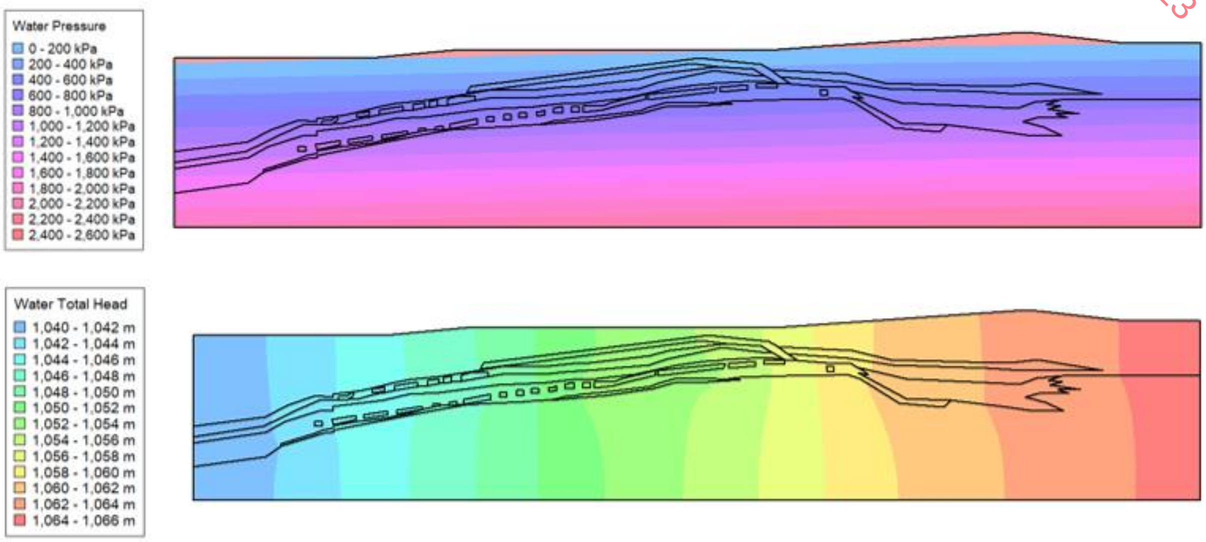
3.5 MODEL RESULTS

The model was calibrated based on the calculated recharge flux and the observed dewatering rate from the Drumgoosat well. The calibration was used to ensure the model accurately replicates the site observations. Hydraulic properties in the model were varied until a reasonable match was achieved to the observed pumping rate.

The model was set up with a steady state time-step to represent current hydrogeological conditions. While mining operations have occurred for several decades, conditions are now considered to be in steady state, so transient model runs were considered unnecessary.

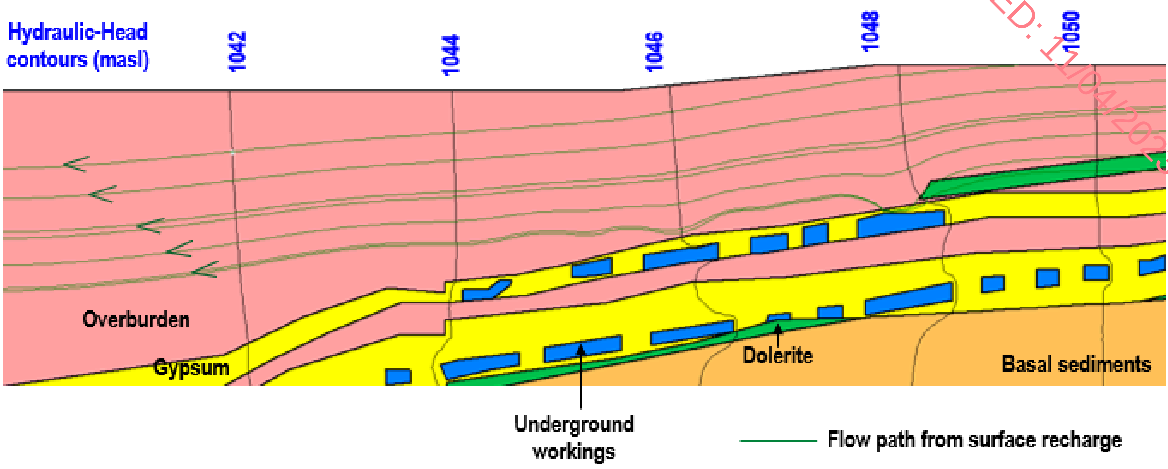
Consequently, the model was set-up with one steady-state stress period to simulate long-term flow at the current equilibrium. The simulated head distribution from the model is shown in Figure 3.4.

Figure 3.4: Simulated steady state modelled heads



The simulated hydraulic head distribution suggests that around half the applied recharge migrates laterally (down-dip) within bedding in the mudstone and along the contact of the mudstone and the Upper Gypsum unit without entry to the mine voids (Figure 3.5). The model shows perched groundwater zones above the roof of the workings, with semi-saturated flow occurring down-up within the strata, rather than vertically downwards to the underground workings. Recharge from surface is percolating slowly downward through the gypsum sequence and becoming retained on lower permeability (K_v) horizons throughout the sequence. The overall groundwater flux moving into the underground mine is equivalent of 195 m^3/day, which is approximately 45% of the groundwater recharge). The model therefore matches well with the observed average pumping rate of 200 m^3/day from the Drumgoosat dewatering borehole.

Figure 3.5: Modelled groundwater flow vectors



4. WATER CHEMISTRY MODEL

4.1 GROUNDWATER CHEMISTRY

The Minerex annual monitoring reports include water chemistry plots for all monitoring wells. Most groundwater in the area is near-neutral to slightly basic pH; with high chloride and sodium and moderate sulphate and calcium. For the current study, the groundwater chemistry characterization has been performed using: (i) monitoring boreholes completed within each of the major hydro-stratigraphic units described in Section 2.2, and (ii) two recent water samples taken from the Drumgoosat dewatering well on 25 February and 24 March 2021 (Appendix A). The two samples from the Drumgoosat dewatering borehole are similar, as follows:

- The sample of 25 February showed elevated values of calcium (422 mg/l), sulphate (2,133 mg/l) and magnesium (99 mg/l). Reported chloride is 278 mg/l and sodium 378 mg/l. The water is gypsum saturated. Bicarbonate alkalinity is 134 mg/l $CaCO_3$ and reported laboratory pH is 7.5.

- The sample taken on 24 March was slightly more concentrated and showed higher values of calcium (545 mg/l), sulphate (2,152 mg/l) and magnesium (125 mg/l). Reported chloride is 289 mg/l and sodium 467 mg/l. Again, the water is gypsum saturated. Bicarbonate alkalinity is 125 mg/l $CaCO_3$. Laboratory reported pH is 7.8.

Data for pH, electrical conductivity (EC) and major ions from sampling campaigns conducted in 2019 are presented in Table 4.1. A consistent trend is evident of increasing TDS with depth. Due to the significant gypsum presence in the mudstone which overlies the Upper Gypsum unit, recharge passing through this sequence characteristically holds concentrations of Calcium (Ca) and sulphate (SO_4) of the order of 500 and 1,400-1,650 mg/L, respectively. Figure 4.1 shows calcium concentrations with time for several of the monitoring wells. Figure 4.2 shows trends in sulphate. Understanding the higher values of calcium and sulphate is important with respect to long term underground mine stability as inflow is subject to partial equilibration with respect to gypsum prior to entry to the flooded mine voids.

Sulphate, electrical conductivity and flow measurements in the Drumgoosat wells are shown in Figure 4.3. Sulphate values are typically within the range 2,000-2,200 mg/l, with a slight increasing trend in the past 12 months. The reported time series values are consistent with the laboratory values (Appendix A) and indicate the water is gypsum saturated.

Table 4.1: Major ion composition of Drumgoosat groundwater (2019 data) in major hydro-stratigraphic units and in water pumped from the mine void

	BOREHOLE	MW5-P2	MW3-P2	MW1-P3	95A	MW3-P2	
	LIHOLOGY	Alluvial	Mudstone Middle	Mudstone Upper	Dolerite	Mine water	Drumgoosat well
HCO_3	**mg/l**	215	195	54		264	
NH3-N	**mg/l**	0.0353	0.186	0.0894	0.611	0.25	
Ca	**mg/l**	57.7	518	494	421	701	
Cl	**mg/l**	7.8	48	32	12	65	
EC	**µS/cm**	431	2478	2390	2610	3354	
Mg	**mg/l**	15.8	78.6	112		106	
NO3-N	**mg/l**	<0.0677	0.03385	<0.0677		0.046	
pH	**SU**	7.68	7.78	7.58	7.38	11	7.59
K	**mg/l**	1.55	7.45	6.56		10	
Na	**mg/l**	16.4	72.1	103		98	
SO4	**mg/l**	18.2	1640	1470	2220	2220	2040

Figure 4.1: Calcium trends with time in monitoring boreholes

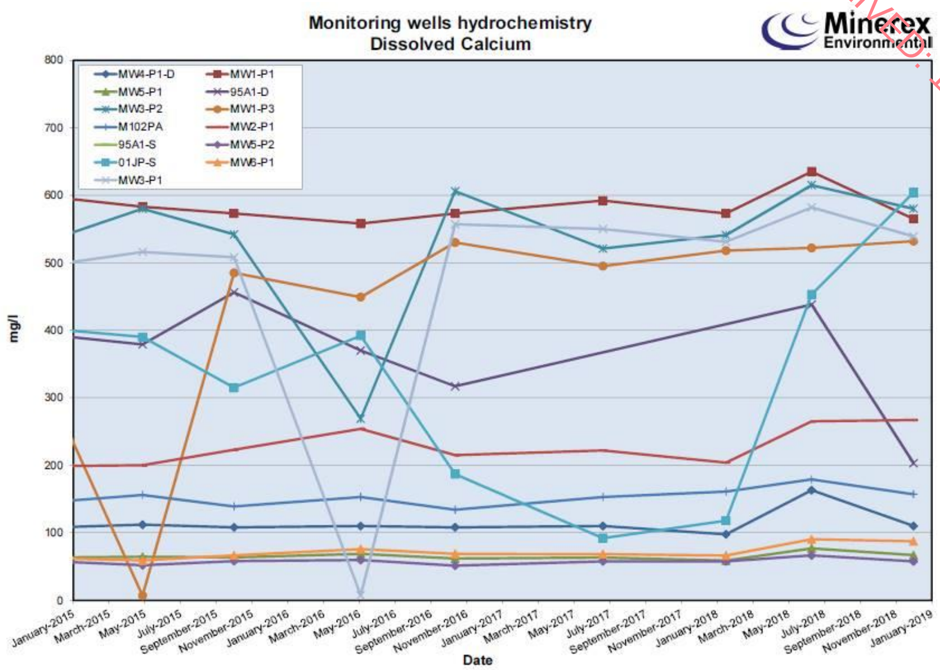


Figure 4.2: Sulphate trends with time in monitoring boreholes

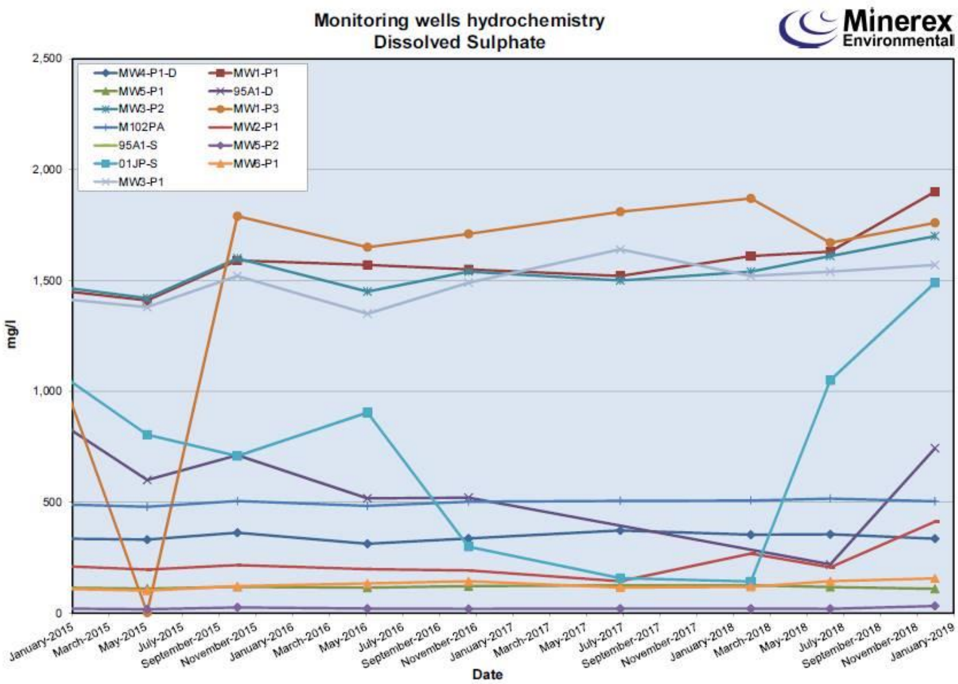
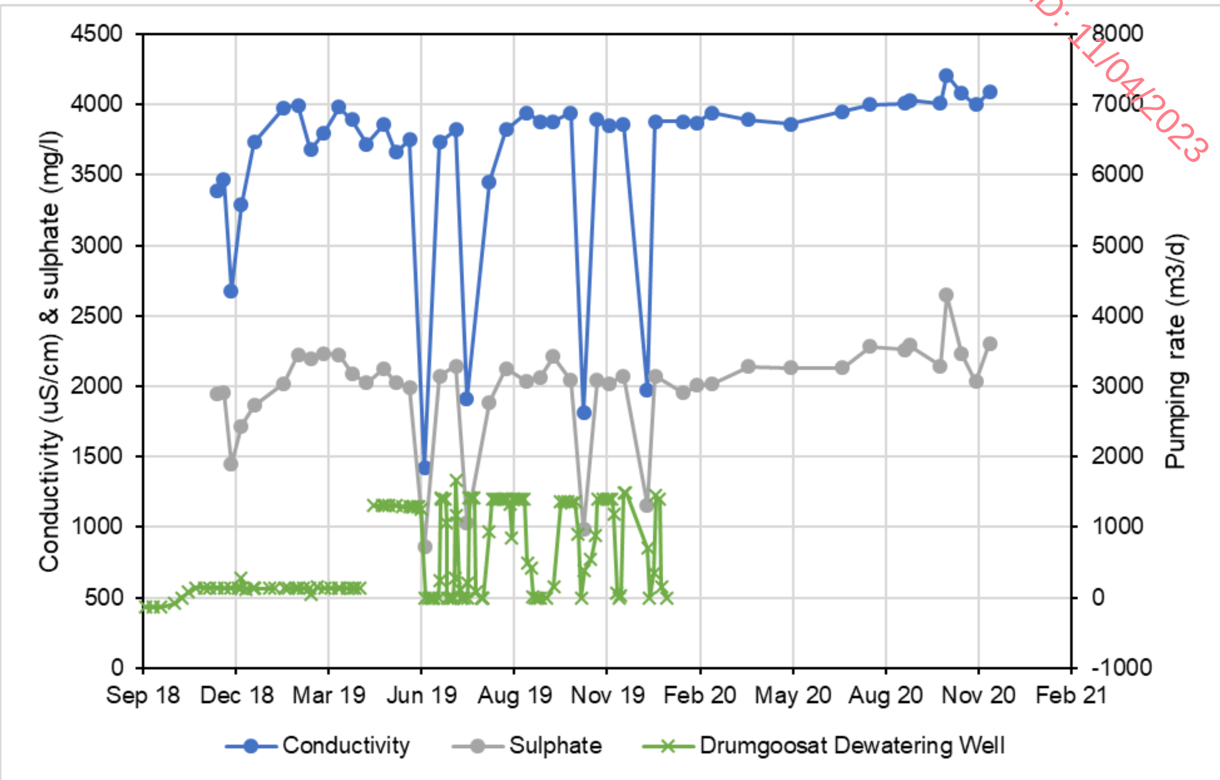


Figure 4.3: Sulphate, electrical conductivity and pumping rate for the Drumgoosat dewatering borehole (2018-2021)



4.2 CONTROLS ON GYPSUM DISSOLUTION

Since the closure of the Drumgoosat mine in 1991, the workings have been partially inundated by natural recharge. Following the intersection of the “June 2018 mine fault” in the Drummond mine, additional water was pumped into the Drumgoosat workings for a period of approximately six months. The estimated total void space in the Drumgoosat workings is of the order of 800,000 m^3. Structural support for the workings is provided by pillars left in place within the gypsum beds during mining.

The potential for gypsum dissolution by groundwater to reduce the long-term stability of the mine workings has been investigated based on the available mine geology and water chemistry data. The potential for gypsum dissolution is influenced by several factors including temperature, mineral purity and crystallinity, macro/micro-structure of the gypsum mass, the rate of water exchange at the reactive surface and, most critically, the extent to which water is under-saturated with respect to gypsum. The last of these variables determines the effective kinetics of gypsum dissolution, in accordance with the general relationship:

Equation 1:

$$\frac{dm}{dt} = KA(C_s - C)$$

Where *m* is the gypsum mass, *t* is time, K is the dissolution coefficient for gypsum in pure water, A is the area of gypsum in contact with water, Cs is the equilibrium (saturation) concentration of gypsum for the ambient temperature and pH condition and C is the actual concentration of gypsum in solution. When the *Cs – C* differential is zero, dissolution of gypsum ceases to occur. This is a relatively common condition in the deepest sectors of flooded mines where the flow is influenced by density stratification of the water within the workings.

4.3 WATER CHEMISTRY MODEL

The significance of gypsum dissolution for long term underground stability of the Drumgoosat workings has been assessed using numerical model estimates of recharge to the mine as a basis for quantifying water residence time in the mine voids. Predicted rates of water exchange in the voids were then integrated into a thermodynamic geochemical model to simulate gypsum dissolution.

Geochemical modelling was undertaken using the public domain thermodynamic equilibrium software PHREEQC. The software is produced and regularly updated by the US Geological Survey and is the industry-standard tool in the minerals sector for simulation of solid-solution interactions and prediction of mine water chemistry. PHREEQC was applied to simulate gypsum dissolution in the Drumgoosat workings using two independent approaches:

- Quantification of the mass of gypsum which would be required to dissolve to maintain a constant condition of saturation within the mine water body. Thermodynamic data drawn from the MINTEQ4 database were used to calculate the equilibrium concentration of gypsum in solution. These were used in combination with recharge rates and 'antecedent' solution chemistry data to define the moles of gypsum which could theoretically dissolve from wall rock per unit time.

- Calculation of the concentrations of Ca and SO_4 which could be sustained in solution within the mine workings at the recharge rates indicated by the numerical groundwater flow model, the antecedent chemistry of the recharge and the kinetics of gypsum dissolution anticipated in the specific setting of the mine voids.

4.4 THERMODYNAMIC LIMITS

The data shown in Table 4.1 indicate that the ratios of Ca/Mg and Ca/Na are high throughout the mudstone and gypsum bed units of the recharge path. The concentration of SO_4 which may be sustained in the mine water will therefore be almost exclusively controlled by gypsum saturation. Using this assertion, modelling was performed in PHREEQC to determine the mass of gypsum which would theoretically be dissolved to maintain constant gypsum equilibrium in the flooded mine void, assuming a recharge rate of 200 m^3/day at a composition as shown for borehole MW1-P3 in Table 4.1. This mass was then applied to calculate an attrition rate for any pure gypsum surface in the mine.

The levels of Ca and SO_4 in the MW1-P3 recharge water are shown by PHREEQC to correspond to a saturation index (SI) of -0.128. Dissolution of around 3.3 moles of gypsum per m^3 of water (90 kg/day) entering the void is shown by the model to produce a positive SI (0.064). At this point, further dissolution should effectively terminate. At a density of 2.0, the total theoretical volume of gypsum subject to dissolution in the mine would be of the order of 16.4 m^3 per annum. Since the Upper Mudstone forms the most upstream part of the flow path for any infiltrating water (see Section 3.3), it is anticipated that much of the theoretical gypsum dissolution would occur above the roof of the workings, and that water which entered the workings would already be at (or close to) an SI of 0.064. The surface attrition rate for pure gypsum would be about 0.075 mm annually, mostly occurring from fractures in the upper mudstone. The layered nature of the flow paths explains why many of the observed natural cavities are within the Upper Mudstone and Upper Gypsum seam, rather than deeper in the sequence.

Most of the gypsum exposed underground and within the pillars is likely to be strongly crystalline and would demonstrate a low rate of water exchange at the reactive surface. The potential for gypsum dissolution would be expected to be low because of the crystalline nature of the pillars and the likelihood that the water is already saturated with respect to gypsum.

4.5 KINETIC CONTROLS

The ability for gypsum dissolution to cause mechanical changes to the formation is more likely to be a function of kinetics (physical movement) and not of thermodynamics (degree of under-saturation and pH). In Palaeozoic and Mesozoic rocks, the kinematics of crystalline gypsum dissolution is typically slow and tends to be associated with water movement (rather than thermodynamics).

Reported alkalinity for the monitoring wells is mostly high but is also variable between sampling stations. For samples that have high alkalinity, the sulphate and calcium are relatively low, suggesting that the water has not had significant residence time within any of the gypsum horizons. Samples that have high sulphate also tend to show high calcium (this is expected) and sodium which suggests the water has had contact with gypsum and other evaporite lithologies. Any groundwater that comes into contact with gypsum will, in principle, cause gypsum to dissolve, provided the water is unsaturated. The rate of dissolution is dependent on the extent of under-saturation and also the pH of the water (lower pH = faster dissolution). Although the groundwater samples for the mudstone are not quite saturated with respect to gypsum, the levels of Ca and SO_4 are high and would likely approach saturation following initial contact with the Upper Mudstone and Upper Gypsum seam. If flow through the fractures or formation voids is sufficiently slow, gypsum will dissolve, reach equilibrium and then begin to re-precipitate.

The concentrations of Ca and SO_4 in mine void water, including that abstracted from the Drumgoosat well, equate from modest to super-saturation with respect to gypsum. This suggests that dissolution is not constrained by residence time or the kinetics of the reaction. Verification of this was undertaken by reference to published experimental data for gypsum dissolution kinetics and by modelling using a kinetic function in PHREEQC.

At an aqueous SI of -0.5, empirical dissolution rates range between 1 x 10^{-3} and $1x10^{-5}$ mmol per cm^{-2} per s^{-1}. Up to an SI of around -0.4, dissolution rates vary in near-linear fashion in accordance with the C*s* - C differential of Equation 1 (above). As water approaches equilibrium, the kinetics of dissolution slow-down and become non-linear. At an SI of -0.1, analogous to the available mudstone groundwater samples overlying the Upper Gypsum seam, a rate of 1 x $1x10^{-8}$ mmol per cm^{-2} per s^{-1} could be considered reasonable. Using the lower of the wall rock surface criteria applied for thermodynamically based estimates of surface attrition, the kinetically constrained limit to gypsum dissolution would be around 112 kg/day, thus modestly exceeding the 90 kg/day required to maintain continuous gypsum equilibrium in the mine water. This confirms that the potential rate of gypsum dissolution from the underground workings would be extremely low.

5. CONCLUSIONS AND RECOMMENDATIONS

The goal of the current study is to assess the hydrogeology of the Drumgoosat mine area and specifically whether on-going dissolution of gypsum may have the potential to influence long term stability.

Underground mining operations at Drumgoosat terminated more than three decades ago. Since then, the mine workings have received natural groundwater recharge which has been pumped out by the Drumgoosat well.

About half of the available groundwater recharge migrates laterally (down-dip) along the stratigraphical (bedding) contacts above the roof of the workings without entry to the mine voids. The amount of water entering the Drumgoosat workings was modelled to be about 200 m^3/day.

Rates of gypsum dissolution in the recharge water are influenced by several factors including initial chemistry, temperature, mineral purity and crystallinity, macro/micro-structure of the gypsum mass, the rate of water exchange at the reactive surface and, most critically, the extent to which water is under-saturated with respect to gypsum.

Groundwater in the mudstone above the workings already has high levels of Ca and SO_4, suggesting that much of the gypsum dissolution would occur as the water percolates through the stratigraphic sequence above the workings. Some of the Ca and SO_4 loading would move down-dip and not enter the workings. The balance of the recharge that entered the workings would likely be already saturated (or close to saturation) with respect to gypsum.

At the low rates of recharge, it is likely that gypsum will dissolve, reach equilibrium and then begin to re-precipitate. The actual rate of gypsum dissolution from the underground workings can be expected to be very low because: (i) the water is already saturated with respect to gypsum, and (ii) most gypsum exposed underground and within the pillars is likely to be strongly crystalline and would demonstrate a low rate of water exchange at the reactive surface. Thus, the potential for gypsum dissolution to effect stability in the underground workings is considered to be low.

A comprehensive monitoring program is already in place to assess the stability of the workings. In addition to this, the instantaneous and cumulative flow from the Drumgoosat well should be monitored on an on-going basis. Field parameters from the pumped water (pH and electrical conductivity) should be monitored at least monthly, along with sulphate. A full water sample should be taken at least annually to confirm the gypsum saturation.

6. LIMITATIONS

Piteau Associates has exercised reasonable skill, care and diligence in obtaining, reviewing, analysing and interpreting the information acquired during this study, but makes no guarantees or warranties, expressed or implied, as to the completeness of the information contained in this report. Conclusions and recommendations provided in this report are based on the information available at the time of this assessment.

In preparing the recommendations contained herein, Piteau Associates has relied on information and interpretations provided by others. Piteau Associates is not responsible for any errors or omissions in this information. This report is comprised of text, tables, figures, photos and appendices, and all components must be read and interpreted in the context of the whole report. The report has been prepared for the sole use of Saint-Gobain Mining Ireland (Ltd.), and no representation of any kind is made to any other party.

Respectfully submitted,

PITEAU ASSOCIATES LTD.

Geoff Beale
Principal

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9.0 CLIMATE

9.1 Introduction

Directive 2014/52/EU recognises that climate change will continue to cause damage and compromise economic development, and that it must be incorporated into the decision-making process. This chapter considers climate change resilience and adaptation, i.e., how the Proposed Development may interact with a changing climate and whether this interaction has the potential to result in significant environmental effects.

This chapter of the EIAR considers and assesses potential effects resulting from the Proposed Development; both the Mine Development and the further development of the Community Sports Complex.

The potential for the Proposed Development to contribute to climate change effects during construction, operational and closure/restoration phases is also assessed.

9.2 Legislative and Policy Context

9.2.1 Relevant Legislation

The need for an assessment of climate impacts is set within an extensive International, European and National legislative and policy context, a summary of which is set out below.

9.2.1.1 International Context

The Kyoto Protocol (adopted in 1997) was the first international agreement in which many of the world's industrial nations committed to a reduction of their emissions of six greenhouse gases (GHGs) in order to prevent global warming. It set binding targets for 37 industrialized countries and the European Community for reducing emissions to an average of five per cent against 1990 levels over the five-year period 2008-2012. This was a strengthening of the United Nations Framework Convention on Climate Change signed by 154 states in Rio de Janeiro in 1992, which had encouraged rather than committed countries to stabilize GHG emissions. The Conference of Parties (COP) is the decision-making body responsible for monitoring and reviewing the implementation of the United Nations Framework Convention on Climate Change. The COP meets every year, unless the Parties decide otherwise. The Paris Agreement was established at COP21 in Paris in 2015 and is an important milestone in terms of international climate change agreements. It is a legally binding international treaty on climate change, the goal of which is to limit global warming to well below 2°, preferably to 1.5° Celsius, compared to pre-industrial levels.

In August 2021, the Intergovernmental Panel on Climate Change (IPCC), which is the United Nations body for assessing the science related to climate change, released the Working Group contribution to the Sixth Assessment Report (AR6). AR6 provides the most recent synthesis of climate data and projections, covering literature and modelling studies and uses much stronger language than previous reports regarding human impact on climate change and the need for GHG mitigation. It summarizes the projections available from an updated ensemble of climate models that include better representations of the physical, chemical, and biological processes, some with higher resolution, and provides evidence of the 'overwhelming' influence of humanity on the climate system.

9.2.1.2 European Context

In October 2014, the European Council agreed the 2030 Climate and Energy Framework, which included actions such as setting out targets for reducing GHG emissions and reforming the EU Emissions Trading Scheme (ETS). The Framework proposed a commitment to an overall EU reduction of at least 40% in GHG emissions by 2030 compared to 1990 levels. The EU ETS legislation was revised in 2018 to enable it to achieve the EU's 2030 emission reduction targets in line with the 2030 Climate and Energy Policy Framework and as part of the EU's contribution to the 2015 Paris Agreement. The EU ETS is implemented in Ireland under S.I. 490 of 2012 and amendments and S.I. No. 261 of 2010 and amendments. The Effort Sharing Regulation was adopted in 2018 as part of the EU's implementation of the Paris Agreement. It established binding annual GHG emission targets for Member States for the periods 2013–2020 and 2021–2030. These targets concern emissions from most sectors not included in the EU ETS, such as transport, buildings, agriculture and waste.

The gypsum industry is included within EU ETS legislation, specifically within Schedule 1 of the European Communities (Greenhouse Gas Emissions Trading) Regulations 2012 (S.I. No. 490 of 2012). The EU ETS is a "cap and trade" scheme where a limit (the cap) is placed on the right to emit specified pollutants over a geographic area and heavy penalties are imposed if companies do not comply. Alternatively, companies can trade emission rights within that area, keeping spare allowances for use in future or selling spare carbon allowances. The Scheme makes investing in environmentally friendly technology economically beneficial for industry. It is administered in Ireland by the EPA.

Saint-Gobain Mining Ireland Ltd (SGMI) holds a Greenhouse Gas Emissions Permit (IE-GHG002-10335-5) under the EU ETS legislation. The permit, which was issued by the EPA in November 2020, relates to the 'Kingscourt Works' installation, i.e. the factory site, approximately 11 km southwest, where the extracted material from the Proposed Development is processed.

9.2.1.3 Irish Context

The Climate Action and Low Carbon Development National Policy Position for Ireland was published in 2014 with the Act of the same name being published in 2015. The Act sets out the national objective of transitioning to a low carbon, climate resilient and environmentally sustainable economy in the period up to 2050. The Act introduced a requirement for the preparation of a National Mitigation Plan and a National Adaptation Framework to specify tools and structures for transitioning to a low carbon economy. The first National Mitigation Plan was published in July 2017 by the Department of Communications, Climate Action and Environment. The Plan was designed to be a whole-of-Government approach to tackling greenhouse gas emission, however, it was subject to a Supreme Court judgement dated July 2020. The judgement identified and concluded that there was a lack of appropriate transparency, which is required in accordance with the Climate Action and Low Carbon Development Act 2015. The outcome of the assessment was that a new National Mitigation Plan would be required. The National Adaptation Framework (NAF) was published in 2018 and sets out the national strategy to reduce the vulnerability of the country to the negative effects of climate change and to promote and assist positive impacts.

The Government of Ireland's Climate Action Plan was published in 2019 and set out a detailed sectoral roadmap to deliver a cumulative reduction in emissions, including the introduction of Carbon Budgets. The Climate Action and Low Carbon Development (Amendment) Bill, 2021 was then published, which amended the 2015 Act of the same name. The Act has been signed into Law, which means that Ireland is now legally bound to develop a carbon neutral economy by no later than the end of 2050. The Climate Action Plan (CAP) 2021 has recently been published, which sets out a detailed sectoral roadmap designed to deliver the climate ambition to deliver a 51% reduction in greenhouse gas (GHG) emissions by 2030, doubling the ambition of the 2019 Climate Action Plan. The Climate Action Plan will be updated annually to align with the legally binding economy-wide carbon budgets

Under the EU's Effort Sharing Regulation, targets are set for Ireland's reduction of non-Emissions Trading Scheme category emissions by 30% by 2030, relative to 2005 levels with annual binding limits set for each year. Legislative proposals to implement these targets were published in July 2021 and these are currently being negotiated at EU level. Greenhouse Gas emissions from the Proposed Development are considered within this non ETS category. The CAP 2021 identifies that, within the enterprise sector, non ETS category installations accounted for 2.3 Mt of CO_2eq in 2018 compared to 5.6 Mt CO_2eq from the ETS category. This amounted to a 3.7% share of total GHG emissions from the non ETS category in that year. The CAP 2021 acknowledges the significant contribution of process GHG emissions from the mineral industry, while acknowledging the necessity of such activity to deliver on societal needs. Many of the measures outlined for the enterprise sector in the CAP 2021 are designed to facilitate this evolution such as ensuring that access to green power is available for manufacturing and provision of state agency support to assist in the development of decarbonisation programmes.

9.2.1.4 Local Context

The need to develop the Climate Action Regional Offices (CAROs) was highlighted in both the National Adaptation Framework and the National Mitigation Plan.

As part of the NAF, Monaghan County Council has prepared a Climate Change Adaptation Strategy 2019 – 2024, which aims to address the provisions of the Climate Action and Low Carbon Development Act 2015 and the National Adaptation Framework (NAF), 2018. This strategy provides insight into recent severe weather events which have impacted County Monaghan, and which may occur more frequently due to climate change. The weather events are summarised in Figure 9.1 below.

Year	Date	Event Type / Name	Outline Description	Severe Weather Event				
				Strong Wind	rainfall Extreme	Heavy Snowfall / Low Temp	Low rainfall / Drought	High Temp
2018	11th October	Storm Callum	Orange wind warning – gale force winds up to 130km/hr- A lot of fallen trees disruption to power lines, roads, business, infrastructure, travel					
2018	September	Storm Ali	Orange Wind Warming – gale force winds of up to 120km/h, stormy conditions					
2018	Summer	High Temperatures, Heat wave & Drought	High Temperatures, Heat wave and drought – distribution to water supply, issues with road maintenance etc…					
2018	February / March	Storm Emma & Beast from the East	Blizzard / Heavy Snowfall / widespread heavy snow drifting. Disruption to business, emergency services, power cuts etc…					
2018	January	Storm Eleanor	Orange Wind Warming – gale force winds of up to 120km/h, stormy conditions					
2017	16th October	Storm Ophelia (Ex-Hurricane Ophelia)	Red warning – gale force winds, heavy rain and storm surges along some coasts (flooding). Disruption to business, power cuts etc and a fatality in County Louth…					
2016	January	Heavy Rain	Wettest January of record – 126% of monthly long term average					
2014	12th February	Storm Darwin	Orange warming for strong winds – classified as a 1 in 20 year event					
2013/14	Winter	Winter Storms	Winter storms – serious coastal damage and widespread, persistent flooding					
2010	Nov / Dec	Winter Cold Spell	Lowest temperatures on record in Dublin Airport (-8.4°C) and Casement Aerodrome (-9.1°C)					
2009/10	Winter	Winter Cold Spell	Coldest winter in almost 50 years (Met Éireann)					
2009	November	Severe flooding	Rainfall totals were highest on record, extensive flooding					
2008	August	Heavy Rain and Flooding	Heavy rain and extensive flooding					
2006	Summer	High Temperature / Heat Wave	Warmest summer since record breaking 1996 (may have been exceeded by 2018)					
1997	24th December	Windstorm	Windstorm					
1995	Summer	High Temperatures, Heat wave & Drought	Warmest Summer on record. Mean temperatures over 2°C above normal. Temp rises to 30°C over a number of consecutive days					
1993	11th November	Severe Flooding	In excess of 100mm of rain in 24 hour period in eastern and midlands					
1987	12-13th January	Heavy Snowfall	12-19cm snow in the east and midlands					
1986	August	Hurricane Charley	Strong winds and rain, worst flooding in 100 years					

Figure 9.1: Severe Weather Events that have impacted County Monaghan. Source: Monaghan County Council Climate Change Adaptation Strategy 2019-2024

Through a review of climate hazards and risks, as well as regional discussions with the regional CARO office, MCC has listed six key thematic areas within the Council that are the most appropriate to target. The six themes, listed below, have been considered in the context of the Project and its potential impact on the themes. The six themes are listed as follows:

- Theme 1: Local Adaptation Governance and Business Operations Goal: Climate Change adaptation considerations are mainstreamed and integrated successfully into all functions and activities of the local authority ensuring operational protocols, procedures and policies implement an appropriate response in addressing the diversity of impacts associated with climate change;

- Theme 2: Infrastructure and Built Environment Goal: Increased capacity for climate resilient structural infrastructure is centred around the effective management of climate risk, informed investment decisions and positive contribution towards a low carbon society;

- Theme 3: Land use and development Goal: Sustainable policies and measures are devised and implemented to influence positive behavioural changes, support climate adaptation actions and endorse approaches for successful transition to a low carbon and climate resilient society;

- Theme 4: Drainage and Flood Management Goal: Great understanding of risks and consequences of flooding and successful management of a co-ordinated approach to drainage and flooding;

- Theme 5: Natural Resources and Cultural Infrastructure Goal: Fostering and implementing meaningful approaches to protecting natural and key cultural assets through an appreciation for the adaptive capacity of the natural environment to absorb the impacts of climate change; and

- Theme 6: Community Health and Wellbeing Goal: Empowered and cohesive communities with strong understanding of climate risks, increased resilience to impacts of climate change with capacity to champion climate action at local level.

MCC has adopted policies in the 2019-2025 County Development Plan in relation to the protection of climate. MCC policies which are relevant to the climate assessment include:

- EECS0 1 - To afford a high level of environmental protection in County Monaghan through the provision of quality environmental services which adhere to the precautionary principle, to provide for sustainable development through the promotion of energy efficiency and renewable energy to deliver a low carbon future for County Monaghan, to implement measures to reduce the human causes of climate change and to consider its effects when formulating development plan policies;

- CCP 1 - To support and encourage the implementation of the National Adaptation Framework 2018 and any updated versions during the lifetime of this Development Plan;

- CCP 2 - To prepare a Climate Change adaptation strategy for County Monaghan having regard to relevant national guidelines and in co-operation with all relevant stakeholders;

- CCP 6 - To support and assist a shift to a low carbon society and a reduction in the dependence on fossil fuels in County Monaghan by implementing measures to deliver energy efficiency, compact urban forms and sustainable transport patterns;

- CCP 8 - To support diversification and innovation in the local economy by endorsing investment in emerging products, services and technologies that assist in the delivery of a low carbon future for County Monaghan;

- CCP 9 - Support and facilitate European and national objectives for climate adaptation and mitigation as detailed in the National Mitigation Plan, National Adaptation Framework and relevant Sectoral Adaptation Plan(s); and

- SDP 4 - To ensure that all storm water discharges shall be restricted onsite attenuation and or other measures to the pre-development levels (green field) in all new developments. All attenuated storage volumes must take into consideration climate change. Guidance is available from The Greater Dublin Strategic Drainage Study Technical Document, Volume 5. This is considered further in Chapter 8.0 of this EIAR.

9.2.2 Relevant Guidance

This assessment has been made with guidance from the 'Guidelines on the information to be contained in environmental impact assessment reports', published in by the EPA in May 2022; 'Environmental Impact Assessment of Projects, Guidance on the Preparation of the Environmental Impact Assessment Report' published by the European Commission in 2017 and, 'Advice Notes for Preparing Environmental Impact Statements', also published in 'draft' by the EPA in September 2015.

Other guidance documents, policy and reports considered in this assessment include:

- Department of the Environment, Climate and Communications - Policy Statement on Mineral Exploration and Mining Critical Raw Materials for the Circular Economy Transition, 2022;

- Design Manual for Roads and Bridges; Sustainability and Environment Appraisal, LA 114 Climate, 2021;

- Enviroguide Consulting; Draft Strategic Environmental Assessment Screening Report for Draft Climate Change Adaptation Strategy for Monaghan County Council, 2019;

- Environmental Law Alliance Worldwide; Guidebook for Evaluating Mining Project EIAs, 2010;

- EPA, Guideline Document entitled Environmental Management in the Extractive Industries, 2006;

- European Commission; Guidance on Integrating Climate Change and Biodiversity into Environmental Impact Assessment, 2013;

- European Commission; Climate Change and Major Projects, 2016;

- IEMA - Assessing Greenhouse Gas Emissions and Evaluating their Significance, 2017;

- RPS (on behalf of the Department of the Environment, Climate and Communications) - SEA Environmental Report for the Policy Statement on Mineral Exploration and Mining, 2021;

- IEMA - EIA Guide to Climate Change Resilience and Adaptation, 2020; and

- Monaghan County Council; Climate Change Adaptation Strategy, 2019-2024.

9.2.3 Climate Change Impacts for Ireland

Climate change is an alteration in the distribution of weather patterns in a region in which such change lasts for an extended period of time (i.e. decades or longer). Climate change refers to a change in meteorological conditions, including temperature, rain and wind that characteristically prevail in a particular region over a period of time (typically 30 years).

Directive 2014/52/EU recognises that climate change will continue to cause damage and compromise economic development, therefore it must be incorporated into the decision-making process with the climate change impacts and vulnerabilities of projects assessed.

Ireland is a party to the Paris Agreement, which, as set out above, is a legally binding agreement with the central aim to strengthen the global response to the threat of climate change. Ireland is also bound by nationally determined contributions designated by the EU on behalf of all Member States and commits the EU to reduce GHG emissions by at least 40% (compared to 1990 levels) by the year 2030. Under the EU's Effort Sharing Regulation, Ireland's non-emission trading scheme sectors the 2020 targets for non-emission trading scheme sectors emissions is 20% below their 2005 levels.

The EPA has published research in 2020, which provides detailed projections of regional climate change in Ireland (EPA, 2020). The research concludes that Ireland's climate is changing, resulting in higher temperatures, changing precipitation patterns and increases in the frequency and intensity of extreme events, with these changes expected to continue and intensify into the future. Amongst the projections within the research, the following trends are predicted by the middle of the century (2041 - 2060):

- Temperatures are projected to increase by 1 - 1.6°C compared with the baseline period (1981 - 2000), with the largest increases in the east;
- Warming will be enhanced at the extremes (i.e. hot days and cold nights), with summer daytime and winter night time temperatures projected to increase by 1 - 2.4°C;
- Substantial decreases of approximately 50% are projected in the number of frost and ice days;
- Summer heatwave events are expected to occur more frequently, with the largest increases in the south; and
- Precipitation is expected to become more variable, with substantial projected increases in the occurrence of both dry periods and heavy precipitation events.

The EPA has also published the 'Status of Ireland's Climate 2020' in August 2021, which has identified clear evidence that global warming is causing the climate to change in Ireland. Included in the findings are the following:

- The annual average surface air temperature in Ireland has increased by over 0.9°C over the last 120 years, with a rise in temperature observed in all seasons;
- Annual precipitation was 6% higher in the period 1989 to 2018, compared to the 30 year period 1961 to 1990; and
- Sea level rise and higher ocean temperatures are also observed in our oceans and coastal areas.

From the above, the most applicable climate variable and hazards for the site are those resulting from weather extremes (drought and heat) and flooding from precipitation. These climate hazards have been identified by Monaghan County Council in Section 3.3.5 of its Climate Change Adaptation Strategy, along with 'Increase in extreme wind events' and 'Sporadic prolonged cold events and snow events' as climatic hazards. Climate change factors such as ocean acidification, sea-level rise and storm surges and waves have been scoped out of this climate assessment, due to the inland location of the Proposed Development.

9.3 Assessment Methodology and Significance Criteria

The approach to establishing the significance of impacts has broadly followed the overall methodology set out in Chapter 2.0 of this EIAR in terms of providing a reasoned judgment of the significance of impacts. In terms of assessing the adaptability of the Application Site, a matrix assessment of the sensitivity of the site against the exposure is used in order to quantify the overall vulnerability. It is important to note that CO_2 emissions have a global effect when they are released into the atmosphere, and it is difficult to assess the scale of significance of CO_2 emissions at a local level.

9.3.1 Assessment of Climate Change Impacts on the Proposed Development

This assessment of the impacts of climate change on the Proposed Development has been based on the European Commission (2016) 'Climate Change and Major Projects' assessment guidance. Although the Proposed Development is not a 'major project', this method is considered suitable guidance for such a climate change impact assessment in the absence of any other applicable guidance.

In designing and planning of major projects the guidance seeks to consider both climate change adaption and mitigation measures. Adapting a project is to ensure adequate resilience is built into the design to cope with relevant climate change impacts, e.g. flooding. Mitigation measures will reduce the project's emissions of greenhouse gases and promote the selection of lower-carbon options in the design.

9.3.2 Adaption to Climate Change

The assessment of project adaptions required first must assess the vulnerability of the Proposed Development and also the risk of impacts from relevant climate hazards.

The sensitivity, exposure and the overall vulnerability of the development over the lifetime of the Proposals has been assessed below according to the most applicable climate variable and hazards. For the Proposed Development the most applicable climate variables and hazards to consider are:

- Increasing precipitation effecting groundwater levels;
- Pluvial (independent of waterbody) and fluvial (dependent on waterbody) flooding;
- The effects of temperature extremes impacting site operations; and
- Extreme wind events.

The sensitivity of various aspects of the development have been assessed in Table 9.1 with regard to the relevant climate hazards identified. On-site assets include any structures and accessible gypsum within the Proposed Development footprint. Inputs to the Site include the raw materials required for Site function, i.e. water and imported fuels. The Mine Development's outputs are the extracted gypsum, mine water and transport linkages, including access to and from the site to the local road network. The Community Sports Complex's outputs are transport linkages, including access to and from the site to the local road network.

Table 9.1: Sensitivity of the Proposed Development to relevant climate hazards

	Climate Variables: Pluvial Flooding and Fluvial flooding	Precipitation & Groundwater Levels	Temperature Extremes	Extreme Wind Events
On-site assets	Low	Medium	Low	Low
Inputs to site (water, fuels, etc.)	Low	Medium	Low	Low
Outputs (Gypsum, treated mine water)	Low	Low	Medium (River Bursk low water discharge limit constraints and potential impact on mine discharge)	Low
Transportation Linkage	Low	Low	Medium	Low
Highest Sensitivity Score	**Low**	**Medium**	**Medium**	**Low**

Table 9.2 assesses the exposure risk of the Proposed Development in relation to current climate and future predicted climate changes. Future impacts have been assessed as low given the limited duration of the mining activities (ca. 30 - 35 years) and the nature of the Community Sports Complex in addition to the mitigations which have been built into the Project at this stage. The risk of exposure in relation to Temperature Extremes has been assessed as medium given the potential knock-on effects of low water levels on mine water discharge limits.

Table 9.2: Exposure of the Proposed Development to future climate change

Exposure	Climate Variables: Pluvial and Fluvial Flooding	Precipitation & Groundwater Levels	Temperature Extremes	Extreme Wind Events
Current Climate	Low	Low	Low	Low
Future Climate	Low	Low	Medium	Low
Highest Score	**Low**	**Low**	**Medium**	**Low**

Table 9.3: Overall vulnerability of the Proposed Development to relevant climate change events

Vulnerability		Exposure (Current & Future Climate)		
		Low	**Medium**	**High**
Sensitivity	**Low**	Pluvial and Fluvial Flooding Extreme Wind Events		
	Medium	Precipitation & Groundwater Levels	Temperature Extremes	
	High			

Table 9.3 presents a combination of the Site's 'Sensitivity' and 'Exposures' to establish the vulnerability of the Proposed Development to climate hazards. The table shows that the greatest risk 'Medium' is from temperature extremes. Temperature extremes can lead to changes in permitted mine water discharge levels within certain exceptionally wet or dry periods. Further adaptions have been inbuilt into the Knocknacran West Mine site (as described in Chapter 8.0) given the relationship between water management and climate change. Good site management in terms of groundwater monitoring and the good management of site excavations and surface waters during very extreme flooding events will be incorporated into the design and operation of the future mine site. Therefore, the vulnerability of the Proposed Development to climate change hazards is assessed as Slight.

9.4 Baseline

The existing Knocknacran Mine has been in full production since 1989, while gypsum mining has a long-standing history in the area. Drummond Mine is adjacent to the Site and shares the Knocknacran processing plant with Knocknacran Mine.

The Site is located approximately 1 km from the Monaghan/Cavan County border, northeast along the River Lagan. The economic activity and employment centres within this area are the town of Carrickmacross to the north and Kingscourt, Co. Cavan to the south.

A number of other industries operate in the wider Kingscourt, Carrickmacross and surrounding areas. These include Kingspan, Breedon Bricks, Rye Valley Foods, Kerry Group, Terex-MDS International, ADN Plastics, Mac Fab Systems and ExCel Plastics.

The lands surrounding the Site can be characterised as rural in nature, with land uses in the area being generally agricultural, single-house residential, commercial/industrial, with a church and primary school in the village of Drumgoosat to the north of the Site. Residential housing in the area is primarily confined to linear ribbon settlements along local roads or isolated properties.

9.4.1 Climate at the Site

The Irish climate is subject to strong maritime influences, the effects decreasing with increasing distance from the Atlantic coast. The climate in the area of the Site is typical of the Irish climate, which is temperate maritime.

The existing Knocknacran Mine site has an active weather station (Met Éireann station 'Kingscourt (Drummond)') which has been recording precipitation at the mine site since 1990. The 11 year (2012 to 2022) monthly precipitation data for this station is presented below in Table 9.4.

Table 9.4: Kingscourt (Drummond) Weather Station, Recorded Monthly Precipitation

Monthly Precipitation (mm)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2012	87.5	37	12	43.5	39.4	170.3	91.1	118.5	65.1	85.7	89.9	139.6
2013	136.5	77.7	81	69	67.3	55.7	78.1	37.3	47.2	212.9	44.5	152.8
2014	164.4	138.2	77.4	64.8	85.1	50.1	34.6	142.1	4.8	139.5	157.5	91.2
2015	112.2	65.2	87	66.1	130	44	103.5	90.8	33.9	61.8	181.6	224
2016	127	108	51.8	74.1	65.2	92.7	76.5	86	78.3	45.8	47.1	74.6
2017	29.8	79.5	86	8.2	67.6	95.1	91	79.7	110.1	96.4	67	76.5
2018	154.1	63.5	77.5	54.5	37.2	-	42.2	77.2	49.8	34.7	131.1	104.8
2019	26.9	53.6	156.7	77.3	40.3	105.1	92.2	170.6	-	-	-	100
2020	63.1	219.9	64.8	18.7	13.2	75.7	96.6	126.6	63.4	108.3	91.2	120.1
2021	129.5	107.8	71.6	19.3	108.3	15.6	31.5	92.3	55.9	106.9	43.8	154.1
2022	35.1	148.1	30	55	76.5	79	25	73.7	149.2	-	-	-

The closest Met Éireann station recording multiple meteorological parameters is located at Ballyhaise, Co. Cavan, ca. 40 km west of the Site. Monthly parameters recorded include minimum, maximum and mean air temperature, m rainfall, minimum grass temperature, wind speed and highest wind gusts (Table 9.5) Hourly wind speed and direction have been summarised from daily data over 11 years (2012- January 2023).

Table 9.5: Ballyhaise, Co. Cavan, Recorded Climate Information

Mean Air Temperature (°C)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2012	5.8	6.7	8.1	6.5	10.5	12.5	13.8	15.5	11.9	8	5.6	4.8
2013	4.7	4.2	2.8	6.5	9.9	13.2	17.4	15.4	13	11.3	6	6.4
2014	4.9	5.4	6.6	9.7	11.6	14.2	15.8	13.4	13.4	10.5	7.5	5.1
2015	4.3	4.1	5.7	7.7	9.3	12.8	13.4	13.8	11.8	10	7.9	7.8
2016	5.5	4.2	6.1	6.6	11.6	14.4	15.1	15.2	13.8	10.1	5	6.3
2017	5.5	5.8	7.7	8.6	12	14	14.6	141	11.9	11	6.3	5.2
2018	4.4	3	4.4	8.3	12.1	15.5	16.1	14.6	11.6	9.2	7.3	7.3
2019	5.2	7	6.9	8.6	10.3	12.7	16.1	15.3	12.8	8.7	5.7	5.5
2020	5.9	5.1	5.9	9.3	11.5	13.7	13.7	15.1	12.8	9.5	7.9	4.6
2021	3.3	5.7	7.3	6.6	9.5	13.8	17.2	15.3	14.4	11.3	8.1	6.6
2022	5.7	6.2	6.6	8.1	12.1	13.4	16	15.6	13	11.4	8.4	3.1
2023	5.4	-	-	-	-	-	-	-	-	-	-	-

Maximum Air Temperature (°C)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2012	11.9	13	19.8	14.7	24.1	22.1	21	22.9	21.1	14.5	13.1	13
2013	12.9	11	9.4	15.1	19	22.7	28.4	21.6	22.1	20	13.2	14.3
2014	11.1	11.4	15.7	18.7	19.2	24.3	25.2	22.3	22.4	17.3	13.6	12.1
2015	13.6	13.1	13.8	18.4	16.4	24	22.3	21.5	19.1	18.4	15.3	15
2016	14.2	11.9	13.7	15.5	22.4	22.9	25.5	23.3	21.5	16.9	13.9	14.9
2017	11.2	12.5	16.2	17	25.1	24.1	24.1	20.7	20.7	17	13.9	13.4
2018	12	12.1	12.3	18.4	23.5	28.8	27.5	22	20.5	20.6	15.1	12.6
2019	11.4	15.5	15.2	20.7	20.1	22.6	24.1	23.7	20.8	15.4	12.6	12.5
2020	13.6	11.7	14.6	19.5	23.8	24.5	21.6	23.6	21.9	15.5	15.2	12
2021	10.7	13.4	16.8	16.9	21.6	21.6	28.9	24.3	23.5	18.8	15.2	13.3
2022	14.5	12.8	17.5	16.7	19.5	22	30.8	27.5	20.3	17.4	17	13.8
2023	12.8	-	-	-	-	-	-	-	-	-	-	-

Minimum Air Temperature(°C)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2012	-1.5	-5.4	-1.6	-2.2	-1.2	3.7	5	7.4	0.3	-1.8	-2.1	-4.3
2013	-2.6	-5.8	-5.9	-6	0.5	4.6	9.9	9.5	3.1	0	-2.7	0.2
2014	-2.1	-0.9	-2.8	-0.6	4.9	4.9	6	2	3	0.5	-1.2	-6.2
2015	-5.2	-4.7	-3.5	-2.1	0.4	2	4.9	5.2	2.6	-0.7	-2	-2.6
2016	-1.5	-3.8	-3.7	-1.5	1.2	5.2	8.1	6	3.5	-0.2	-4.3	-3.4
2017	-4.1	-3.2	-2.7	1	1.1	5.5	6.2	5	2	0.9	-0.7	-4.6
2018	-5.5	-4.5	-5.2	-3.2	1	5	6.5	4.2	0.4	-2.2	-2.3	0.3
2019	-3.4	-3.5	-1.1	0.3	-1.2	3.1	5.6	7.9	4.1	-2.7	-4.1	-1.9
2020	-3.9	-0.6	-2.4	-1.7	-1.7	3.2	5.2	4.4	-1.5	1.6	0.2	-3.5
2021	-7.4	-2.8	-1.3	-3.4	-1.9	3.8	9.5	5.3	5.4	2.4	-0.7	0.6
2022	-3.1	-0.8	-4.4	-2.3	3.1	4.9	9.1	7	3.3	2.9	-0.8	-7
2023	-6.1	-	-	-	-	-	-	-	-	-	-	-

Mean Maximum Air Temperature(°C)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2012	8.5	8.9	12.4	10.8	15	15.9	17.4	19.2	15.6	11.7	8.4	7.6
2013	7.1	7.3	5.9	10.8	13.6	17.9	22	18.8	16.5	14.3	8.9	9
2014	7.4	8.1	10.1	14	15.1	18.6	20.1	17.1	18	14.2	10.4	7.6
2015	7.4	7.2	9.6	13.1	13	17.1	17	17.6	15.5	13.8	11.2	11
2016	8.1	7.5	9.8	10.8	16.3	18.2	18.7	18.8	17.1	13.4	8	9.2
2017	8.3	8.7	11.3	12.2	17.2	17.7	18.7	17.9	15.7	14.2	9.4	7.8
2018	7.2	6.4	7.9	12	17	20.8	20.6	18.3	15.5	12.8	10.1	9.3
2019	7.5	10.4	10.4	12.5	14.8	16.7	20.1	18.9	16.8	12.1	8.3	7.9
2020	8.3	8.4	9.7	14.3	16.7	17.5	17	18.8	16.7	12.5	10.8	7
2021	6.1	8.2	10.4	11.8	14.3	18.2	21.6	19.1	18.2	14.4	10.6	8.8
2022	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5
2023	7.8	-	-	-	-	-	-	-	-	-	-	-

Mean Minimum Air Temperature(°C)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

2012	3.2	4.6	3.8	2.3	6	9.2	10.2	11.8	8.3	4.3	2.9	2
2013	2.3	1	-0.2	2.3	6.1	8.4	12.8	11.9	9.5	8.2	3	3.9
2014	2.4	2.6	3.1	5.5	8.1	9.7	11.5	9.7	8.8	6.8	4.6	2.6
2015	1.2	1.1	1.8	2.3	5.5	8.4	9.9	10.1	8.1	6.1	4.6	4.7
2016	2.9	1	2.4	2.4	6.9	10.6	11.6	11.7	10.6	6.7	2	3.4
2017	2.8	2.9	4	4.9	6.8	10.4	10.5	10.3	8.1	7.9	3.3	2.6
2018	1.6	-0.3	1	4.7	7.1	10.2	11.5	11	7.7	5.6	4.5	5.4
2019	2.9	3.7	3.4	4.7	5.8	8.6	12.1	11.7	8.7	5.3	3	3.1
2020	3.4	1.9	2.1	4.3	6.3	9.8	10.3	11.4	8.9	6.4	5	2.1
2021	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
2022	2.9	3.3	1.6	3.6	8.4	9.7	12	10.6	9	8.2	5.6	0.3
2023	3	-	-	-	-	-	-	-	-	-	-	-

Monthly Precipitation (mm)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2012	99.2	52.5	22.9	65.6	43.7	185.1	104.8	92.5	84.3	93.1	83.8	103.1
2013	128.2	64	46.1	75.8	83.2	52.7	80.7	38.7	59.4	148.6	44.7	136.3
2014	127.4	151.9	71.8	45.1	103.7	71.1	77.4	107	10.8	-	139.7	91.3
2015	137.3	66.7	81.7	72.3	121.6	36.5	134.5	112.1	35.2	64.7	135.5	270.9
2016	106.7	98.5	67.9	62.4	-	77.6	92.5	74.6	91.9	41.5	55.6	72.9
2017	32.8	72.6	80.3	16.2	54.5	84.2	109.2	95.9	108.5	95.8	93.9	109.2
2018	171.3	78.4	72.3	70.1	49.9	40.9	69.2	99	38.5	53.3	89.8	104.4
2019	43.7	54.3	149.3	64.1	35.9	115.6	52.4	164.5	164.3	83.5	103	84.1
2020	59.2	212.8	77.8	32.8	26.2	99.5	129.7	138.4	60.4	113.3	100.7	111
2021	107.4	89.5	83.9	19.5	84.9	20.8	44.8	133.4	71.8	120.3	46.3	110
2022	43.7	122.9	32.7	62.6	76	76.2	39.5	52	135.8	205.2	118.1	84.2
2023	92.7	-	-	-	-	-	-	-	-	-	-	-

Grass Minimum Temperature(°C)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2012	-5.3	-	-4.5	-6.5	-4.3	0.5	2.7	2.9	-2.3	-6.1	-5.5	-6.6
2013	-5.6	-8.2	-7.9	-8	-1.9	1.8	7.4	5.6	-1.6	-2.6	-5.8	-2.2
2014	-4.7	-3.8	-5.8	-1.7	2.1	1.7	2.2	-0.5	0.3	-2.3	-5.1	-8.7
2015	-9.3	-8.9	-7.2	-6.3	-3.1	-1.3	1.7	3.5	0.2	-2.1	-4.7	-3.5
2016	-6.8	-6.8	-5.1	-5.5	-1.5	1.7	3.9	3.5	-1.1	-1.8	-7.3	-5.2
2017	-6.7	-6.7	-5.1	-2.4	-1.5	1.1	0.5	1.9	-0.6	-	-	-6.2
2018	-8.6	-9.3	-11.3	-8.4	-3.1	1.7	4.7	4.9	-3.9	-5.8	-5.8	-4.2
2019	-7.4	-9.3	-5.8	-3.3	-5.1	0.8	1.3	3.4	0.9	-6.5	-9.1	-7.4
2020	-8.6	-6.3	-5.8	-4.6	-7.3	-1.4	0.7	2.1	-5.5	-2.5	-5.2	-8.7
2021	-12.6	-6.5	-5.2	-9.6	-7.1	1	5.2	1.6	4.5	2.3	-2.6	-4.5
2022	-4.1	-1.7	-8.4	-7.2	-1.1	-0.6	6.2	2.8	0.1	0	-1.5	-10.8
2023	-11.7	-	-	-	-	-	-	-	-	-	-	-

Mean Wind Speed (knot)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2012	8.6	7	6.6	6.5	5.5	5.4	5.2	6.2	6.8	5.1	6.5	7.2
2013	7.2	6.3	7.3	8	7.5	5.3	4.5	5.8	5.7	6.2	5.5	9.9
2014	7.8	9.8	7.3	6.5	5.7	4.6	5.1	5.9	3.9	-	5.2	7.8
2015	8.9	6.5	7.9	5.7	7.3	6.5	5.9	5.8	5	5	8	9.6
2016	7.8	7.4	6.2	6.3	5.5	4.8	5.3	5.9	6.8	4.8	4.9	6.8

2017	6.1	8.1	7	5.6	5.7	6.4	5.5	5.6	6.1	7.3	5.6	6.4
2018	8.1	6.8	7.1	7.1	5.6	4.5	4.7	5.5	6.2	6	7.8	7.1
2019	5.5	8.2	7.4	6.8	4.9	5.7	5.4	6.1	5.3	6	5	7.3
2020	8	9.7	7.2	5.6	5.8	5.8	5.4	5.1	5.7	6.5	6.7	6.5
2021	5.3	8.8	6.8	4.8	5.5	5.3	3.5	4.3	4.4	6	5.8	6.4
2022	6.1	8.9	5.9	5.8	6.1	5.8	4.6	4.5	4.6	7	7.3	5.4
2023	6.6	-	-	-	-	-	-	-	-	-	-	-

Highest Gust (knot)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2012	52	33	45	34	38	33	25	32	34	26	37	50
2013	52	36	38	43	34	30	27	31	37	32	33	50
2014	45	47	38	38	31	26	28	30	23	39	38	41
2015	47	44	46	36	40	38	32	37	25	35	48	44
2016	47	45	40	36	34	28	28	33	38	30	29	41
2017	36	47	32	31	31	32	28	26	33	50	30	48
2018	63	39	38	44	30	41	31	26	57	36	42	41
2019	41	49	47	38	28	42	31	33	33	32	30	45
2020	50	49	42	36	49	34	34	51	35	42	37	44
2021	34	42	43	30	35	29	21	31	28	34	37	44
2022	41	42	36	38	32	41	26	26	34	35	39	34
2023	39	-	-	-	-	-	-	-	-	-	-	-

The information presented in Table 9.2 above provides an overview of the climatic conditions at the Site. Over the time period for which data is provided, the wettest months in terms of total rainfall for the period are January and December, shortly followed by February and August. The data shown in Table 9.2 indicates that the driest month in the Site area is April, shortly followed by May and September. The monthly rainfall recorded at both the Kingscourt weather station and the Ballyhaise station have been compared, and it was found that the two stations have slightly varying recorded rainfall but both stations show the same seasonal rainfall trends.

There is an expected seasonal variability in temperature (lower temperatures in winter months and higher in summer months). A wind-rose for the Ballyhaise station is presented in Figure 9.2 for the period January 2012 to January 2023. It is evident that the prevailing winds are from a southwesterly direction.

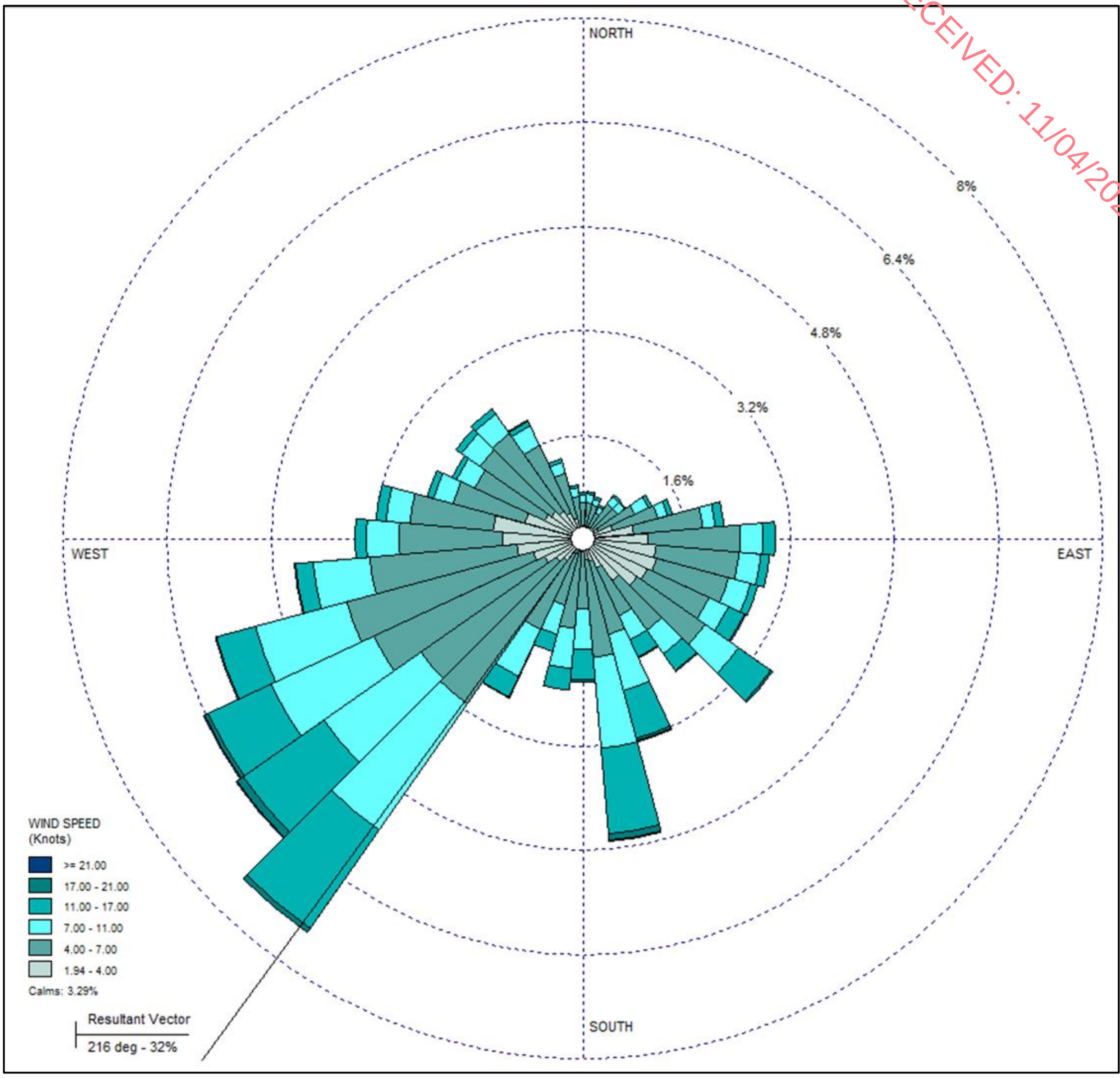

Figure 9.2: Dominant wind direction at Ballyhaise over eleven years (Assessment Period January 2012 to January 2023)

9.5 Key Characteristics of the Proposed Development

9.5.1 Construction Phase: Community Sports Complex

During this phase, the existing Community Sports Complex will be further developed. The initial phase of this development has been constructed (Reg. Ref.: 20/365), and the next phase will involve extending the Community Sports Complex with the construction of two further playing pitches, one with a perimeter running track, an all-weather pitch, a new club building, including a sports hall, a handball alley, changing rooms & toilets, a viewing gallery, a part-covered grandstand, additional parking and associated siteworks.

9.5.2 Construction Phase: Mine Development

During this phase:

- A temporary diversion of the R179 is proposed and a Cut-and-Cover Tunnel will also be constructed;
- One residential and three unoccupied houses and sheds will be demolished;
- The existing processing plant on the existing Knocknacran Open-Cast Mine site will be refurbished; and
- A new vehicular entrance will be constructed to the existing mine site from the L4816.

9.5.3 Operational Phase: Community Sports Complex

During this phase, the Community Sports Complex will be in operation.

9.5.4 Operational Phase: Mine Development

The proposed phased extraction of gypsum by open-cast mining methods at Knocknacran West is to expose and recover the Upper and Lower gypsum seams/units remaining after the cessation of mining from the Drumgoosat underground mine in 1989. In parallel, the Knocknacran Mine will be backfilled and remediated to near original ground.

During this phase:

- Open Cast mining will be undertaken to allow extraction of the Gypsum from the Drumgoosat Underground mine area closed in 1989. The gypsum extracted will maintain a continuous supply of mineral as the current Knocknacran mine will be exhausted as the new mine is brought into operation;
- The proposed Mine Development sees the replacement of gypsum mining at the Knocknacran Open-Cast Mine with the mining of gypsum at Knocknacran West Open-Cast Mine. Both mine sites are comparable in size and nature of operations;
- Overburden and Interburden will be stripped to expose the Gypsum Mineral;
- The gypsum remaining in the former Drumgoosat Underground Mine will be extracted by open-cast mining methods;
- The existing Knocknacran Mine will be restored to near original ground level;
- The existing plant site will process and despatch the extracted gypsum;
- The existing Drumgoosat dewatering pump, will be relocated to an existing borehole on the Knocknacran West site to continue to provide dewatering;
- The stripping of the site will be undertaken in a series of campaigns at specific times and last for defined periods of time (typically < 6 months) over the life of the proposed Mine Development.

9.5.5 Restoration/Closure Phase: Community Sports Complex

There is no proposal to close the Community Sports Complex development, and this phase is therefore not applicable in this case.

9.5.6 Restoration/Closure Phase: Mine Development

During this phase:

- The new Knocknacran West site will be returned to grassland and a waterbody;
- The existing Knocknacran site will be returned to near original ground level;
- The existing Knocknacran Plant site will be partially dismantled whereby mine plant is removed; and
- In line with the current CRAMP it is presented that here that a suitable developer would be sought to utilise the general buildings existing on the existing site for a light industrial usage into the future. This would be subject to a future developer seeking the necessary permits for continuation of use and change of use from mining to a non-mining use.

9.6 Potential Effects

Climate Change Effects of the Proposed Development: Carbon Footprint and Greenhouse Gas

Scoped emissions from the Proposed Development have been summarised in Table 9.6 below and are detailed for the relevant parameters, for the aspect of the Proposed Development and for the relevant phase considered. Scoped emissions consider the direct emissions from the Proposed Development, the indirect emissions from site related requirements and activities, and indirect emissions not under the control of the Proposed Development.

Emissions from vehicles during the extraction and restoration phases of mining activities, and vehicular emissions related to the Community Sports Complex, can add to the receiving air environment. With regards to climate impacts, it is assessed that CO_2 will be emitted from vehicle exhausts during the construction, operational and restoration phases of existing and Proposed Development, where relevant.

The electricity emission factor source used in the quantification of GHG is 334 gCO_2/kWh, which was obtained from page 26 of the SEAI Report- Energy in Ireland, 2020 Report.

The diesel/gas oil emission factor source used in the quantification of GHG is the Country Specific NCV, and the CO_2 emission factor for use in AIER Report-2020 Version 19 September 2019.

For the calculation of scope 2 emissions, SGMI have committed that all electricity will be sourced from certified CO_2 neutral sources in line with SGMI corporate policy and there will therefore be no CO_2 impact from electrical consumption. Where data on electricity usage is available this has been described in the relevant section below, but no emission data has been included in the calculation of total GHG emissions from the Site. For the Community Sports Complex, the development is aiming to receive an A2 energy rating and use green energy.

SGMI have pledged to create net-zero carbon emissions by no later than 2050 and their investment in Research & Development allows them to create innovative technologies which are used to minimise the negative impacts of construction and manufacturing processes on the climate.

SGMI have developed an onsite recycling process for off-cut plasterboard generated on construction sites. These will be collected and brought back to the plasterboard manufacturing facility for recycling and reuse, where traceability certificates outlining the lifecycle of the construction material cut-offs will be issued.

SGMI's goal is to minimise the environmental impact of their business and, where possible, provide environmental benefits to all stakeholders by recycling, reusing and creating new innovative systems, products and sales routes. In order to help meet this goal SGMI are BES 6001 certified. The British Standards Institution (BSI) states the following in relation to BES 6001:

"BES 6001 has been published to enable construction product manufacturers to ensure and then prove that their products have been made with constituent materials that have been responsibly sourced. The standard describes a framework for the organisational governance, supply chain management and environmental and social aspects that must be addressed in order to ensure the responsible sourcing of construction products."

Scope 3 emissions may be beyond the control of the Applicant; however, SGMI have identified the opportunity for influencing positive environmental performance of its suppliers through assessing and comparing their operations and products in terms of CO_2 emissions and general sustainable development. This area of focus for the organisation is one of its four 'levers for action' identified in its CO_2 Roadmap Towards Carbon Neutrality by 2050 (see Appendix 9.1). Through this, SGMI can ensure that they are able to influence their supply chains towards more environmentally sustainable practices. Therefore, Scope 3 emissions have not been quantified for each of the development stages.

Table 9.6: Scoped emissions for the Project

Scope	Direct and Indirect Emissions from the Proposed Development
Scope 1: **Direct emissions**	Fuel combustion in on-site plant on the mine sites Fuel combustion in road truck haulage Fuel combustion in Community Sports Complex vehicles Carbon emissions from overburden and interburden stripping on the Knocknacran West site Emissions from processing plant
Scope 2: **Indirect emissions**	Carbon produced from the generation of electricity used during mining related activities and at the Community Sports Complex
Scope 3: **Other indirect emissions not under the control of the Project**	Indirect emissions from services supplied to the mine site and Community Sports Complex, (i.e. Scope 1 and Scope 2 emissions from contractors) Embodied energy used in building materials Indirect emissions from final product uses, e.g. discarded waste, plasterboard.

9.6.1 Construction Phase: Community Sports Complex: Carbon Footprint and Greenhouse Gas

Construction Phase: Community Sports Complex: Fuel Consumption in on-site plant

The construction phase is estimated as 2 years for the Community Sports Complex.

Distances used in calculations are assumed to be worst case/longest routes, however, the routes will only be this length for short periods of time and the actual fuel consumption is expected to be lower.

A fuel consumption rate of 0.77 litres/tonne/km has been calculated from operating records of mine material moving operations.

The type of fuel for construction will primarily be commercial diesel.

The total estimated volume of commercial diesel to be used during the construction of the Community Sports Complex is ca. 3,426 litres.

Table 9.7, shows the basis of the calculation.

Table 9.7: Fuel consumption for the construction phase – Community Sports Complex

Construction Activity	Approx. material to be moved within site (tonnes)	Length travelled (worst-case) (m)	Fuel consumption per tonne moved 1 km (litres)	Approx. Fuel consumption per activity (litres)
Construction of Sports Facility	22,250	200	0.77	3,426

Construction Phase: Community Sports Complex: Fuel Combustion in Road Truck Haulage

The volume of soil to be hauled to the Community Sports Complex for the construction of the proposed playing pitches is ca. 22,250 tonnes. At this stage in the project, the source of the material is not yet known, estimates for road haulage fuel usage have been calculated for distances of 25 km, 50 km or 100 km, these are shown in Table 9.8, below.

Table 9.8: Potential road haulage fuel consumption for the Community Sports Complex construction phase

Fuel Consumption (litres) per 100 km (30 tonne truck)	Approx. tonnes of material to be moved	25 km round trip approx. litres of diesel consumed	50 km round trip approx. litres of diesel consumed	100 km round trip approx. litres of diesel consumed
57	22,250	20,034	40,068	80,100

**The 57l per 100 km diesel consumption is based on the fuel usage of the 30 tonne road trucks which are used in the existing operations*

Construction Phase: Community Sports Complex: Indirect Emissions

The main source of emissions relating to the construction phase of the Community Sports Complex will be the emissions described above. Due to the nature of the construction activities, electricity usage is not anticipated and therefore it has been screened out of the assessment. If small amounts of electricity are required, as previously discussed, these will be sourced from green energy and there will therefore be no CO_2 impact from electrical consumption.

9.6.2 Construction Phase: Mine Development: Carbon Footprint and Greenhouse Gas

Construction Phase: Mine Development: Fuel Consumption in on-site plant

The construction phase is estimated as 1 year for the Mine Development. Mine Development activities include the construction of temporary R179 road diversion, Cut-and-Cover Tunnel construction, the demolition of the 4 houses and the relocation of the mine entrance.

The type of fuel for construction will primarily be commercial diesel.

All diesel fuel consumed in the operations of the mine is recorded. This fuel is used for the operation of transport jeeps, drill rigs, excavators, trucks and loading shovels. Based on operational records it has been calculated that 0.77 litres of diesel is used in the mining and transport of 1 tonne of material per 1 km. This calculation has been used to estimate the onsite diesel usage in the following sections.

The estimated volume of commercial diesel to be used for mine development is ca. 39,372 litres.

Distances used in calculations are assumed to be worst case/longest routes, however, the routes will only be this length for short periods of time and the actual fuel consumption is expected to be lower. Calculations are shown in Table 9.9, below.

Table 9.9: Fuel consumption for the construction phase – Mine Development

Construction Activity	Approx. material to be moved within site (tonnes)	Length travelled (worst-case) (m)	Fuel consumption per tonne moved 1 km (litres)	Approx. Fuel consumption per activity (litres)
Temporary Diversion of R179	40,000	190	0.77	5,852
Cut-and-Cover Tunnel	187,500	125	0.77	18,047
Demolition of houses	80	326	0.77	20
Relocation of mine entrance	3,460	20	0.77	53
Screening berms	200,000	100	0.77	15,400

Construction Phase: Mine Development: Fuel Combustion in Road Truck Haulage

Haulage of material from the Mine Development during the construction phase is limited, as most material will be retained onsite for reuse (e.g., overburden and interburden used in restoration). Material associated with the demolition of the houses and black top removal (temporary diversion and entrance relocation) will be sent offsite for disposal to a licenced facility, by a licenced waste contractor for proper disposal. As an approximation, ca. 2,640 tonnes of black top will be transported off-site during the construction phase of the Mine Development and replaced with a similar amount when the road diversion is complete along the R179.

Additionally, approximately half the volume of the material from the demolition of the 4 houses (ca. 40 tonnes) will be transported off-site to a licenced facility by a licenced waste contractor for proper disposal. The destination for the waste is not yet known, estimates of fuel usage are provided below in Table 9.10 for distances of 25 km, 50 km or 100 km.

Table 9.10: Potential road haulage fuel consumption for the construction phase – Mine Development

Fuel Consumption (litres) per 100 km (30 tonne truck)	Approx. tonnes of material to be moved	25 km round trip approx. litres of diesel consumed	50 km round trip approx. litres of diesel consumed	100 km round trip approx. litres of diesel consumed
57*	2,640	2,564	5,130	10,260

**The 57l per 100 km diesel consumption is based on the fuel usage of the 30 tonne road trucks which are used in existing operations*

Construction Phase: Mine Development: Indirect Emissions

The main source of emissions relating to the construction phase will be the Scope 1 emissions described above. Due to the nature of the mine construction activities (construction of a tunnel, road diversion, screening berms and the relocation of the entrance) electricity usage is not anticipated and therefore it has been screened out of the assessment. If small amounts of electricity are required, as previously discussed, SGMI have committed that all electricity will be sourced from certified CO_2 neutral sources in line with SGMI corporate policy and there will therefore be no CO_2 impact from electrical consumption at the mine.

9.6.3 Operational Phase: Community Sports Complex: Carbon Footprint and Greenhouse Gas: Scoped Emissions

Under amendments to Part L of the Building Regulations, the new building will require to be compliant with the nearly Zero Energy Buildings (nZEB) standard. Energy efficiency mechanical and electrical systems will be employed to achieve a sustainable, low carbon and "A rated" building design. Space heating, hot water generation and lighting are the primary energy sources of energy demand from this element of the proposals.

There is no road haulage of material associated with the operational life of the Community Sports Community.

Operational Phase: Community Sports Complex: Operational Phase - Carbon produced from the generation of electricity used during community sports complex activities

The community sports complex has a floor space of approximately 2,827 m^2 and is likely to achieve an A2 energy rating. An A2 energy rating has an energy use ranging from 25 to 50 kwh. The calculated annual energy use is presented in Table 9.11. Electricity will be sourced from certified CO_2 neutral sources.

Table 9.11: Potential electricity consumption for the operational phase – Community Sports Complex

Total Gross Floor Area (m^2)	Minimum A2 Rating Energy Use (kwh)	Maximum A2 rating Energy Use (kwh)	Annual Electricity Use (minimum A2 rating)	Annual Electricity Use (maximum A2 rating)
2826.50	25	50	70,663	141,325

9.6.4 Operational Phase: Mine Development: Carbon Footprint and Greenhouse Gas

Operational Phase: Mine Development: Fuel Consumption in on-site plant

Based on the estimated volume of gypsum to be extracted (ca. 9 Mt), the estimated volume of diesel to be used is ca. 5,485,634 litres over ca. 30 years of operations (Table 9.12).

To enable the extraction of gypsum, stripping of overburden and interburden will be undertaken on a campaign basis. Based on the estimated volume of overburden and interburden to be moved over the operational life (ca. 28.5 Mt and rehandling of ca. 4.9 Mt for final restoration) of the Knocknacran West Open-Cast Mine, the estimated volume of diesel to be used is ca. 29,941,450 litres over ca. 30 years of operations (Table 9.12). A 30% reduction from phase 4 onwards in diesel fuel consumption is included in this calculation. This is based on fleet replacements, during the operational life of the mine, which are expected to have improved fuel efficiency or even to be replaced with electric vehicles.

There is a lot of work taking place to de-carbonise mine transport with the development of electric vehicles. The Applicant is aware and keen to reduce emissions over the life of the proposed development and is currently exploring ways to incorporate electric vehicles into its mining fleet and reduce diesel fuel needs onsite as technology develops.

Table 9.12: Operational diesel usage during the proposed mine development

Phase	Worst Case Distance Travelled (km)	Litres Diesel Consumed per km	Approx. Tonnes Gypsum	Approx. Litres Diesel
Phase 1	0.92	0.77	20,000	14,168
Phase 2	0.92	0.77	900,000	637,560
Phase 3	0.92	0.77	1,700,000	1,204,280
Phase 4	0.92	0.54*	1,700,000	842,996
Phase 5	1.1	0.54*	1,700,000	1,007,930
Phase 6	1.1	0.54*	3,000,000	1,778,700
Estimated total litres of diesel consumed during gypsum extraction				5,485,634
Phase	**Worst Case Distance Travelled (km)**	**Litres Diesel Consumed per km**	**Approx. Tonnes Overburden and Interburden**	**Approx. Litres Diesel**
Phase 1	2	0.77	1,800,000	2,772,000
Phase 2	2	0.77	3,000,000	4,620,000
Phase 3	2	0.77	5,000,000	7,700,000
Phase 4	2	0.54*	8,000,000	8,624,000
Phase 5	1.1	0.54*	7,000,000	4,150,300
Phase 6	1.1	0.54*	3,500,000	2,075,150
Estimated total litres of diesel consumed during proposed operational overburden and interburden removal				29,941,450

* A 30% reduction in diesel fuel consumption is included in this calculation. This is based on fleet replacements, during the operational life of the mine, which will have increased fuel efficiency or replacement with electric vehicles.

Operational Phase: Mine Development: Fuel Combustion in Road Truck Haulage

Road haulage for the operational phase consists of haulage of gypsum from the site to the Kingscourt processing and manufacturing facility, as currently occurs. A fully loaded (30 Tonnes Gypsum) haulage trucks in use consumes 57L/100 kms over the course of the round trip from the mine to the factory.

It is proposed that ca. 9 Mt gypsum be hauled by road truck over the life of the Mine Development. This equates to ca. 4,025,700 litres of diesel over the operational life. A 30% reduction from phase 4 onwards in diesel fuel consumption is included in this calculation. This is based on future fleet replacements (during the operational life of 30 years), and vehicles having increased fuel efficiency, or the replacement of vehicles with electric vehicles.

Operational Phase: Mine Development: Carbon emissions from overburden and interburden stripping on the mine sites

In relative scale the carbon release from overburden and interburden will be minimal, however it's contribution to carbon emissions is noted. Overburden and interburden will be used in the phased restoration of the Knocknacran Open-Cast Mine during the first half of the Mine Development (ca. 15 years). During the later half of the Mine Development, overburden and interburden will be stored in the north of the Knocknacran West site. During extraction of Knocknacran West Mine it is considered that the restoration of Knocknacran will positively contribute to the carbon sequestration of the sites. The fuel usage associated with the transport/ haulage of the material related with overburden and interburden stripping have been included in the calculations undertaken and reported in Table 9.12.

Operational Phase: Mine Development: Emissions from processing plant

The fuel usage associated with the transport/ haulage of the material to the processing plant have been included in the calculations undertaken and reported in Table 9.12. No other Scope 1 emissions are anticipated from the operation of the processing plant as the plant will be fuelled by electricity (Scope 2) and the usage is calculated below in Table 9.13.

Operational Phase: Mine Development: Operational Phase - Carbon produced from the generation of electricity used during mining related activities

An estimated 23.9 KwH/tonne of electricity is currently consumed during gypsum processing at the mine site, this is presented in Table 9.13. Electricity is consumed in pumping water from the Knocknacran open-cast sump to the River Bursk, crushing gypsum rock in primary and secondary crushers, and transporting the gypsum by conveyor from Drummond Mine and around the plant site . With the exception of the addition of an overland conveyor in the proposed development, electrical consumption will be comparable to the existing electrical usage.

All electricity is sourced from certified CO_2 neutral sources in line with SGMI corporate policy.

Table 9.13: Electricity usage during production for a 6 month period

Process	6 month electricity usage	
Open-Cast Production in 6 month period	36,435	tonnes
Water Pumping Electricity Consumption	1,656	KwH
Processing Consumption (includes crushing and conveying)	867,796	KwH
Total Electricity Consumption	869,452	KwH
Consumption per tonne of Product	23.9	KwH / Tonne

9.6.5 Restoration/Closure Phase: Community Sports Complex: Carbon Footprint and Greenhouse Gas: Scoped Emissions

There is no decommissioning associated with the Community Sports Complex, this phase is scoped out.

9.6.6 *Restoration/Closure Phase: Mine Development: Carbon Footprint and Greenhouse Gas: Scoped Emissions*

Restoration/Closure Phase: Mine Development: Fuel Consumption in on-site plant

During the restoration/closure phase, ca. 4,900,000 tonnes of material will be moved within the mine sites, equating to ca. 2.905,210 litres of diesel to be used in this phase. A 30% reduction in diesel fuel consumption is included in this calculation (Table 9.14). This is based on fleet replacements, during the operational life of the mine, which will have increased fuel efficiency or replacement with electric vehicles.

Table 9.14: Restoration phase diesel usage during the proposed mine development

Phase	Worst Case Distance Travelled (km)	Litres Diesel Consumed per km	Approx. Tonnes Overburden and Interburden	Approx. Litres Diesel	Comments
Phase 7	1.1	0.54	4,900,000	4,150,300	Material previously stored in Phases 5 & 6 to be relocated in Phase 7 during restoration of Knocknacran West
Estimated total litres of diesel consumed during proposed final restoration				2,905,210	

Restoration/Closure Phase: Mine Development: Fuel Combustion in Road Truck Haulage

Haulage of material from the mine site during the restoration phase is dependent on the decommissioning plan for the plant site. Currently, it is proposed that some of the existing plant site will be decommissioned and other plant and buildings would remain onsite for future reuse by another developer. It is considered here that the fuel combustion associated with the construction phase will be similar in loads compared to the restoration/closure phase and Table 9.15 provides the values used in this phase.

Table 9.15: Potential road haulage fuel consumption for the restoration/closure phase – Mine Development

Fuel Consumption (litres) per 100 km (30 tonne truck)	Approx. tonnes of material to be moved	25 km round trip approx. litres of diesel consumed	50 km round trip approx. litres of diesel consumed	100 km round trip approx. litres of diesel consumed
57*	2,720	2,564	5,130	10,260

**The 57l per 100 km diesel consumption is based on the fuel usage of the 30 tonne road trucks which are used in the mine operations*

Restoration/Closure Phase: Mine Development: Indirect Emissions

The anticipated main source of emissions relating to the restoration/ closure phase will be the emissions described above. Due to the nature of mine restoration/ closure activities, electricity usage is not anticipated and therefore it has been screened out of the assessment. If small amounts of electricity are required, as previously discussed, SGMI have committed that all electricity will be sourced from certified CO_2 neutral sources in line with SGMI corporate policy and there will therefore be no CO_2 impact from electrical consumption at the mine.

9.6.7 Significance of Effect: Proposed Development: Carbon Footprint and Greenhouse Gas

There is the potential for greenhouse gases to be generated as a result of the Proposed Development. As the Proposed Development relates to two already operational sites (a sports complex and a mine site) and activities are likely to consider at a similar rate, a qualitative assessment of the change in potential GHG emissions has been undertaken for the Proposed Development using data presented in Sections 9.6.1 – 9.6.6.

Operational GHG emissions are estimated to remain in the range 3,000 to 5,000 tpa CO_{2e}, which is consistent with the current emissions from the Mine Development. No emissions relating to electricity usage are included in these figures as SGMI currently and in the future have committed that all electricity be sourced from certified CO_2 neutral sources in line with SGMI corporate policy. The Community Sports Complex electricity has also been scoped out as it will be sourced from $C0_2$ neutral sources.

The greatest likely contributor to greenhouse gas emissions from the Proposed Development relates to the development of the open-cast Knocknacran West Mine. The proposed extraction rate for the mine represents a continuation of mineral extraction and processing at a similar rate to that currently being achieved at the existing Knocknacran Mine and processing plant. Therefore, the anticipated greenhouse gas emission projections are already considered and accounted for within the EPA's 2020-2040 Emissions Projections published in June 2021. This report forms part of the national EU reporting obligation and an assessment of the Irelands progress towards achieving its emissions reduction targets for 2020 and 2030 as set out under the EU Effort Sharing Regulation described in Section 0. These EPA projections indicate that Ireland can meet its non ETS greenhouse gas targets by 2030 if actions within the 2019 Climate Action Plan and further flexibilities, set at Government level, are implemented.

The Community Sports Complex represents a replacement for facilities that have been lost as a result of the September 2018 subsidence event. Under amendments to Part L of the Building Regulations, the new building will require to be compliant with the nearly Zero Energy Buildings (nZEB) standard. Energy efficiency mechanical and electrical systems will be employed to achieve a sustainable, low carbon and "A rated" building design. For the Community Sports Complex, the development is aiming to receive an A2 energy rating and use green energy. Space heating, hot water generation and lighting are the primary energy sources of energy demand from this element of the proposals. Specific energy efficient and carbon reduction measures include the following:

- The use of heat pumps and Photo Voltaic technology to provide energy to the building;
- Provision of gas / heat pumps to serve the zoned heating and hot water system;
- LED lighting solutions to include room occupancy control, sensors and switching; and
- Measures such as the installation of self-closing and time delayed taps and showers, and inclusion of low flow WC cisterns will be incorporated to reduce water consumption.

Site preparation for the new Knocknacran West Mine will involve clearance of soil, interburden and overburden in the areas that have previously been used for a mixture of agricultural and amenity uses, including an area of semi-natural woodland that had become established on former brownfield land associated with previous mining activities. This material will be temporarily stockpiled for reuse during the restoration of the existing Knocknacran Mine site. The Knocknacran West Mine site will be restored following mining activities, to include potential carbon sinks such as a waterbody, gently sloping grassland, and native scrub and tree species.

A provisional Closure, Restoration and Aftercare Management Plan (CRAMP) has been prepared (Appendix 3.3), which sets out the closure and aftercare proposals following cessation of mining operations. This will be controlled by the EPA through the IE Licencing procedure. Following this, it is envisaged that the former mining areas will transition to an aftercare period, which will be of reduced scope and intensity to the monitoring carried out during the closure works.

Appendix 3.3 sets out details of the closure and aftercare vision for the Application Site, which will be developed in line with Saint-Gobain's Stakeholder Management Plan. The CRAMP will evolve through the life of the mine, taking community and statutory interests into account. Opportunities for least CO_2 generating options will be sought (e.g. through seeking to ensure future re-use of infrastructure) and opportunities for CO_2 sequestration at the Application Site will be maximised as far as possible.

The estimated annual emissions relating to the Proposed Development are approximately 0.6% (construction phase) and 8.7% (operational phase) and 3.7% (restoration phase) of the EPA projections for the gypsum component of the mineral industry sector, which is reported to be 2 to 2.5% of the total GHG emissions for the minerals industry[1], when considering the conservative assumptions e.g. maximum travel distances. When considering the emissions for the whole mineral industry sector, this decreases to approximately 0.01% (construction phase) and 0.2% (operational phase) and 0.1% (restoration phase) of the EPA projections. As discussed in Chapter 9.0 of the EIAR, the proposed extraction rate for the mine represents a continuation of mineral extraction and processing at a similar rate to that currently being achieved at the existing Knocknacran Mine and processing plant. Therefore, the anticipated greenhouse gas emission projections are already considered and accounted for within the EPA's 2020-2040 Emissions Projections published in June 2021.

It is therefore considered that the potential for additional greenhouse gas emissions associated with the Proposed Development (compared to the existing development) are deemed to be imperceptible, which is not significant for the construction, operational and restoration/closure phases. It is possible that long-term plans for the future restoration of the Mine Development may have the potential to contribute to beneficial impacts.

9.7 Mitigation and Management

9.7.1 Mitigation and Management: Construction Phase: Community Sports Complex

Consumption of electricity at the Community Sports Complex will be minimised as far as possible through design. In line with the Energy Hierarchy, energy efficiencies and incentives will be inbuilt into the electrical infrastructure and management practices.

Overburden will be stockpiled on the mine site within the screening berms, which will be planted. Coupled with the ecological screening areas set aside, the perimeter berms will seek to minimise carbon loss through soil stripping. Soils stripping during wetter periods will also ensure that carbon losses are reduced compared with warmer drier periods.

[1] Department of the Environment, Climate and Communications. RPS, SEA Environmental Report. Policy Statement for Mineral Exploitation and mining, 2021

As CO2 is a key gas linked to climate change, the following mitigation measures will be put in place to limit vehicle and plant emissions:

- No vehicles or plant will be left idling unnecessarily;
- Vehicles and plant will be well maintained in accordance with manufacturer's specifications or best practice. Should any emissions of dark smoke occur (except during start up) then the relevant machinery will be stopped immediately, and any problem rectified before being used;
- Engines and exhaust systems will be regularly serviced according to the manufacturer's recommendations and maintained to meet statutory limits/opacity tests;
- During road haulage, full loads will be transported where possible to minimise the carbon footprint; and
- Minimising the double handling of materials.

The Community Sports Complex will ensure that environmentally sustainable practices are promoted and incorporated into the construction life of the development.

9.7.2 Mitigation and Management: Construction Phase: Mine Development

Consumption of electricity at the Mine Development will be minimised as far as possible through design. In line with the Energy Hierarchy, energy efficiencies and incentives will be inbuilt into the electrical infrastructure and management practices.

SGCPI focuses on optimisation of energy consumption and greenhouse gas reduction in its operations. One of the ways in which SGCPI optimises its energy consumption and reduces its greenhouse gas emissions is by buying 100% green energy. Appendix 9.2 contains the company's latest certificates which confirm that all of the electricity it used in 2020 was sourced from 100% renewable energy. Energy use reduction and efficiency will also be promoted in all components of the Mine Development including efficient site lighting using LED lighting.

As CO_2 is a key gas linked to climate change, the following mitigation measures will be put in place to limit vehicle and plant emissions:

- No vehicles or plant will be left idling unnecessarily;
- Vehicles and plant will be well maintained in accordance with manufacturer's specifications or best practice. Should any emissions of dark smoke occur (except during start up) then the relevant machinery will be stopped immediately, and any problem rectified before being used;
- Engines and exhaust systems will be regularly serviced according to the manufacturer's recommendations and maintained to meet statutory limits/opacity tests;
- During road haulage, full loads will be transported where possible to minimise the carbon footprint; and
- Minimising the double handling of materials.

The Mine Development will ensure that environmentally sustainable practices are promoted and incorporated into the construction life of the development.

9.7.3 Mitigation and Management: Operational Phase: Community Sports Complex

Consumption of electricity at the Community Sports Complex will be minimised as far as possible through design. In line with the Energy Hierarchy, energy efficiencies and incentives will be inbuilt into the electrical infrastructure and management practices.

Energy use reduction and efficiency will be promoted in all components of the development including efficient site lighting using LED lighting, particularly in relation to the lighting of the sports pitches.

The Community Sports Complex will ensure that environmentally sustainable practices are promoted and incorporated into the operational life of the development.

9.7.4 Mitigation and Management: Operational Phase: Mine Development

Soil stripping during wetter periods will also ensure that carbon losses are reduced compared with warmer drier periods.

SGCPI focuses on optimisation of energy consumption and greenhouse gas reduction in its operations. One of the ways in which SGCPI optimises its energy consumption and reduces its greenhouse gas emissions is by buying 100% green energy. Appendix 9.2 contains the company's latest certificates which confirm that all of the electricity it used in 2020 was sourced from 100% renewable energy. Energy use reduction and efficiency will also be promoted in all components of the Mine Development including efficient site lighting using LED lighting.

As CO_2 is a key gas linked to climate change, the following mitigation measures will be put in place to limit vehicle and plant emissions from the mining activities:

- No vehicles or plant will be left idling unnecessarily;
- Vehicles and plant will be well maintained in accordance with manufacturer's specifications or best practice. Should any emissions of dark smoke occur (except during start up) then the relevant machinery will be stopped immediately, and any problem rectified before being used;
- Engines and exhaust systems will be regularly serviced according to the manufacturer's recommendations and maintained to meet statutory limits/opacity tests;
- During road haulage, full loads will be transported where possible to minimise the carbon footprint per load of exported materials; and
- Minimising the double handling of materials.

SGMI have pledged to create net-zero carbon emissions by no later than 2050 and their investment in Research & Development allows them to create innovative technologies which are used to minimise the negative impacts of construction and manufacturing processes on the climate.

In addition, SGMI have developed an onsite recycling process for off-cut plasterboard generates on construction sites. These will be collected and brought back to the plasterboard manufacturing facility for recycling and reuse, where traceability certificates outlining the lifecycle of the construction material cut-offs will be issued.

- Adherence to the British Standards Institution (BSI) in relation to BES 6001 (or other equivalent future standard);
- Meeting SGMI's 'levers for action' identified in its CO_2 Roadmap Towards Carbon Neutrality by 2050 (see Appendix 9.1). Through this, SGMI can ensure that they are able to influence their supply chains towards more environmentally sustainable practices.

9.7.4.1 SGMI Environmental Policy

SGMI focuses on optimisation of energy consumption and greenhouse gas reduction in its operations. One of the ways in which SGCPI optimises its energy consumption and reduces its greenhouse gas emissions is by buying 100% green energy. Appendix 9.2 contains the company's latest certificates which confirm that all of the electricity it used in 2020 was sourced from 100% renewable energy. Energy use reduction and efficiency will also be promoted in all components of the Mine Development including efficient site lighting using LED lighting.

Mitigation of climate change effects of the proposed Mine Development is focused on the reduction of greenhouse gas emissions in order to minimise global warming. Major projects consider mitigation through the selection of lower carbon options and the adaption of management practices.

The mining activities undertaken as part of the Project are operated by SGMI, who is committed to responsible operation and a focusing on optimizing energy consumption and reducing greenhouse gas emissions during its manufacturing processes and end use of its products. Saint-Gobain's environmental objectives for 2025 (reducing CO_2 emissions by 20%) have been validated by the Science-based Targets initiative.

As part of the September 2019 global Climate Action Summit, Saint-Gobain has committed to creating net-zero carbon emissions by no later than 2050, in line with 1.5 ^{o}C scenarios. This commitment means that Saint-Gobain has pledged to make its contribution to keeping global temperature increase within 1.5 ^{o}C above pre-industrial levels. Saint-Gobain will achieve this by setting out interim targets and steps which will take into account the specificities of its processes and its investment cycles and will filter through to its mining activities during the course of the Project.

Saint-Gobain designs, produces and distributes solutions that contribute themselves to the reduction of CO_2 emissions, including thermal insulation solutions that promote energy efficiency. Within three months, thanks to Saint-Gobain's energy savings, their insulation solutions compensate the CO_2 emissions linked to their production.

The end-use product, which is produced from the gypsum on the Site, is used in technology which has been designed to be innovative and increase the energy efficiency of new builds and increase the thermal renovation of the current building stock. Further details relating to Saint-Gobain's climate change policy are included in Appendix 9.1.

In this regard, the mining aspects of the Project are in line with addressing Themes 2, 3, 5 and 6 of MCC's Climate Adaptation Strategy (Section 9.2.1.4).

9.7.5 Mitigation and Management: Restoration/Closure Phase: Community Sports Complex

There is no proposed decommissioning of the Community Sports Complex and so this is not considered further.

9.7.6 Mitigation and Management: Restoration/Closure Phase: Mine Development

Consumption of electricity at the Mine Development will be minimised as far as possible through design. In line with the Energy Hierarchy, energy efficiencies and incentives will be inbuilt into the electrical infrastructure and management practices.

As CO_2 is a key gas linked to climate change, the following mitigation measures will be put in place to limit vehicle and plant emissions:

- No vehicles or plant will be left idling unnecessarily;
- Vehicles and plant will be well maintained in accordance with manufacturer's specifications or best practice. Should any emissions of dark smoke occur (except during start up) then the relevant machinery will be stopped immediately, and any problem rectified before being used;
- Engines and exhaust systems will be regularly serviced according to the manufacturer's recommendations and maintained to meet statutory limits/opacity tests;
- During road haulage, full loads will be transported where possible to minimise the carbon footprint; and
- Minimising the double handling of materials.

9.8 Monitoring

9.8.1 Monitoring: Construction Phase: Community Sports Complex

- Monitoring will be undertaken in line with any conditions set by MCC;
- The appointed Main Contractor will be required to produce a final CMP, which will document appropriate procedures and responsible persons when working on and around utilities and services infrastructure within and around the site;
- Any monitoring associated with authorisation or consents (e.g., construction discharges or those associated with operational activities) will be incorporated into the Main Contractor's CMP and will be adhered to.

9.8.2 Monitoring: Construction Phase: Mine Development

- Monitoring will be undertaken in line with any conditions set by MCC;
- The appointed Main Contractor will be required to produce a final CMP, which will document appropriate procedures and responsible persons when working on and around utilities and services infrastructure within and around the site; and

- Any monitoring associated with authorisation or consents (e.g., construction discharges or those associated with operational activities) will be incorporated into the Main Contractor's CMP and will be adhered to..

9.8.3 Monitoring: Operational Phase: Community Sports Complex

The Community Sports Complex will ensure that environmentally sustainable practices are promoted and incorporated into the operational life of the development.

9.8.4 Monitoring: Operational Phase: Mine Development

The Mine Development will ensure that environmentally sustainable practices are promoted and incorporated into the operational life of the development.

- Monitoring will be undertaken in line with any conditions set by the IE Licence; and
- Emissions from the Mine Development will be reported in the Annual Environmental Report (AER) as part of the IE Licence.

9.8.5 Monitoring: Restoration/Closure Phase: Community Sports Complex

There is no proposed decommissioning the Community Sports Complex and so this is not considered further here.

9.8.6 Monitoring: Restoration/Closure Phase: Mine Development

- Monitoring will be undertaken in line with any conditions set by the IE Licence; and
- Emissions from the Mine Development will be reported in the Annual Environmental Report (AER) as part of the IE Licence.

9.9 Residual Effects

9.9.1 Community Sports Complex

The residual effect of the proposed Community Sports Complex on microclimate and climate change are considered to be **Imperceptible** after mitigation measures have been applied.

9.9.2 Mine Development

The residual effect of the proposed Mine Development on microclimate and climate change are considered to be Imperceptible**,** and **Not Significant** after mitigation measures have been applied.

Carbon release from soils will occur during the stripping on the Knocknacran West Mine site. However, upon restoration and maturation of the planted areas of the site, and restoration of mining areas within the Application Site, there will be a permanent effect (>60 years) of carbon sequestration, resulting in a positive effect on the microclimate.

9.10 Cumulative Effects

9.10.1 The Project – Community Sports Complex and Mine Development

Construction Activities

Due to the construction timeline a number of the Community Sports Complex and Mine Development construction activities will occur simultaneously, although these will be located in different places across the Site. All construction activities occurring during an annual period have been considered as part of this assessment.

Operational Activities

All operational activities occurring during an annual period have been considered as part of this assessment.

GHG Emissions

As both GHG emissions from the site will be not significant, and that both the Community Sports Complex and Mine Development are continuations of historical developments within the area, the cumulative effect will be similar to the current and will not be significant.

Air Quality

An increase in summer and winter rainfall volume and periods of higher intensity rainfall (storms) could lead to increased dust dampening and suppression. This would result in less entrainment and dispersion of dust particles as the increased rainfall would result in particles being less available to be mobilised by the air.

In the summer, higher air temperatures could result in changes to chemical reactions which occur in the atmosphere. If temperatures increase, there could be an increase in photochemical reactions leading to an increase in ozone concentrations in the atmosphere.

Increases in temperature may also trigger an increase in the demand for cooling of buildings, including air conditioning, which may result in increased carbon and greenhouse gas emissions through increased energy demand.

Increases in wind speed could change the dispersion patterns of pollutants.

Due to the scale of the Project, the limited relevant predicted climatic changes over the anticipated life of the project and the limited sensitivity of the Site, effects of climate on air quality are deemed to be Slight.

Noise

The projected windier, wetter and warmer environment is not anticipated to result in any significant change to future noise or vibration levels arising from the Project.

Landscape and Visual

The predicted seasonal variations in rainfall i.e., wetter winters and drier summers could create unfavourable conditions for the establishment of trees and shrubs, particularly during prolonged periods of drought, or where waterlogging of the ground persists. This could increase plant mortality and the effectiveness of screening around the periphery of the Project, along with potential increased on-going maintenance costs. Given that landscaping proposals will be developed with the knowledge and requirement to consider climate resilience, the impacts are deemed to be Slight.

Water and Flood Risk

In the future, increases in winter rainfall volume and periods of higher intensity rainfall (storms) could lead to increased runoff, greater surface water flows and more incidents of flooding. Current predictions suggest that more flash floods in summer and bigger floods in winter could be expected.

In the summer, higher air temperatures could lead to higher surface water temperatures leading to greater evaporation and reduced flows. Rainfall could be less and more intense leading to potential increases in erosion and suspended solid concentrations during sudden high intensity rainfall events on dry ground. Less overall summer rainfall could also lead to lower flows in watercourses and possibly poorer quality (i.e., caused by changes in land use and the quality of runoff). Changes in surface water flow regime through the year caused by changes in rainfall distribution could alter the mobility and dilution of nutrients and contaminants (i.e., lower dilution in summer due to lower flow rates would result in higher concentrations, and lower flow rates could lead to algal blooms and lower oxygen). Lower summer flows and water levels also have the potential to result in reduced surface water resource availability.

The potential flood risk has been considered in Chapter 8.0, and it is considered likely that the Proposed Development will result in a reduced risk of surface water flooding in the local area.

Geology, Ground Conditions and Groundwater

The Application Site relates to a historical mine and an area of known gypsum deposit. The Community Sports Complex will not affect or interact with the geology at the Site.

Knocknacran Gypsum Mine is a designated geological heritage site (Site Code MN010). Changes in rainfall, temperature and wind are not anticipated to result in any change to geological conditions that could affect the Proposed Development.

In terms of ground conditions and groundwater, higher air temperatures and windier conditions could result in higher evaporation and reduced soil saturation. Reduced soil saturation in drier and warmer summers could lead to reduced groundwater recharge in the summer, and the winter groundwater recharge period could be shortened due to autumn and winter rainfall balancing the soil moisture deficit before recharging groundwater. This may be compensated to some extent by increased winter rainfall. However, aquifers are recharged more effectively by prolonged steady rain, so changes in rainfall regimes could lead to more runoff to surface water rather than recharge to ground during higher intensity summer and winter rainfall events.

If recharge and groundwater levels were to decrease, there could be increased frequency and severity of groundwater droughts. Conversely, if groundwater recharge increases at certain times of the year there could be an increase in the frequency and severity of groundwater-related floods. If groundwater levels in contaminated ground rise due to climate change, this could lead to the mobilisation of historical contamination that was previously above groundwater level highs, which could impact baseline groundwater quality and ground quality. As set out in Chapter 7.0, however, soils are protected through careful site management, thereby reducing the potential for soil contaminant mobilisation.

Higher future temperatures and the potential reduction in the availability of surface water resources could also lead to a greater demand on groundwater resources for urban/industrial supplies and agricultural irrigation. Improvements in water use efficiency are expected to take place in parallel with climate change.

Due to the scale and timeframe of the Project, coupled with the fact that there is no issue with groundwater supply currently, the predicted climatic changes over the anticipated life of the project are deemed to be Slight.

Ecology and Biodiversity

Climate change presents a risk to native wildlife and to the ecosystem services provided by natural capital, for example clean water.

At a local level (i.e., the spatial extent of the assessment defined for the Project), the projected windier, wetter and warmer environment is not expected to result in any significant change to the baseline biodiversity features of the Project. Mine restoration plans will consider emerging climate change evidence and data as they are developed to ensure that opportunities for biodiversity enhancement will be sought.

9.10.2 The Project and other offsite projects (existing/reasonably foreseeable future)

The nearest extractive industry site to the Project which may have the potential to cumulatively effect the local climate include the underground Drummond Mine adjacent to the southern boundary of the existing Knocknacran site. However, no significant cumulative climate impacts are anticipated. There are no further extractive industries within 1 km of the site boundary.

There are four extractive industry sites located within 5 km of the Project. These are; (i) Cormey Clay Pit, Breedon Brick Ltd's open-cast clay quarry, located ca. 1.5 km south of the Site. (ii) an associated site located ca. 4 km south of the Site, (iii) Limestone Industries Ltd limestone quarry, located ca. 2 km west of the Site, and (iv) Roadstone Barley Hill open-cast quarry located ca. 4 km southeast of the Site. Given the nature (open pit) and size of the activities at the Project, it is not anticipated that any noticeable cumulative effects will arise relating to the climatic environment that could be attributed to the interaction of several extractive industries in close proximity to each other.

Losset ADN Materials Ltd. also have a planning application under consideration (Reg. Ref. 22/254) and are located ca. 1 km to the north of the Project site. Based on a review of the current planning file data (to date 27th March 2023), this development is not seeking to materially change their development or air quality and climate impacts.

The cumulative effects are deemed **Not Significant** between the Project and other offsite Projects.

9.11 'Do-Nothing' Scenario

If the Project does not proceed there are not perceived to be any changes to climate vulnerabilities or climate change emissions at the site compared to current operations. Without the proposed Mine Development, the Irish building industry would be reliant on the importation of gypsum or gypsum products from abroad, which would have an associated carbon cost and climate implications.

9.12 Difficulties Encountered

The assessment of GHG emissions has required some assumptions regarding the quantification of emissions from the Site. Current GHG emissions are reported collectively for the existing mine Site and a separate processing facility and as a result there have been difficulties defining the emissions from each source.

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APPENDIX 9.1
Saint-Gobain Climate Policy Documents

CLIMATE 9.0

PRESS RELEASE

November 12, 2020

SAINT-GOBAIN SETS OUT ITS CO_2 ROADMAP TOWARDS CARBON NEUTRALITY BY 2050

Saint-Gobain today sets out its CO_2 roadmap for achieving carbon neutrality. The roadmap incorporates the Group's new commitments through to 2030 in terms of reducing not only its direct and indirect carbon dioxide emissions, but also the emissions along its value chain. These new targets for 2030 have been validated by the Science-Based Targets (SBT) initiative[1] which considers them aligned with the Group's 2050 net-zero commitment. To meet its targets, Saint-Gobain will dedicate a targeted capital expenditure and R&D budget of around €100 million per year until 2030. This approach will be the basis for the decisions that the Group will take to achieve carbon neutrality by 2050.

Saint-Gobain's response to climate change

Besides its efforts to become carbon neutral in its operations, Saint-Gobain provides solutions to its customers and end-users to address the climate and environmental challenges that they face. In the construction industry, which accounts for around 40% of global CO_2 emissions, Saint-Gobain develops and markets solutions to improve the energy efficiency in buildings, and solutions with a reduced carbon footprint – such as for light construction – designed to replace traditional, more carbon-intensive heavy building materials.
Elsewhere, through its High Performance Solutions segment, the Group helps the transport industry in its transition thanks to lightweight and more energy efficient solutions. It also aids industrial producers by providing them with solutions to reduce energy consumption in their manufacturing processes.

On September 23, 2019 in New York, Saint-Gobain formalized its support for the UN Global Compact's "Business Ambition for 1.5°C". In doing so, it committed to achieving carbon neutrality, or net-zero CO_2 emissions, by no later than 2050. As a consequence, the Group will reduce its carbon emissions to a maximum by 2050 and employ measures to absorb any residual emissions.

Today, Saint-Gobain is unveiling its new ambitions and the main axes of its CO_2 roadmap towards carbon neutrality in 2050, which comprises several stages: the 2025 targets confirmed by the Group represent the first milestone, which is supplemented by new targets for 2030.

[1] Science-Based Targets, a joint initiative of CDP, the UN Global Compact, the World Resources Institute (WRI) and the World Wildlife Fund (WWF), and one of the We Mean Business coalition commitments, defines and promotes best practice in science-based target setting, and independently assesses and approves companies' targets to accelerate the transition to a low-carbon economy.

Intensified efforts

This commitment is part of an approach pursued over many years, which has seen Saint-Gobain set out formal targets to reduce its environmental footprint, in particular a reduction in CO_2 emissions (Scope 1 + 2) by 20% between 2010 and 2025 at iso-production. In 2019 Saint-Gobain achieved a 14.5% reduction versus 2010 on this basis, leaving the Group well-placed to meet its 2025 target. The reduction targets for 2030 reflect how the Group is accelerating and enhancing its efforts. After having validated Saint-Gobain's 2025 ambition in 2019, the SBT initiative has now validated the Group's targets for 2030, recognizing how the Group has accelerated and deepened its ambitions in line with its target to become carbon neutral by 2050.

New 2030 targets

- Reduction in its direct and indirect CO_2 emissions (scope 1 + 2) to 9 million tons, i.e., of 33%[2] in absolute terms compared with 2017;
- Reduction in its scope 3 CO_2 emissions of 16% in absolute terms, for all relevant categories for Saint-Gobain[3], compared to 2017.

Levers for action

In order to reduce its CO_2 emissions and achieve carbon neutrality, the Group is focusing its efforts on four key levers:

1) Optimization and reduction of its energy use:
   - Installation of equipment and digital tools to adjust energy consumption as closely as possible to requirements: launch of a large-scale Group program combining the installation of sensors, the use of algorithms in production chains and the training of engineers;
   - Increase the proportion of lost heat re-used, reduction of standby losses, improved insulation and extension of heat recovery systems.

2) Innovation in its processes, both industrial and product design:
   - Development of detailed roadmaps for each industrial process, supplemented by action plans developed and implemented by each country, based on knowledge of the local market and regulatory environment;
   - Product design: lighter products, products made using low-carbon raw materials, products with high recycled content.

3) Transition towards carbon-free energy:
   - Substitution of high carbon-based energies by zero or lower carbon-based energies: green electricity, replacement of heavy fuel with natural gas, replacement of natural gas by biogas;
   - Substitution of carbon-based energy with decarbonized energy requiring substantial modification of our processes (post-2030): direct electrification or green hydrogen.

[2] Reduction of 30% in absolute terms compared to actual emissions in 2017, and of 33% compared to 2017 emissions as adjusted for acquisitions made between 2017 and the date on which the targets were validated.

[3] Purchased goods and services, energy-related activities, upstream and downstream transport and distribution, business travel, and end-of-life treatment of products sold (categories validated by the SBT).

4) Mobilization of suppliers and new initiatives in transport:
   - For suppliers: comparison of their performance on the basis of CO_2 emissions criteria both in terms of their operations and for the products concerned, signature of our Responsible Purchasing Charter, collection of detailed information on their commitments in terms of sustainable development, encouraging large emitters to adopt an SBT approach;
   - For transport: optimized logistics, fuel efficiency improvements, use of decarbonized fuels, replacement of road transport by rail & water, working alongside logistics suppliers.

For any residual emissions the Group intends to investigate carbon capture and sequestration solutions.

Intensified commitment
The Group is rolling out measures to support its roadmap towards to carbon neutrality.
CSR objectives now represent a larger share of long-term management incentive criteria: their weighting is raised from 15% to 20%, with CO_2 objectives increasing from 5% to 10%.
In addition, two internal carbon prices are used: €30 per ton for industrial investments and €100 per ton for R&D investment in breakthrough technology.
Finally, the Group will allocate a budget of around €100 million per year until 2030 to targeted capital expenditure and R&D investments in order to achieve its targets.

Pierre-André de Chalendar, Chairman and Chief Executive Officer of Saint-Gobain, commented:
"*Our commitment to carbon neutrality guides our actions and our decisions at all levels of the organization. The long-term approach needed is aligned with that of our stakeholders. We have an important responsibility as a major industrial group and committed actor, and finding solutions to environmental challenges has been at the heart of our strategy for many years now. In addition to working towards its own carbon neutrality, Saint-Gobain makes a very significant positive contribution to our environment and our markets through products, solutions and services that help our customers transition to a low-carbon economy. Our insulating solutions sold in one year enable the avoidance of over 100 times the Group's greenhouse gas emissions, which represents the prevention of over 1,200 million tons CO_2 equivalent over their lifespan.*"

Benoit Bazin, Chief Operating Officer, added:
"*For businesses like ours, achieving carbon neutrality in 2050 means taking action today. 2030 is just around the corner and the decade ahead of us is crucial. In addition to ongoing improvement and operational excellence programs, we deploy R&D efforts and make targeted investments which will enable us to further accelerate our action thanks to disruptive innovations. Our employees are fully committed to the cause and more than ready to take on this challenge.*"

Our CO_2 roadmap is embedded in our environmental strategy
These CO_2 targets reflect an acceleration and expansion in the Group's scope of action compared to its 2025 goals. They are part of a series of new commitments for 2030 in other key areas of its environmental strategy:

- Natural resources and circular economy: 80% reduction in non-recovered production waste[4]; 30% increase in virgin raw materials avoided[5];
- Water: 50% reduction in industrial water withdrawal[6], zero discharge in drought areas[7];
- Packaging: 100% recyclable packaging, containing more than 30% recycled or biosourced materials;
- Product portfolio: third-party verified Environmental Product Declarations (EPD), based on Life Cycle Analysis (LCA) for 100% of our product ranges[8].

The Group's extensive exposure to the renovation market means it is ideally placed to play a decisive role in national and European stimulus plans focused on the energy transition, which should support Saint-Gobain's structural growth.

Saint-Gobain's medium and long-term outlook is robust thanks to its successful strategic and organizational choices: sustainability – thanks to our solutions to protect our planet while offering comfort and wellbeing – and enhanced customer performance. This strategy is perfectly in tune with the Group's purpose: "**Making the world a better home**".

A presentation on Saint-Gobain's roadmap to carbon neutrality is available on our website. To find out more about the Group's commitments and its path to carbon neutrality, visit https://www.saint-gobain.com/en/net-zero-carbon.

[4] Compared to 2017.
[5] In absolute terms, compared to 2017.
[6] For all sites, compared to 2017.
[7] Compared to 2017. Aqueduct's tools map water risks such as floods, droughts, and stress, using open-source, peer reviewed data. https://www.wri.org/aqueduct/about
[8] Compared to 2017.

ABOUT SAINT-GOBAIN

Saint-Gobain designs, manufactures and distributes materials and solutions which are key ingredients in the wellbeing of each of us and the future of all. They can be found everywhere in our living places and our daily life: in buildings, transportation, infrastructure and in many industrial applications. They provide comfort, performance and safety while addressing the challenges of sustainable construction, resource efficiency and climate change.

€42.6 billion in sales in 2019
Operates in 70 countries
More than 170,000 employees

For more information about Saint-Gobain
Visit *www.saint-gobain.com*
and follow us on Twitter *@saintgobain*

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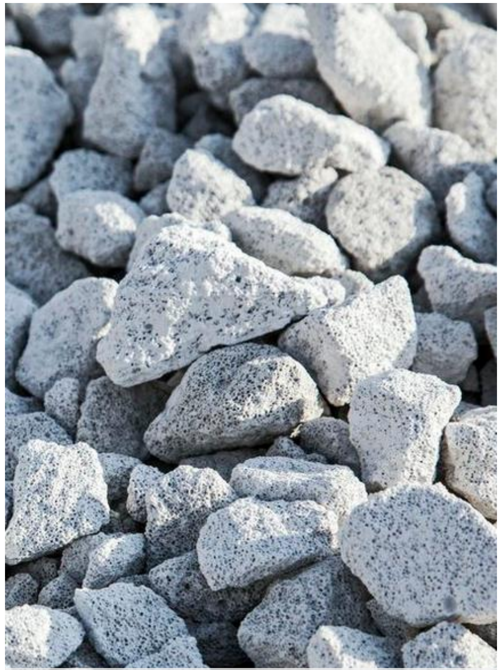
SAINT-GOBAIN

Saint-Gobain carbon neutrality: leading towards sustainable Building & Industry

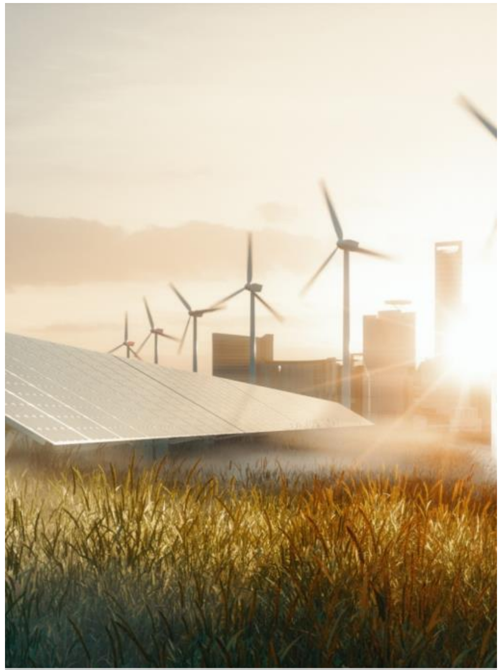
SAINT-GOBAIN

THE CHALLENGE IS TO MEET GROWING NEEDS WITH LESS CARBON & RESOURCES

40%
of CO_2 emissions due to **buildings**



x 2
Raw material use **by 2060**



+12%
in Energy demand **by 2030**

x 3
Passenger transport **2015-2050**

Saint-Gobain's solutions play a critical role in addressing these challenges

Sources: IEA, World Bank, OCDE, BCC research

SAINT-GOBAIN

Our CO_2 Roadmap

Embedded in our CSR Roadmap

Solidifies our status as an ESG leader

SAINT-GOBAIN

SUSTAINABILITY: A LONG-STANDING COMMITMENT FOR SAINT-GOBAIN

Before 2015	2015-2025
2003 **Saint-Gobain Principles of Conduct and Action**	**2015** Setting of **ambitious targets** by 2025: -20% CO_2 emissions; -80% water discharge; -50% non-recovered waste (*vs. 2010 at iso-production*)
2003 Signature of the UN **Global Compact**	**2019** Signature of UN Global Compact pledge targeting carbon neutrality by 2050
2009 **Compliance program** formalization	
2014 **Sustainable habitat** roadmap	
2015 SUSTAINABLE DEVELOPMENT GOALS	

Next step: Setting out the path to reach net-zero carbon by 2050

SAINT-GOBAIN

ON OUR WAY TO CARBON NEUTRALITY, 2030 IS OUR NEXT MILESTONE

In our processes

2030		2050
Science-Based Targets		
Scope 1 + 2 (Direct + Indirect)	**-33%**	
Scope 3 (Value chain)	**-16%**	**Objective 2050** **ZERO CARBON**

Absolute emission reduction vs. 2017

In our solutions offering

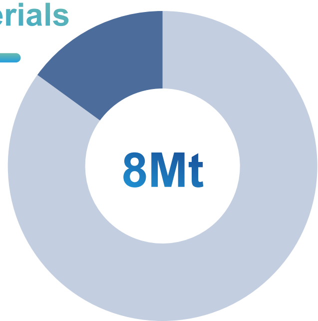
- **Offer the best low-CO_2 and sustainable solutions in our markets**
- **Enable our customers to decarbonize their processes**

SAINT-GOBAIN

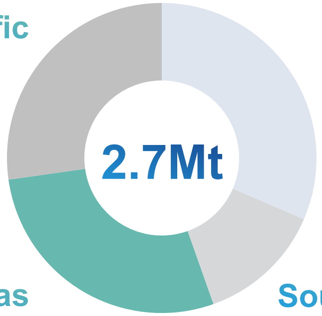
WE ACT UPON ALL 3 EMISSION SCOPES

2019 CO_2 emissions

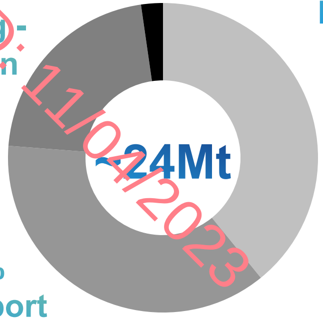
Scope 1 (Direct)



Scope 2 (Indirect)



Scope 3 (Value chain)



Levers for action

Innovate on our processes
industrial, product design

Optimize/reduce our energy use

Transition to carbon free energy

Suppliers & Logistics
raw materials & transports

SAINT-GOBAIN

INNOVATE ON OUR PROCESSES: LEVERAGE OUR UNIQUE GREEN INNOVATION CAPABILITIES

Scope 1 & 2

Short Term

Industry 4.0

- **Deploy widely 4.0 technology** including sensors and data acquisition tools
- Leverage data collected to streamline and optimize processes

Recycling

- Accelerate on **material disposal locations** for our customers in our distribution outlets
- Improve our **product design** to facilitate recycling
- Adapt our **production processes** to accommodate higher proportion of recycled content

Medium and Long Term

Raw material reduction

- Accelerate on **light products**
- Substitute **with low carbon alternatives** keeping same mix
- Accelerate on **recycled content**
- Rethink **our formulations or processes**

Carbon Capture

- **Develop** CCU[1] technologies to be integrated in our production processes
- **Validate technical solutions,** gradually deploy them across industrial footprint

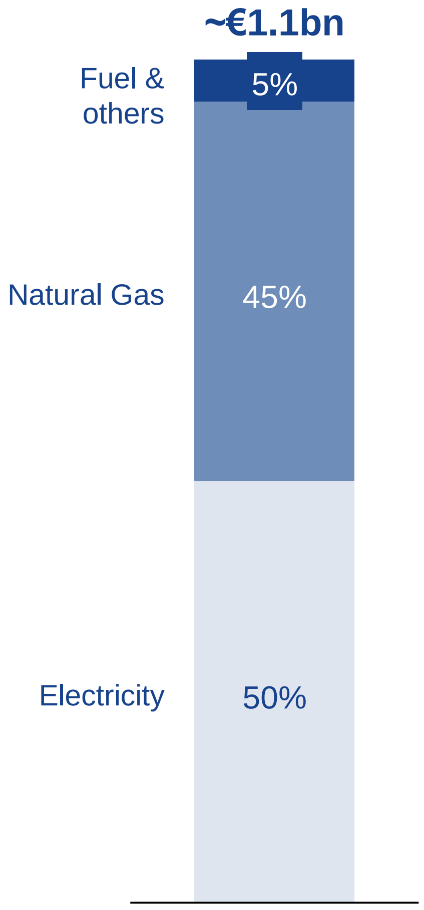
Cleantech at the core of our innovation and R&D

1. Carbon Capture Utilization

SAINT-GOBAIN

REDUCE ENERGY USE/TRANSITION TO CARBON FREE ENERGY: OPTIMIZE NOW, SHIFT TO CLEAN ENERGY FOR MEDIUM TERM

Scopes 1 and 2



2020f Energy bill

Short Term

Reduce consumption

Maximize energy efficiency

- **Leveraging industry 4.0 and data analytics**
- **Implementing heat capture and reuse**

WCM BY SAINT-GOBAIN

Medium and Long Term

Develop technology to transition away from fossil fuels

Transition according to local energy mix

Fossil fuels

Biofuel
(biogas, biomass…)

Green hydrogen or synthetic fuel

Direct electrification

Or

"Boosting"
(electricity, oxygen…)

Shift our mix to green electricity

Market mechanisms

Green Certificates

Power purchase agreements (PPA)

18% *of total electricity consumption in 2019*

Direct investments in renewables

Glass plant in India: Solar panels on roof producing ~4GWh for plant

SAINT-GOBAIN

SUPPLIERS & LOGISTICS: TACKLE EMISSIONS IN SUPPLIERS & TRANSPORT

Scope 3

Engage all our suppliers

Levers

- **Responsible purchasing charter**
- **SBT approach adoption**
- **Data transparency**
- **Benchmarking, selection criteria**

Key actions

- Benchmark suppliers, select them taking into account CO_2 emissions
- **89%** of non-trade suppliers & **86%** of trade suppliers covered by Supplier charter
- Gather detailed CO_2 emissions and other sustainability **data** *(questionnaires, common approach + testing)*
- Engage large emitters to adopt **SBT** approach *(focus on cement, soda ash, paper, distribution suppliers)*

Reduce emissions from transport

Levers

- **Optimize logistics**
- **Improve fuel efficiency**
- **Use decarbonized fuels**
- **Replace road by rail & water**

Examples of key actions

Fret21: part of COP21, to push carriers to cut CO_2 emissions

Evoluvert: NGV[1]-fueled trucks in Point.P distribution centers

Control Tower: truck filling rate monitor, route optimization in LATAM

Leverage our impact on the value chain

1. Natural Gas Vehicle

SAINT-GOBAIN

STRONG COMMITMENT TO SUPPORT OUR PATHWAY TO CARBON NEUTRALITY

INCENTIVES

ESG metrics part of long term management incentives

- CSR targets relative weight at 20% in 2020 up from 15% with CO_2 emissions accounting for 10% (vs. 5% previously)

CARBON PRICE

Internal carbon prices

- 30€/t for industrial investments
- 100€/t for R&D investment in breakthrough technology

€100m

INVESTMENTS

Annual CAPEX and R&D investments over the next ten years

Our CO_2 Roadmap

Embedded in our CSR Roadmap

Solidifies our status as an ESG leader

SAINT-GOBAIN

WE PLACE CORPORATE SOCIAL RESPONSIBILITY AT THE HEART OF OUR BUSINESS MODEL

OUR CSR ROADMAP

1

BUSINESS ETHICS

To share our values with our stakeholders to build together over the long term

2

HEALTH & SAFETY

Our first responsibility is to guarantee the health and safety of our employees and our stakeholders

3

CLIMATE CHANGE

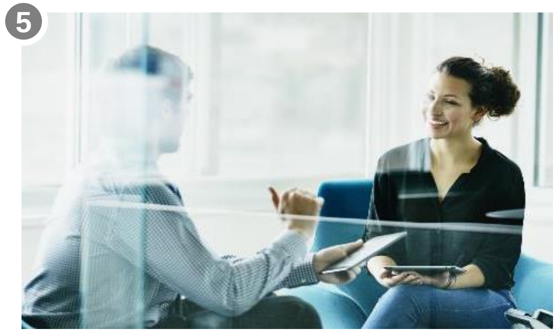
To contribute to the emergence of a low-carbon economy capable of preserving the common good

4

CIRCULAR ECONOMY

To change the way we design, produce and distribute our products and solutions to develop the circular economy

5



INCLUSION & DIVERSITY

To have broadly diverse teams to build an open and engaging corporate culture

6

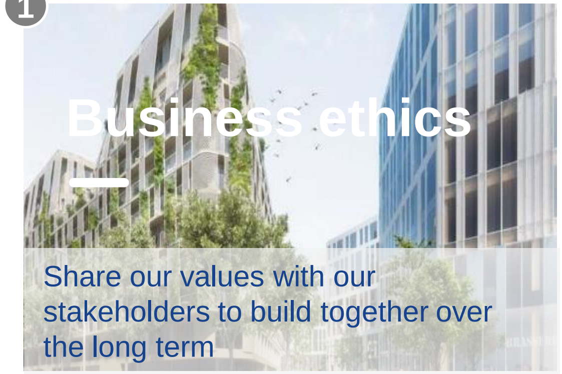
LOCAL & INCLUSIVE VALUE CREATION

To be a corporate citizen everywhere

SAINT-GOBAIN

WE ARE MAKING PROGRESS ON ALL OUR PILLARS (1/3)

1



Our achievements

Ethics

93% of new managers trained in Principles of Conduct & Action

Responsible purchasing

89% Non-trade suppliers covered by the supplier charter

86% Trade suppliers covered by the supplier charter

Compliance

100% of managers trained in competition law

89% of new managers trained in anti-corruption program

2

Health & Safety for all the employees

2.2 Total Recordable Accident Rate (TRAR)

*down from 9.9 in 2010**

Committed to reduce our TRAR below 2 by 2025

Health charter for our employees, clients, suppliers and neighbours

For and with our stakeholders

Main priority during pandemic crisis

Adapted our processes to interact safely amongst our employees, with our suppliers, welcome our customers in strict adherence to sanitary measures

* 2019 includes contractors, 2010 only internal employees

SAINT-GOBAIN

WE ARE MAKING PROGRESS ON ALL OUR PILLARS (2/3)

Our achievements

3

Contribute to the emergence of a low-carbon economy capable of preserving the common good

Products & Solutions contributing

Largest EPD[1] issuer: 1,300+ verified EPD in >31 countries; Best-in-class

Operations & supply chain

-14.5% **CO_2 emissions (scope 1 + 2)** *vs. 2010 at iso-production*

New objectives from our 2030 roadmap

-50% **Industrial water withdrawal, with no discharge in drought areas** *vs. 2017*

100% **Life Cycle Analyses for 100% of Group product ranges**

-33% **Scope 1 + 2**

-16% **Scope 3**

SBT-approved vs. 2017 emissions on an absolute basis

4

Change the way we design, produce and distribute our products, solutions to develop the circular economy

Integrate recycled materials in our products and solutions, adapt manufacturing processes

8.5Mt **Virgin raw materials avoided in 2019**

11.5% **Reduction of non-recovered waste** *vs. 2010*

Create collection networks / services to upcycle wastes

120 **Collection points in our distribution network**

New objectives from our 2030 roadmap

+30% **Avoided virgin raw materials** *vs. 2017*

-80% **Non-recovered waste** *vs. 2017*

100% **Recyclable packaging**

>30% **Recycled or bio-sourced content on packaging**

1. Environmental Product Declaration

SAINT-GOBAIN

CLIMATE CHANGE: WE ARE IDEALLY POSITIONED TO PLAY A MAJOR ROLE IN THE EUROPEAN RENOVATION WAVE

2030 ambition raised by the European Commission

-55%
greenhouse gas emissions*

-18%
energy consumption for heating and cooling*

x2
building energy efficiency **renovation rate** objective

Renovation wave:
35m buildings
to be renovated by 2030, priority to public buildings, such as **schools** and **hospitals**

€275bn
Annual additional investment needs in building renovation

** Compared to 1990*

Renovation in the EU: >€10bn annual sales for Saint-Gobain

Source: European Commission, October 2020

SAINT-GOBAIN

CLIMATE CHANGE: DECARBONIZED SOLUTIONS PROVIDER

~60% Sales contributing directly or indirectly to lower CO_2 emissions

~50% Sales for the renovation market*

+42% Growth in electric vehicle mobility**

** Estimation*
*** In 2019*

Eclaz Glass

+20% energy efficiency
+10% thermal insulation
+10% solar gain

New glass wool

-40% CO_2 emissions
thanks to energy savings

External thermal insulation

30% heating savings
Gain of up to **3** energy classes

Sekurit solutions

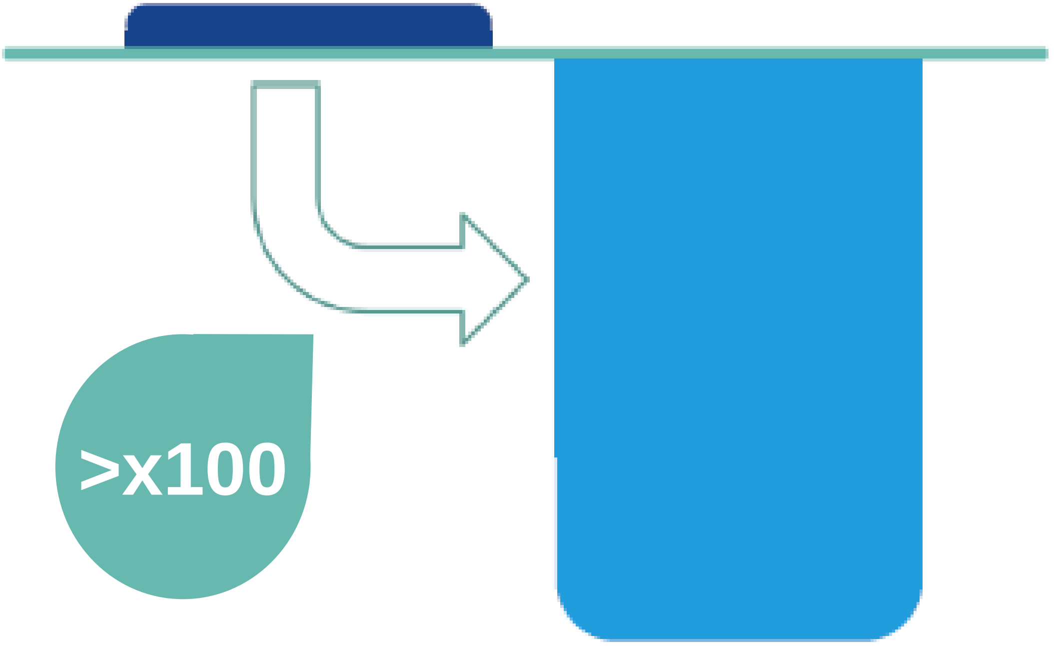
Thermally insulating glazing
for greater autonomy of electric vehicles
+30km autonomy

SAINT-GOBAIN

CLIMATE CHANGE: EXAMPLES OF AVOIDED EMISSIONS

Saint-Gobain CO_2 emissions in one year (scope 1+2)

10.8Mt



-1,200Mt

Avoided emissions thanks to our insulation solutions sold in a year[1]

Example of Glass wool

A typical ISOVER glass wool product has amortized the CO_2 emitted in its production, transport & disposal just 3 months after installation

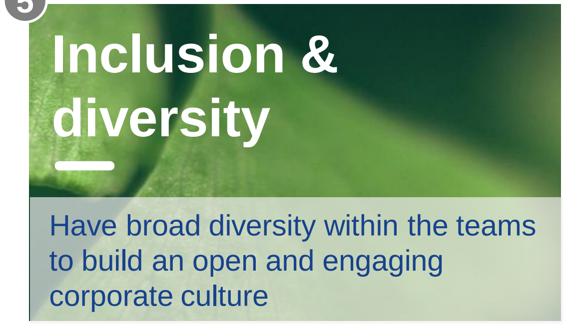
1. Internal methodology developed in partnership with EY Sustainable Performance & Transformation: Avoided emissions calculated as difference between greenhouse gas emissions associated with product Life Cycle Analyses & gain unlocked by the product vs. a reference basic solution multiplied by its lifespan (e.g 30 years for insulation, 50 for glass). Reference solution & scenario defined for each product in portfolio

SAINT-GOBAIN

WE ARE MAKING PROGRESS ON ALL OUR PILLARS (3/3)

Our achievements

5



Increase diversity

- **91.4%** **Global Diversity Index**
- **24.2%** **women managers** vs. 17.5% in 2010
- **17.1%** **women senior managers** vs. 5% in 2010

Promote diversity

'Women In Network'

Be inclusive

Bloomberg Gender-Equality Index

New diversity objective

30% **Women on average on all our business ExCos by 2025**

6

For and with our employees

- **78%** **Employees responding to satisfaction survey**
- **79.1%** **Employees received training in 2019**
- **9%** **of shares held by employees through PEG[1]**

With local communities as recognized trusted local partner

More than 65,000 beneficiaries of the Saint-Gobain Foundation programs in 15 countries

For and with the families of our employees

CARE BY SAINT-GOBAIN

Social protection program launched for all the employees and their families

1. Group Savings Plan

SAINT-GOBAIN

Our CO_2 Roadmap

Embedded in our Sustainability Roadmap

Solidifies our status as an ESG leader

SAINT-GOBAIN

OUR ACTIONS ARE REFLECTED IN POSITIVE ESG RATINGS

Agency	Saint-Gobain rating	Comparative elements
SUSTAINALYTICS	**LOW** ESG risk	Rank 7/124 in building materials industry group
MSCI	**A**	
ISS-oekom	**Prime (C+)**	Among top 10% in industry
vigeo eiris	**52/100**, Robust	Ranked 3/26 in sector
Bloomberg	Included in **Gender-Equality Index**	Only 325 companies globally included in index
CDP DISCLOSURE INSIGHT ACTION	Member of « **Climate Change A list** »	182 companies globally in list >8,300 participating
WSJ	**20th** on list of Top 100 most sustainably managed companies	Out of more than 5,500 publicly traded businesses assessed

Indexes

MSCI 2019 Constituent MSCI ESG Leaders Indexes

Member 2019/2020 STOXX ESG LEADERS INDICES

FTSE4Good

Third party collaboration

SCIENCE BASED TARGETS
DRIVING AMBITIOUS CORPORATE CLIMATE ACTION

Top EMPLOYER GLOBAL 2020
CERTIFIED EXCELLENCE IN EMPLOYEE CONDITIONS

SAINT-GOBAIN

CONCLUSION: SAINT-GOBAIN, AN ESG LEADER

RECEIVED: 11/04/2023

Environmental

- **A key solution provider** for energy efficiency and lower carbon alternatives
- **Net-zero Carbon** by 2050, with new 2030 targets: -33% scope 1+2, -16% scope 3
- **Circular economy:** +30% avoided virgin raw materials by 2030 by further increase in recycled content; -80% non recovered waste; 100% recyclable packaging; >30% recycled or bio-sourced content on packaging

Social

- **Safety:** accident reduction
- **Social Protection program:** 'CARE by Saint-Gobain'
- **Diversity:** 30% women on average on all our business ExCos by 2025
- **Business Ethics training**: for 100% new managers in first year
- **Social dialogue:** 1,437 social agreements in 2019
- **Foundation:** 40 projects sponsored in 15 countries; more than 65,000 beneficiaries of the Foundation programs

Governance

- **Independent directors:** 73% of the board & Lead Independent Director
- **Diversity:** 45% women on Board
- **2 employee directors** on Board and one representative of the employees shareholders
- **Management compensation includes ESG objectives**
- **Corporate Social Responsibility Board Committee**
- **Specific training for board members:** climate change, circular economy, biodiversity

SAINT-GOBAIN

MAKING THE WORLD A BETTER HOME

Appendix

SAINT-GOBAIN

SBT VALIDATED OUR OBJECTIVES

SCIENCE BASED TARGETS
DRIVING AMBITIOUS CORPORATE CLIMATE ACTION

Science-Based Targets

- Platform set up during COP21
- 4 partner organizations:

UN GLOBAL COMPACT | CDP DISCLOSURE INSIGHT ACTION | WORLD RESOURCES INSTITUTE | WWF

- Trusted organization considered as reference (TCFD,…)

A rigorous process to validate targets

Scenarios and targets

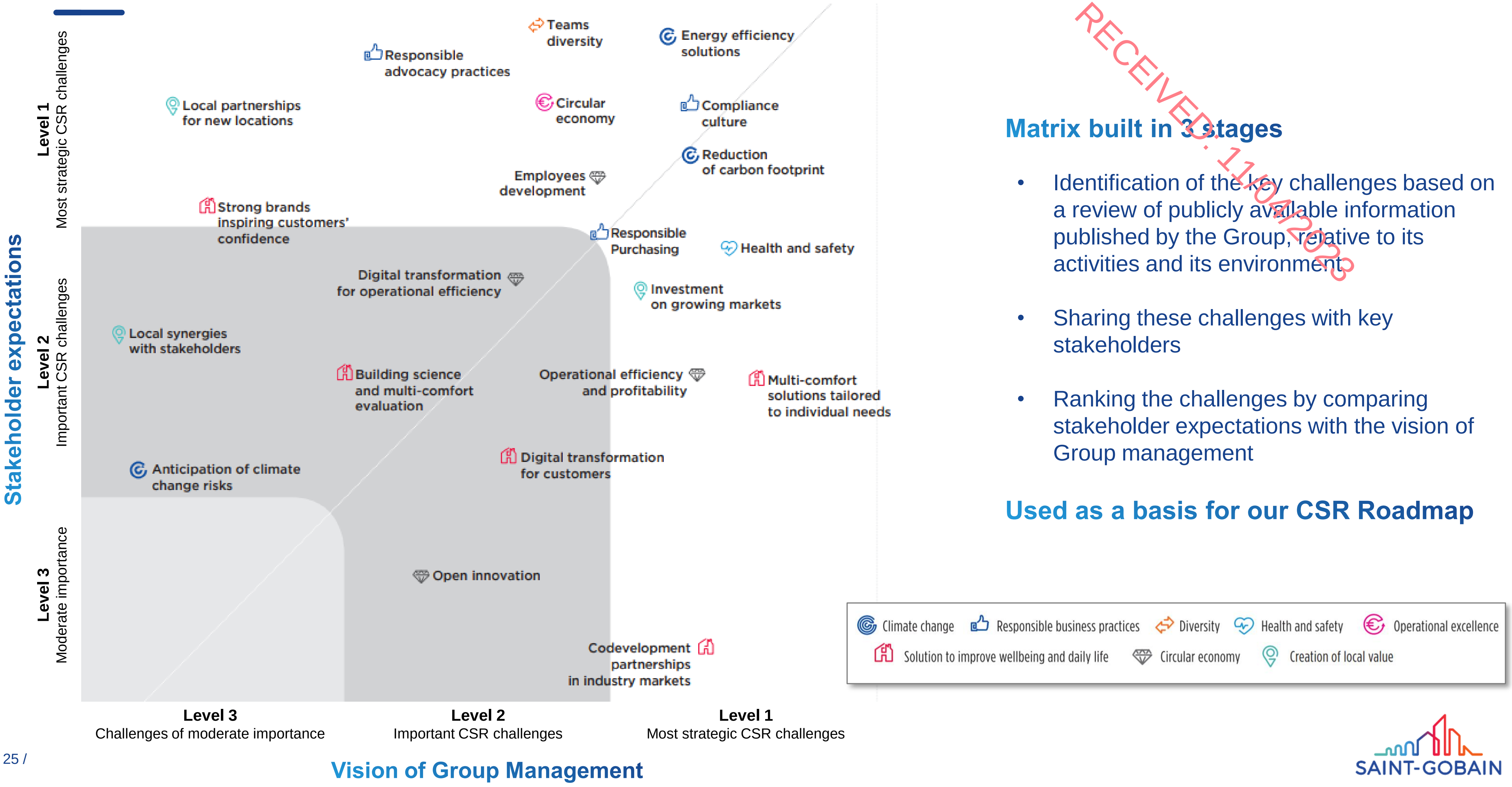
- Scenarios developed to help organizations define their medium term objectives (5 to 15 years)
- >1,000 companies involved of which 500 have mid-term objectives approved
- Long term approach to reach carbon neutrality in line with 2019 pledge
- Saint-Gobain commitment:

Commit to Net Zero carbon by 2050 & follow at least the path of "Well below 2°C" scenario

Source: SBT communication

SAINT-GOBAIN

MATERIAL ISSUES ARE MAPPED AND MONITORED CLOSELY



Matrix built in 3 stages

- Identification of the key challenges based on a review of publicly available information published by the Group, relative to its activities and its environment
- Sharing these challenges with key stakeholders
- Ranking the challenges by comparing stakeholder expectations with the vision of Group management

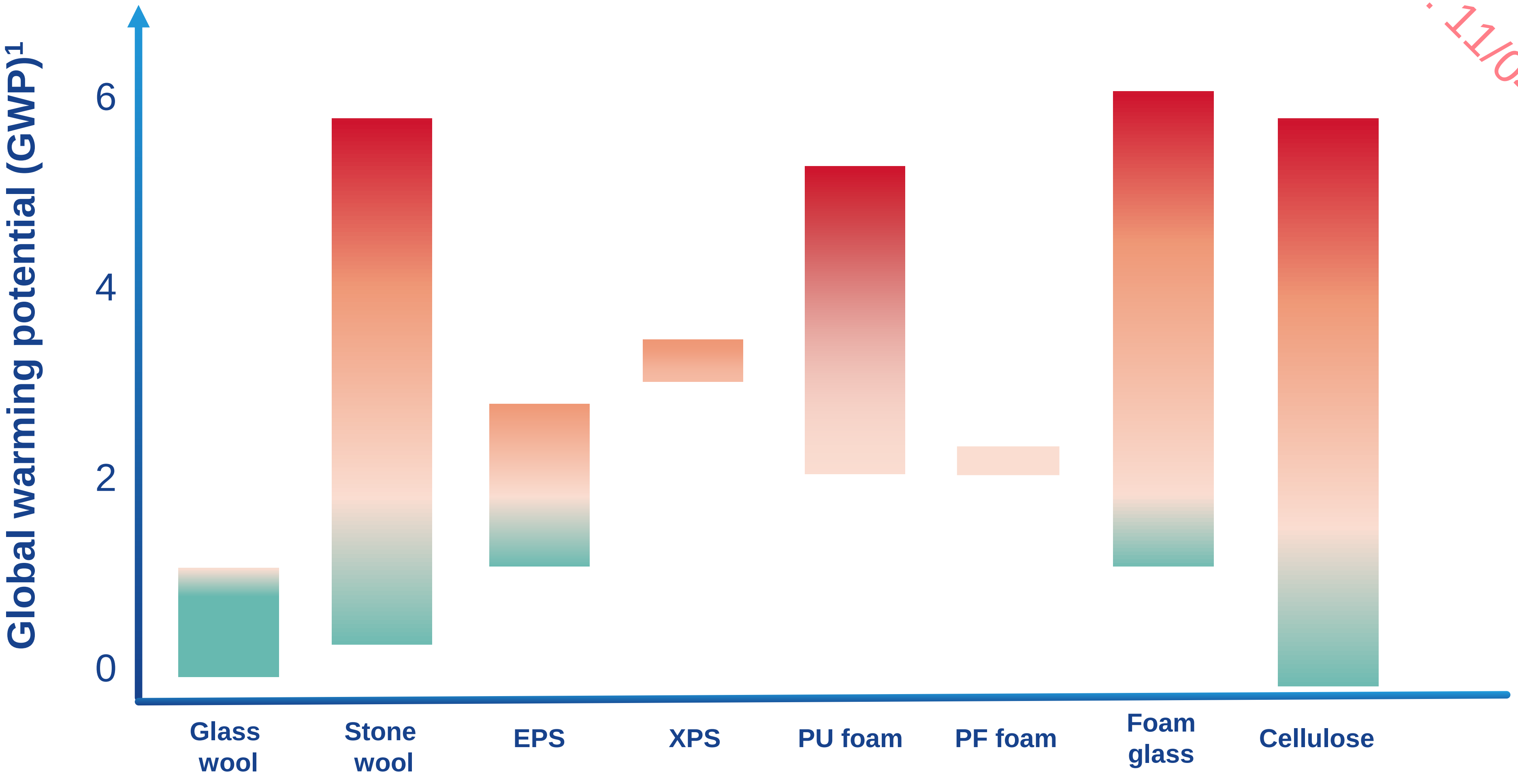
Used as a basis for our CSR Roadmap

SAINT-GOBAIN

WE FOCUS ON SOLUTIONS WITH THE BEST LIFE CYCLE PERFORMANCE

Illustration: Insulation solutions

Global warming potential by product at equivalent insulation performance: the lower the better



1. Global warming potential (kg CO_2 eq./ functional unit)
Source: Energy & Buildings 162 (2018)

SAINT-GOBAIN

APPENDIX 9.2

Saint-Gobain Renewable Energy Certificate

RECEIVED: 11/04/2023

CERTIFICATE OF 100% RENEWABLE ENERGY

AWARDED TO

SAINT GOBAIN CONSTRUCTION PRODUCTS - CARRICKMARCROSS

Congratulations, the electricity you used in 2021 from Flogas Enterprise was 100% Renewable Energy.

By using Flogas Enterprise for your electricity, you saved the equivalent of 15,440.58 trees and Scope 2 emissions of 926.43 tCO_2e (tonnes of carbon dioxide CO_2 equivalent).
Account No: 10000087082 Acutal Usage: 3,590.832

Flogas Enterprise Renewable Technology type 2021

Wind	74.04%
Biomass LFG	18.12%
Solar	1.98%
Anaerobic Digestion CHP	5.76%
Hydro	0.08%

Bryan Hennessy

Bryan Hennessy, Head of Regulation

FLO GAS

Energy for Enterprise

100% renewable energy based on the fuel mix disclosure 2021, issued by the CRU Sept '22

CONTENTS

TABLES

FIGURES

APPENDICES

10.0 AIR QUALITY

10.1 Introduction

The following Chapter assesses the likely impacts of the Proposed Development on the receiving (air) environment. The Mine Development proposes to extract gypsum remaining in the former Drumgoosat Underground Mine by open-cast mining methods and to restoration the existing Knocknacran Mine to near original ground level and the continued use of the existing Knocknacran Processing Plant. The Sports Complex Development provides for the further development of the Community Sports Complex which is currently permitted (and operational) onsite under Reg. Ref. 20/365.

10.2 Legislative and Policy Context

10.2.1 European Air Quality Directives

The European Union (EU) Directive on Ambient Air Quality Assessment and Management came into force in September 1996 (96/62/EC) and defines the policy framework for 12 air pollutants known to have harmful effects on human health and the environment. Air quality limit values (ambient pollutant concentrations not to be exceeded after a given date) for the pollutants are set through a series of Daughter Directives. The first Daughter Directive (1999/30/EC) sets limit values for NO_2 and PM_{10} (amongst other pollutants) in ambient air.

Following the Daughter Directives, EU Council Directive 2008/50/EC on ambient air quality and cleaner air for Europe (CAFE) came into force in June 2008, consolidating the existing air quality legislation, making provision for Member States to postpone attainment deadlines and allowing exemption from the obligation to limit values for certain pollutants, subject to strict conditions and assessment by the European Commission. Directive 2008/50/EC was transposed into Irish legislation in 2011 through The Air Quality Standards Regulations 2011. The Directive merged the four daughter directives and EU Council decision into a single directive on air quality. The new Directive also introduced a new limit value for $PM_{2.5}$ but does not change the existing air quality standards.

10.2.2 National Air Quality Legislation

The Air Pollution Act (1987) is the primary legislation relating to air quality in Ireland and provides the means for local authorities to take the measures that they deem necessary to control air pollution.

The Air Quality Standards Regulations (2011) transpose the Directive on ambient air quality (2008/50/EC) into Irish law. These regulations establish limit values and thresholds for various pollutants in ambient air.

The Environmental Protection Agency (EPA) monitor the levels of various pollutants against the standards set out in EU and Irish legislation. The EPA are the competent authority for annual reporting to the Minister for the Environment, Heritage and Local Government and the European Commission.

10.2.3 Other Relevant Legislation

Legislative references considered specifically for the assessment of air quality from extraction activities, and relevant statutory instruments in a planning context include:

- European Communities (Environmental Impact Assessment Regulations) 1989 (S.I. No. 349 of 1989);
- Section 177F of the Planning & Development Act 2000 as amended;
- Directive 2014/52/EU of the European Parliament and of the Council, (amending Directive 2011/92/EU);
- European Union (Planning and Development) (Environmental Impact Assessment) Regulations 2018, S.I. 296 of 2018; and
- Planning and Development Regulations 2001 (as amended).

10.2.4 Relevant Guidance

This assessment has been undertaken with guidance from the 'Guidelines on the information to be contained in Environmental Impact Assessment Reports', published in 'draft' by the EPA in August 2017; 'Environmental Impact Assessment of projects, guidance on the preparation of the Environmental Impact Assessment Report' published by the European Commission in 2017 and, 'Advice Notes for Preparing Environmental Impact Statements', also published in 'draft' by the EPA in September 2015.

Other guidance documents considered in this assessment include:

- IAQM; Guidance on the Assessment of Mineral Dust Impacts for Planning, 2016;
- IAQM; Guidance on the assessment of dust from demolition and construction, 2014;
- EPA; Guideline Document entitled Environmental Management in the Extractive Industries, 2006;
- EPUK & IAQM; Land-Use Planning and Development Control: Planning for Air Quality, 2017;
- Irish Concrete Federation – Environmental Code 2nd Edition, October 2005;
- Environmental Management in the Extractive Industry, EPA 2006;
- Quarries and Ancillary Activities – Guidelines for Planning Authorities – DOEHLG, April 2004;
- Process Guidance Note 3/16 (12) – Secretary of State's Guidance for Mobile Crushing and Screening, DEFRA (UK), September 2012;
- Process Guidance Note 3/8 (12) – Secretary of State's Guidance for Quarry Processes, DEFRA (UK), September 2012;
- Safe Quarry – Guidelines to the Safety, Health and Welfare at Work (Quarries) Regulations 2008 – Health and Safety Authority, 2020;
- Environmental Protection Agency's Annual Air Quality in Ireland Report 2021; and
- UK Environment Agency - Air Emissions Risk Assessment for Your Environmental Permit, published in February 2016, updated and accessed in July 2022.

10.2.5 Relevant Planning Objectives

The Monaghan County Development Plan 2019-2025 acknowledges that there is an increasing demand for aggregates and that new areas for extraction of aggregates and minerals are a significant natural resource in the county. To address this the Council notes that planning policies should be carefully constructed to avoid adverse effects on aggregate resources and related extractive industries, and that the proposed plans should be developed in a sustainable manner not to cause adverse effects.

Monaghan County Council has adopted policies with the 2019-2025 County Development plan in relation to the protection of air quality from deposited dust and fine particulates. Relevant Monaghan County Council policies relevant to this assessment of population and human health include:

- **AQP1** – Quality and Cleaner Air for Europe (CAFE) Directive (2008/50/EC) and ensure that all air emissions associated with new developments are within the Environmental Quality Standards as set out in the Air Quality Standards Regulations 2011 (SI No. 180 of 2011) (or any updated/superseding documents). Promote the preservation of best ambient air quality compatible with sustainable development in accordance with EU Ambient Air.

- **AQP2** – To contribute towards compliance with air quality legislation; greenhouse gas emission targets; management of noise levels; and reduction in energy usage.

- **DM2** – To assess proposals for development in terms of, inter alia, potential impact on existing adjacent developments, existing land uses and/or the surrounding landscape. Where proposed developments would be likely to have a significant adverse impact on the amenities of the area through pollution by noise, fumes, odours, dust, grit or vibration, or cause pollution of air, water and/or soil, mitigation measures shall be implemented to eliminate adverse environmental impacts of reduce them to an acceptable operating level.

- **ERP2** – To promote development involving the extraction of mineral reserves and their associated processes, where the planning authority is satisfied that any such development will be carried out in a sustainable manner that does not adversely impact on the environment or on other land uses. Consideration in this regard shall be given to the impact of the development on the local economy.

10.2.6 Air Quality Standards

Table 10.1 below shows the limit or target values, specified by the CAFE Directive 2008/50/EC, relevant to this assessment.

Gaseous Pollutants

Table 10.1: Air Quality Standards

Pollutant	Limit Value Objective	Averaging Period	Limit Value ug/m^3	Basis of application Limit
SO_2	Protection of human health	1 hour	350	Not to be exceeded more than 24 times in a calendar year
		24 hours	125	Not to be exceeded more than 3 times in a calendar year
	Protection of vegetation	Calendar year	20	Annual mean
		1 Oct to 31 Mar	20	Winter mean
NO_2	Protection of human health	1 hour	200	Not to be exceeded more than 18 times in a calendar year
		Calendar year	40	Annual mean
NO_x (NO_2 + NO)	Protection of ecosystems	Calendar year	30	Annual mean
PM_{10}	Protection of human health	24 hours	50	Not to be exceeded more than 35 times in a calendar year
		Calendar year	40	Annual mean
$PM_{2.5}$ Stage 1	Protection of human health	Calendar year	25	Annual mean
$PM_{2.5}$ Stage 2		Calendar year	20	Annual mean

Coarse Particulates

The impact of dust is usually monitored by measuring rates of dust deposition. According to the Environmental Protection Agency (EPA) Guideline Document entitled Environmental Management in the Extractive Industries (April 2006), there are no Irish statutory standards relating specifically to dust deposition thresholds for inert mineral dust. There are a number of methods to measure dust deposition but only the German TA Luft Air Quality Standards (TA Luft, 1986) specify a method of measuring dust deposition – the Bergerhoff Method (German Standard VDI 2119, 1972) – with dust nuisance.

On this basis, the EPA recommend a dust deposition limit value of 350 mg/m^2/day (**Error! Reference source not found.**) (when averaged over a 30-day period) be adopted at site boundaries associated with extraction related activities. This limit value has been applied in this assessment.

Table 10.2: Dust Emission Limit Values

Procedures	Monitoring Frequency	Standard
Dust Emissions	Monthly	<350 mg/m^2/day; Bergerhoff Method

10.3 Assessment Methodology and Significance Criteria

10.3.1 Study Area

Construction Dust Assessment

This assessment relates to the proposed non-mining activities related to the relocation of the Community Sports Complex, the road diversion, the Cut-and-Cover tunnel and the new vehicular access point to the existing Knocknacran and Drummond Mine site from the L4816.

The IAQM Guidance on the Assessment of Dust from Demolition and Construction (2014) states that human receptors within 350 m of the boundary of a site or 50 m of the route(s) used by construction vehicles on the public highway, up to 500 m from a Site exit point should be considered for construction activities. The full assessment in contained in Appendix 10.1 of this report.

Mineral Dust Assessment

It has been found that deposited dust does not generally travel beyond 400 m (IAQM, Appendix 2, 2016), therefore all receptors within 500 m of the Site boundary are conservatively considered. The guidance states that it is commonly accepted that the greatest impacts from particulates will occur within 100 m of the source, with the potential for travel up to 400 m.

For full consideration of the effects of particulates on the access road (R179), in the absence of any methodology within the IAQM minerals guidance, the IAQM Guidance on the Assessment of Dust from Demolition and Construction (2014) has been considered.

This guidance states that human receptors within 50 m of routes used by vehicles for 350 m from a site exit point should be considered for mineral dust impacts. For this reason, the haul road for the mining activities will be subject to a 50 m buffer, which will then extend 350 m out onto the L4816 road in a southerly direction to account for the possibility of dust track-out (movement of dirt and dust from a construction site onto a public road) from exiting vehicles. A 350 m length buffer has been applied from the point at which the Site exits onto the L4816 public road. HGV vehicles will only enter and exit the Site using the southerly section of the L4816, therefore, the northbound section has not been included in the assessment. The full assessment in contained in Appendix 10.2 of this report.

10.3.2 Assessment Methodology

Background Air Quality

The 1-hour concentrations for background NO_2 have been calculated using methodology taken from *"UK Environment Agency Air Emissions Risk Assessment for Your Environmental Permit",* published in February 2016, updated and accessed in July 2022.

Construction Dust Assessment

The IAQM Guidance on the Assessment of Dust from Demolition and Construction (2014) has been used for assessing the impacts of deposited dust from the construction related activities, for both the Community Sports Complex and Mine Development construction phases. It follows a standard source-pathway-receptor methodology and considers the potential effects from earthworks, construction and trackout.

The following steps, as defined in the IAQM 2014 guidance, were followed when assessing potential impacts:

- Step 1 – Screen the requirement for detailed assessment – Applicable human and ecological receptors were identified and the distance to the Proposed Development and relevant construction routes determined;
- Step 2 – Assess the risk of dust effects – The potential risk of dust impact occurring for each activity was determined, based on the magnitude of the potential dust emissions and the sensitivity of the receptors;
- Step 3 – Identify the need for site-specific mitigation. Based on the risk of impact occurring, site-specific mitigation measures were determined; and
- Step 4 – Define (residual) impacts and their significance. The significance of the potential residual dust effects (taking mitigation into account) for each activity was determined.

The guidance states that human receptors within 350 m of the boundary of the site or 50 m of the route(s) used by construction vehicles on the public highway should be considered.

The potential dust emission magnitude is based on the scale of the anticipated works and associated activities and classified as small, medium or large, as defined in the IAQM 2014 guidance. The sensitivity of the area has been assessed independently for potential dust soiling effects on people and property and the potential human health impacts from elevated PM_{10} concentrations.

The full assessment in contained in Appendix 10.1 of this report.

Mineral Dust Assessment

The IAQM Guidance on the Assessment of Mineral Dust Impacts for Planning (2016) has been used for assessing the impacts of deposited dust from extraction activities. It follows a standard source-pathway-receptor methodology.

The residual source emissions are characterised based on the scale of the operations and the Site activities and are classified as either small, medium or large. Guidance on the appropriate scale of the residual source is provided in the IAQM guidance, Appendix 4 (2016). This source characterisation includes consideration of the routine management and mitigation measures which have or will be undertaken at the Site.

The pathway from the source to the receptor is assessed considering the distance and direction of receptors to the source relative to the prevailing wind and local meteorology. The local meteorological data is also used to assess the frequency of the winds in each direction. It has been found that deposited dust does not generally travel beyond 400 m (IAQM, Appendix 2, 2016), therefore all receptors within 500 m of the Site boundary are conservatively considered. The guidance states that it is commonly accepted that the greatest impacts will occur within 100 m of the source, with the potential for travel up to 400 m.

For full consideration of the effects of the access road, in the absence of any methodology within the IAQM minerals guidance, the IAQM Guidance on the Assessment of Dust from Demolition and Construction (2014) has been considered. This guidance states that human receptors within 50 m of the routes used by vehicles for 350 m from the Site exit point should be considered. For this reason, the route was subject to a 50 m buffer, which extended 350 m out onto the L4816 public road in a southerly direction to account for the possibility of track-out from exiting vehicles. For conservatism, a 350 m length buffer was applied from the point at which the Site exits onto the L4816 public road.

The full assessment in contained in Appendix 10.2 of this report.

10.3.3 Assessment of Significance

Construction Dust Assessment

This assessment relates to the proposed non-mining activities related to the relocation of the Community Sports Complex, the road diversion, the Cut-and-Cover tunnel and the new vehicular access point to the existing Knocknacran and Drummond Mine site from the L4816.

A qualitative assessment of dust impacts from construction activities has been undertaken in line with Institute of Air Quality Management (IAQM); Guidance on the Assessment of Dust from Demolition and Construction, 2014. The detailed assessment is included in Appendix 10.1.

To define the risk of impacts from either dust soiling effects and human health impacts, the dust emission magnitude has been combined with the sensitivity of the area to determine the potential risk of dust impacts with no mitigation applied. Table 10.3, Table 10.4, and Table 10.5 depict the assessment matrix used for earthworks, construction and track-out.

Table 10.3: Risk of Dust Impacts Matrix - Earthworks

Sensitivity of Area	Dust Emission Magnitude		
	Large	***Medium***	***Small***
High	High Risk	Medium Risk	Low Risk

Medium	Medium Risk	Medium Risk	Low Risk
Low	Low Risk	Low Risk	Negligible

Table 10.4: Risk of Dust Impacts Matrix - Construction

Sensitivity of Area	Dust Emission Magnitude		
	Large	***Medium***	***Small***
High	High Risk	Medium Risk	Low Risk
Medium	Medium Risk	Medium Risk	Low Risk
Low	Low Risk	Low Risk	Negligible

Table 10.5: Risk of Dust Impacts Matrix - Track-out

Sensitivity of Area	Dust Emission Magnitude		
	Large	***Medium***	***Small***
High	High Risk	Medium Risk	Low Risk
Medium	Medium Risk	Low Risk	Negligible
Low	Low Risk	Low Risk	Negligible

Mineral Dust Assessment

This chapter presents an assessment of the potential air quality effects associated with the proposed activities at the Site. The effects have been assessed in the context of relevant national, regional and local air quality policies.

A qualitative assessment of dust impacts from all mining related activities has been undertaken in line with Institute of Air Quality Management (IAQM); Guidance on the Assessment of Mineral Dust Impacts for Planning, 2016.

The criteria for the categorisation of the frequency of potentially dusty winds (Table 10.6) and the receptor distance from source (Table 10.7) is used to define the pathway effectiveness (Table 10.8).

The residual source emissions and the pathway effectiveness are combined to predict the Dust Impact Risk as shown in Table 10.9.

Table 10.6: Categorisation of Potentially Dusty Winds

Pathway Effectiveness	Criteria
Infrequent	Frequency of winds (>5 m/s) from the direction of the dust source on dry days are less than 5%
Moderately Frequent	Frequency of winds (>5 m/s) from the direction of the dust source on dry days are between 5% and 12%
Frequent	Frequency of winds (>5 m/s) from the direction of the dust source on dry days are between 12% and 20%
Very Frequent	Frequency of winds (>5 m/s) from the direction of the dust source on dry days are greater than 20%

Table 10.7: Categorisation of Receptor Distance from Source

Category	Criteria
Distant	Receptor is between 200 m and 400 m from the dust source
Intermediate	Receptor is between 100 m and 200 m from the dust source
Close	Receptor is less than 100 m from the dust source

Table 10.8: Pathway Effectiveness

		Frequency of Potentially Dusty Winds			
		Infrequent	Moderately Frequent	Frequent	Very Frequent
Receptor Distance Category	Close	Ineffective	Moderately Effective	Highly Effective	Highly Effective
	Intermediate	Ineffective	Moderately Effective	Moderately Effective	Highly Effective
	Distant	Ineffective	Ineffective	Moderately Effective	Moderately Effective

Table 10.9: Estimation of Dust Impact Risk

		Residual Source Emissions		
		Small	Medium	Large
Pathway Effectiveness	Highly Effective Pathway	Low Risk	Medium Risk	High Risk
	Moderately Effective Pathway	Negligible Risk	Low Risk	Medium Risk
	Ineffective Pathway	Negligible Risk	Negligible Risk	Low Risk

The final step is to assess the likely magnitude of the dust effects (Table 10.10). This is determined using both the dust impact risk and the receptor sensitivity. Receptor sensitivity is classified as either low, medium or high based on the receptor type.

Table 10.10: Descriptors for Magnitude of Dust Effects[1]

		Receptor Sensitivity		
		Low	Medium	High
Dust Impact Risk	High Risk	Slight Adverse Effect	Moderate Adverse Effect	Substantial Adverse Effect
	Medium Risk	Negligible Effect	Slight Adverse Effect	Moderate Adverse Effect
	Low Risk	Negligible Effect	Negligible Effect	Slight Adverse Effect
	Negligible Risk	Negligible Effect	Negligible Effect	Negligible Effect

A traffic screening assessment of effects from road traffic emissions has been undertaken in accordance with the Environmental Protection UK/Institute of Air Quality Management guidance document 'Land –Use Planning & Development Control: Planning for Air Quality' (EPUK/IAQM 2017).

10.4 Baseline

10.4.1 Site Location

The existing Knocknacran Mine is an open-cast gypsum mine located in the Townland of Knocknacran, Co. Monaghan, approximately 7 km from Carrickmacross, Co. Monaghan and 7 km from Kingscourt, Co. Cavan. The operational phase 1 development of the Community Sports Complex (Reg. Ref. 20/365) is located adjacent to the existing Knocknacran open-cast area.

Knocknacran Mine and the Community Sports Complex are bordered to the north by the R179 Kingscourt to Carrickmacross road. To the north of the R179, is the proposed Knocknacran West Mine site. The location of the Site is shown in Figure 10.1 below.

[1] In the absence of any other guidance, the magnitude of dust impacts assessed in line with the IAQM guidance is taken as the significance of dust impacts

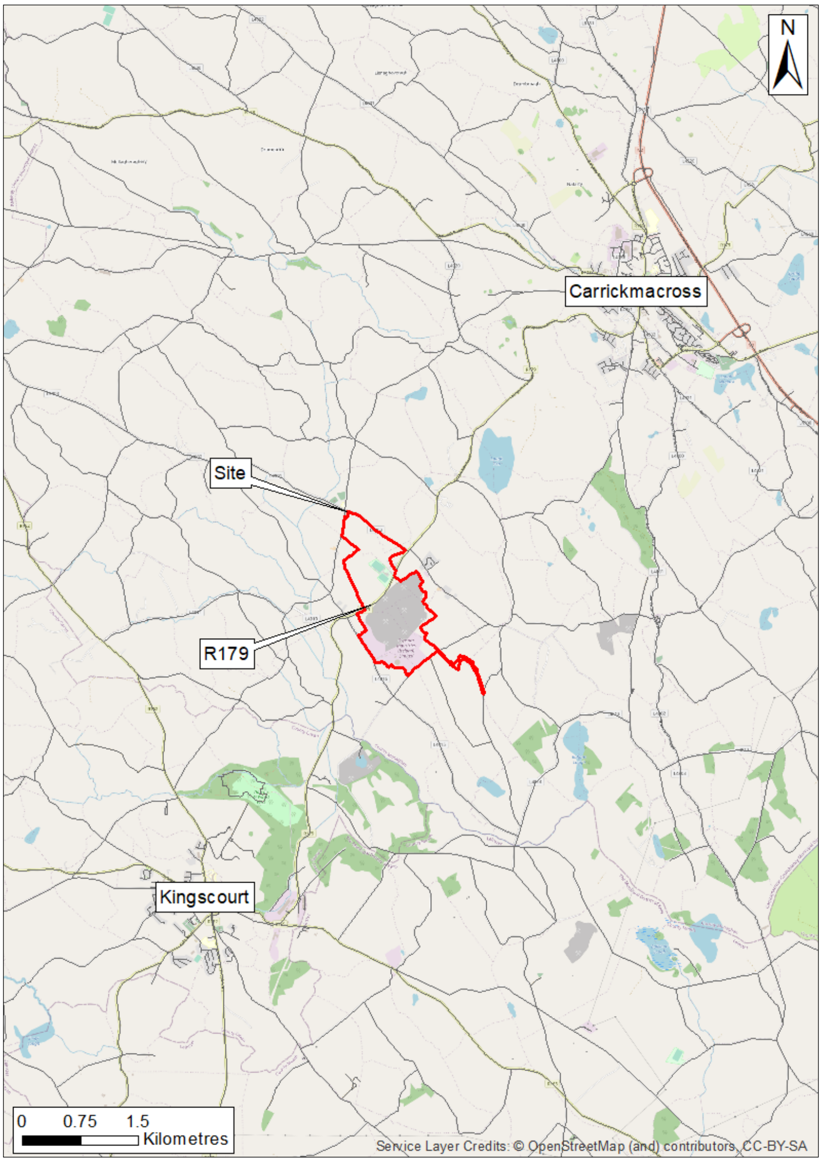


Figure 10.1: Site Location

10.4.2 Existing Environment

The lands surrounding the Site can be characterised as rural in nature, with mixed land use of agricultural, residential, small-scale commercial, a church and primary school in the village of Drumgoosat to the north of the Site. Residential housing in the area is primarily concentrated to linear ribbon settlements along local roads.

The existing Knocknacran Mine has been operated as an open-cast mine since 1989, with recent expansions in 2007 and 2017. The existing Community Sports Complex has been operational since August 2022. Figure 10.2 illustrates the proposed layout of the Site in relation to the surrounding areas.

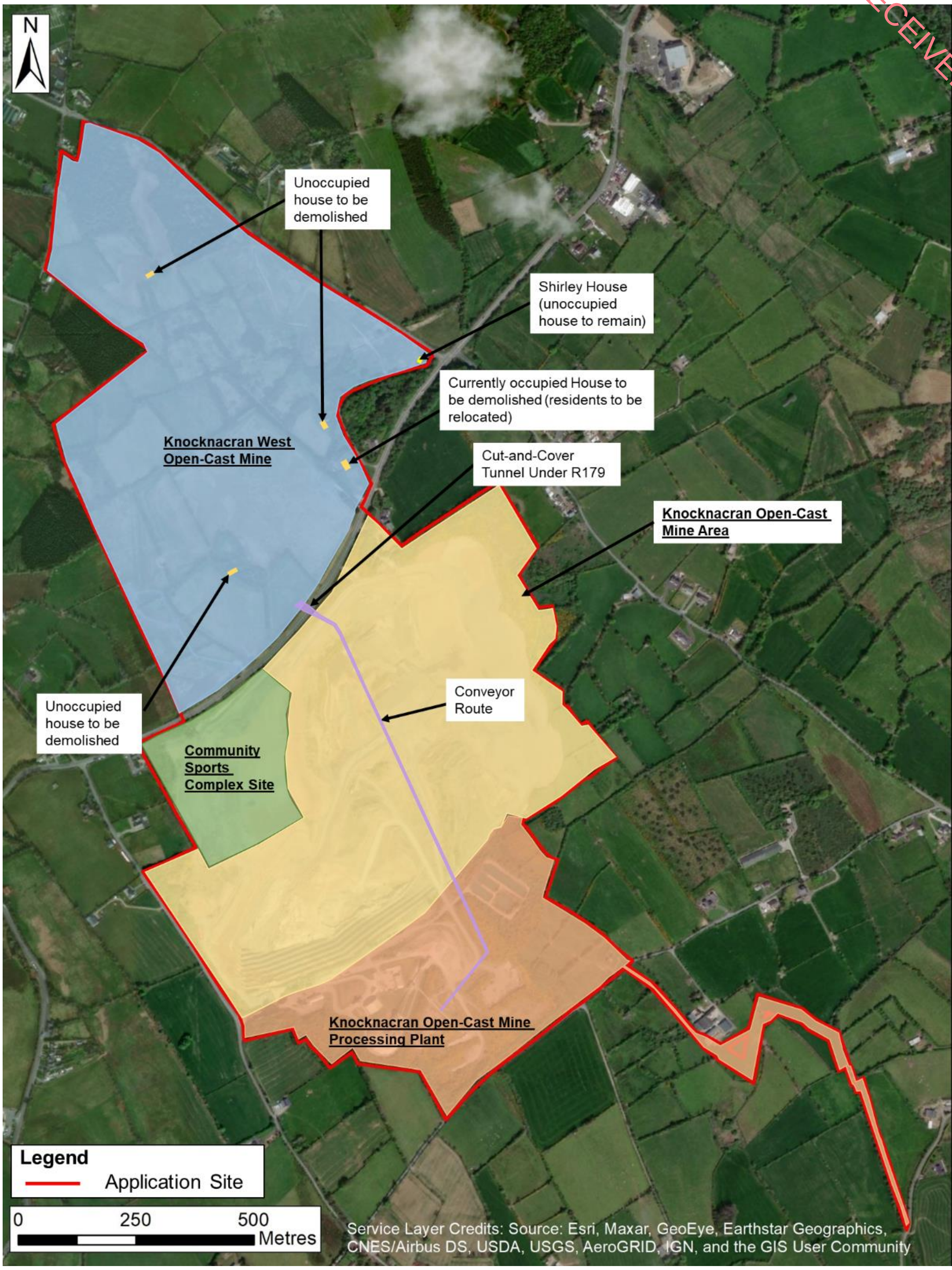


Figure 10.2: Aerial showing Site Layout

10.4.3 Receptors

Receptors identified for the purpose of the assessment of construction dust from the Community Sports Complex are shown in Figure 10.3 and for the construction dust from the proposed Mine Development in Figures 10.4 to 10.6.

Receptors identified for the purpose of the assessment of mineral dust from the proposed Mine Development are shown in Figure 10.7.

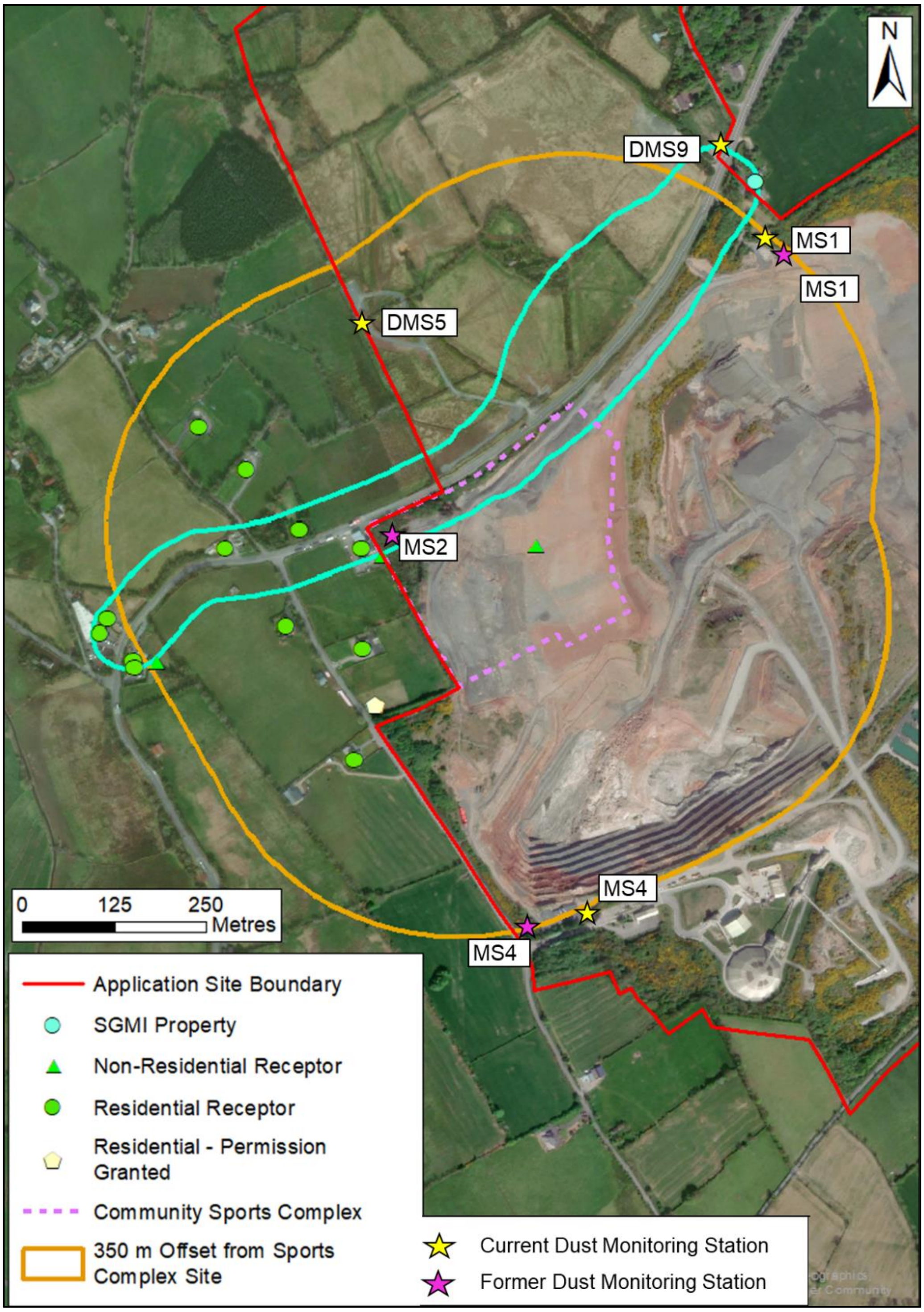


Figure 10.3: Community Sports Complex Construction Dust Assessment Study Area and Identified Receptors

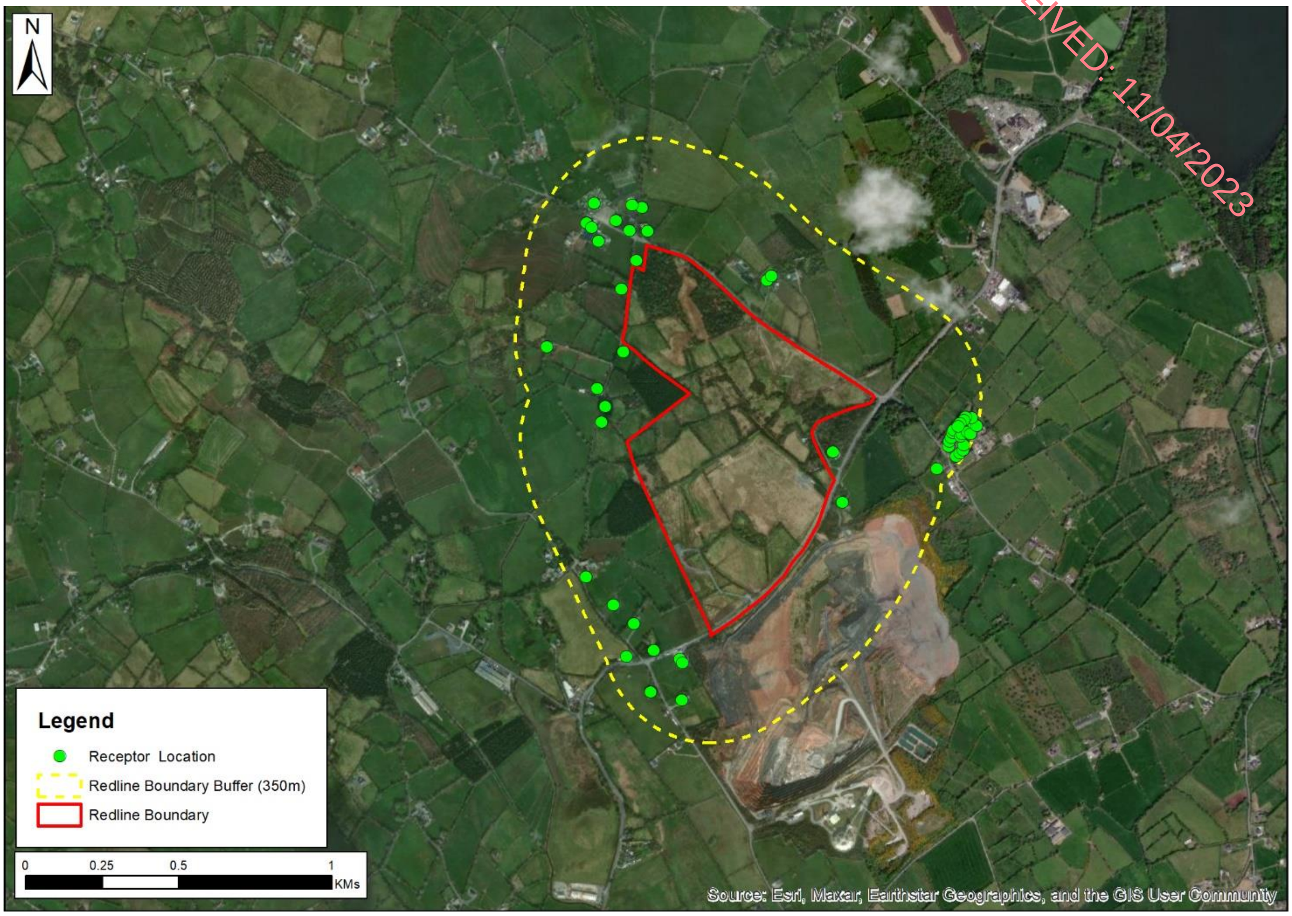


Figure 10.4: Mine Development Construction Dust Assessment Study Area and Identified Receptors

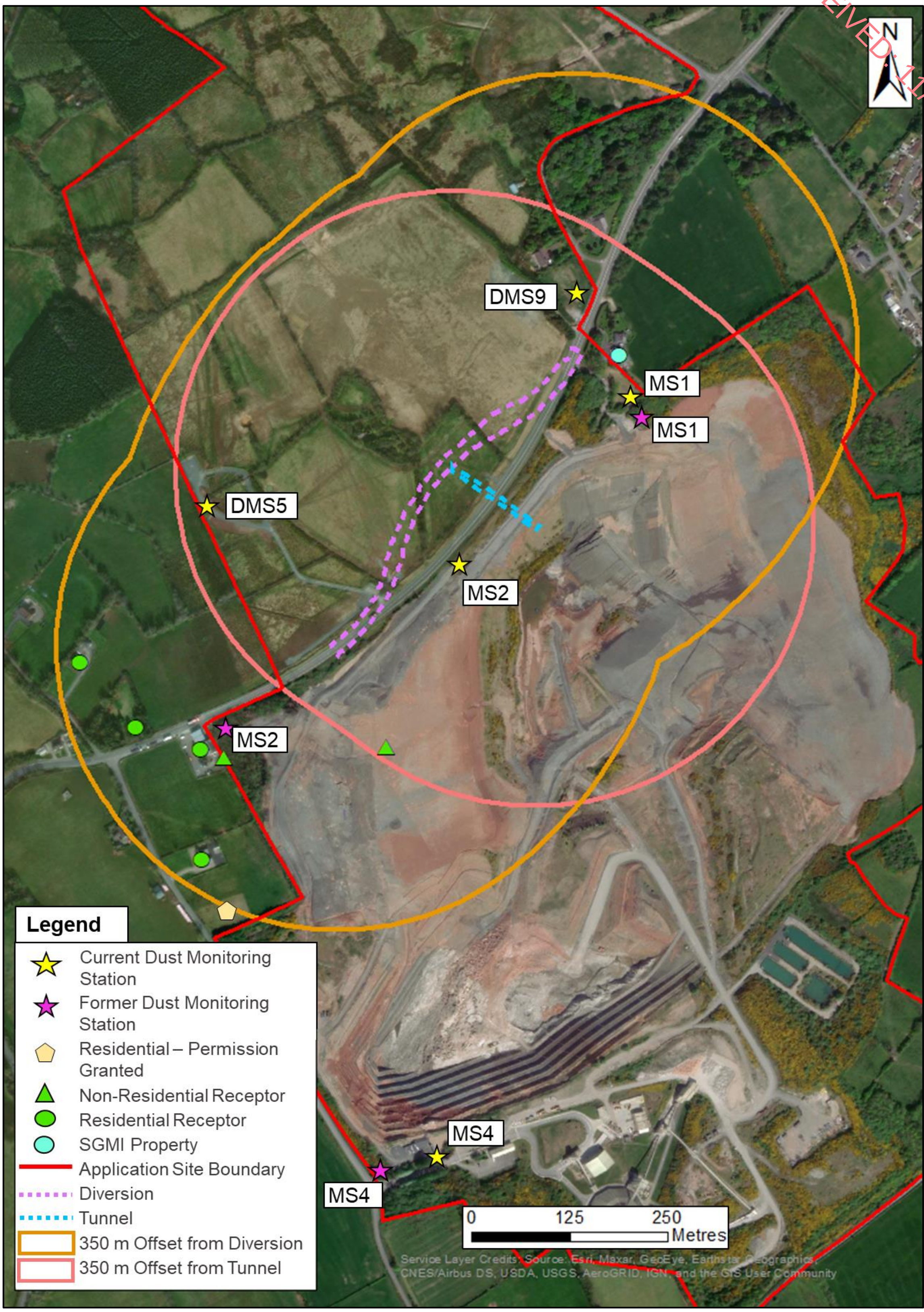


Figure 10.5: Cut-And-Cover Tunnel and Road Diversion Construction Dust Assessment Study Area and Identified Receptors

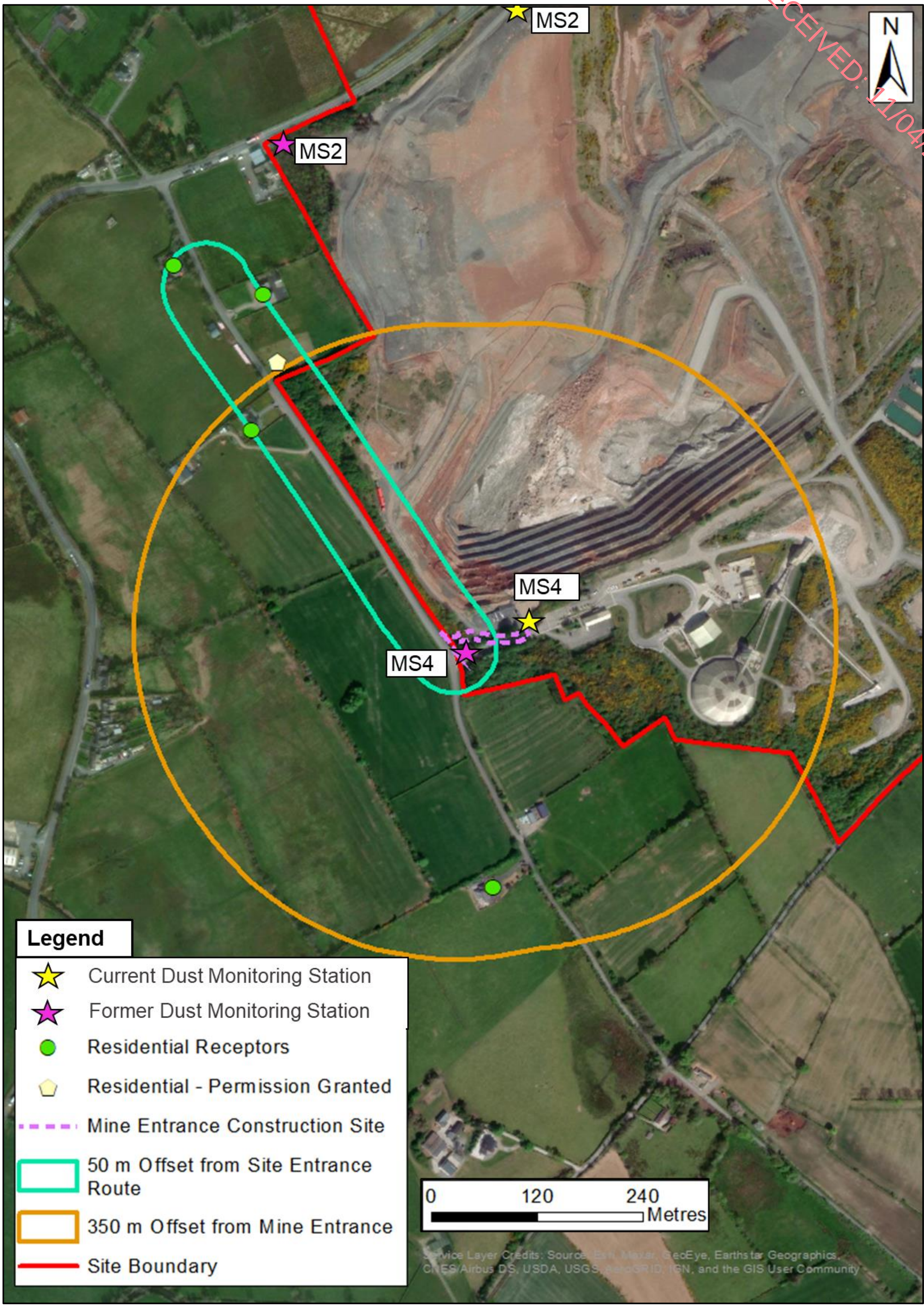


Figure 10.6: Mine Entrance Construction Dust Assessment Study Area and Identified Receptors

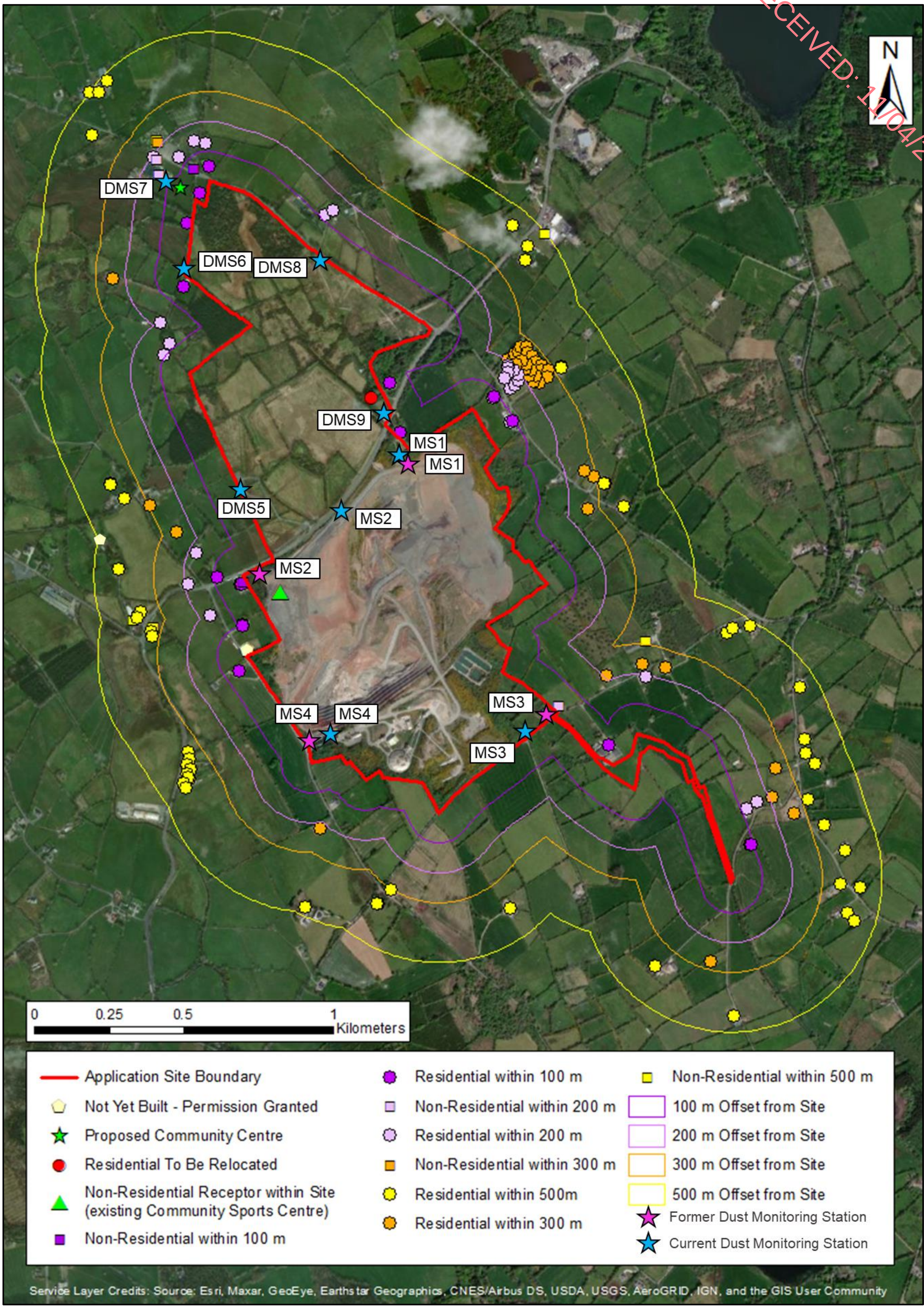


Figure 10.7: Mineral Dust Assessment Study Area and Identified Receptors

10.4.4 Climate at the Site

The Irish climate is subject to strong maritime influences, the effects decreasing with increasing distance from the Atlantic coast. The climate in the area of the Site is typical of the Irish climate, which is temperate maritime.

The existing Knocknacran Mine site has an active weather station (Met Éireann station 'Kingscourt (Drummond)') which has been recording precipitation at the mine site since 1990. The 11 year (2012 to 2022) monthly precipitation data for this station is presented below in Table 10.11.

Table 10.11: Kingscourt (Drummond) Weather Station, Recorded Monthly Precipitation

Monthly Precipitation (mm)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2012	87.5	37	12	43.5	39.4	170.3	91.1	118.5	65.1	85.7	89.9	139.6
2013	136.5	77.7	81	69	67.3	55.7	78.1	37.3	47.2	212.9	44.5	152.8
2014	164.4	138.2	77.4	64.8	85.1	50.1	34.6	142.1	4.8	139.5	157.5	91.2
2015	112.2	65.2	87	66.1	130	44	103.5	90.8	33.9	61.8	181.6	224
2016	127	108	51.8	74.1	65.2	92.7	76.5	86	78.3	45.8	47.1	74.6
2017	29.8	79.5	86	8.2	67.6	95.1	91	79.7	110.1	96.4	67	76.5
2018	154.1	63.5	77.5	54.5	37.2	-	42.2	77.2	49.8	34.7	131.1	104.8
2019	26.9	53.6	156.7	77.3	40.3	105.1	92.2	170.6	-	-	-	100
2020	63.1	219.9	64.8	18.7	13.2	75.7	96.6	126.6	63.4	108.3	91.2	120.1
2021	129.5	107.8	71.6	19.3	108.3	15.6	31.5	92.3	55.9	106.9	43.8	154.1
2022	35.1	148.1	30	55	76.5	79	25	73.7	149.2	-	-	-

The closest Met Éireann station recording multiple meteorological parameters is located at Ballyhaise, Co. Cavan, ca. 40 km west of the Site. Monthly parameters recorded include minimum, maximum and mean air temperature, m rainfall, minimum grass temperature, wind speed and highest wind gusts (Table 10.12) Hourly wind speed and direction have been summarised from daily data over 11 years (2012- January 2023).

Table 10.12: Ballyhaise, Co. Cavan, Recorded Climate Information

Mean Air Temperature (°C)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2012	5.8	6.7	8.1	6.5	10.5	12.5	13.8	15.5	11.9	8	5.6	4.8
2013	4.7	4.2	2.8	6.5	9.9	13.2	17.4	15.4	13	11.3	6	6.4
2014	4.9	5.4	6.6	9.7	11.6	14.2	15.8	13.4	13.4	10.5	7.5	5.1
2015	4.3	4.1	5.7	7.7	9.3	12.8	13.4	13.8	11.8	10	7.9	7.8
2016	5.5	4.2	6.1	6.6	11.6	14.4	15.1	15.2	13.8	10.1	5	6.3
2017	5.5	5.8	7.7	8.6	12	14	14.6	141	11.9	11	6.3	5.2
2018	4.4	3	4.4	8.3	12.1	15.5	16.1	14.6	11.6	9.2	7.3	7.3
2019	5.2	7	6.9	8.6	10.3	12.7	16.1	15.3	12.8	8.7	5.7	5.5
2020	5.9	5.1	5.9	9.3	11.5	13.7	13.7	15.1	12.8	9.5	7.9	4.6
2021	3.3	5.7	7.3	6.6	9.5	13.8	17.2	15.3	14.4	11.3	8.1	6.6
2022	5.7	6.2	6.6	8.1	12.1	13.4	16	15.6	13	11.4	8.4	3.1
2023	5.4	-	-	-	-	-	-	-	-	-	-	-

Maximum Air Temperature (°C)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2012	11.9	13	19.8	14.7	24.1	22.1	21	22.9	21.1	14.5	13.1	13
2013	12.9	11	9.4	15.1	19	22.7	28.4	21.6	22.1	20	13.2	14.3
2014	11.1	11.4	15.7	18.7	19.2	24.3	25.2	22.3	22.4	17.3	13.6	12.1
2015	13.6	13.1	13.8	18.4	16.4	24	22.3	21.5	19.1	18.4	15.3	15
2016	14.2	11.9	13.7	15.5	22.4	22.9	25.5	23.3	21.5	16.9	13.9	14.9
2017	11.2	12.5	16.2	17	25.1	24.1	24.1	20.7	20.7	17	13.9	13.4
2018	12	12.1	12.3	18.4	23.5	28.8	27.5	22	20.5	20.6	15.1	12.6
2019	11.4	15.5	15.2	20.7	20.1	22.6	24.1	23.7	20.8	15.4	12.6	12.5
2020	13.6	11.7	14.6	19.5	23.8	24.5	21.6	23.6	21.9	15.5	15.2	12
2021	10.7	13.4	16.8	16.9	21.6	21.6	28.9	24.3	23.5	18.8	15.2	13.3
2022	14.5	12.8	17.5	16.7	19.5	22	30.8	27.5	20.3	17.4	17	13.8
2023	12.8	-	-	-	-	-	-	-	-	-	-	-

Minimum Air Temperature(°C)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2012	-1.5	-5.4	-1.6	-2.2	-1.2	3.7	5	7.4	0.3	-1.8	-2.1	-4.3
2013	-2.6	-5.8	-5.9	-6	0.5	4.6	9.9	9.5	3.1	0	-2.7	0.2
2014	-2.1	-0.9	-2.8	-0.6	4.9	4.9	6	2	3	0.5	-1.2	-6.2
2015	-5.2	-4.7	-3.5	-2.1	0.4	2	4.9	5.2	2.6	-0.7	-2	-2.6
2016	-1.5	-3.8	-3.7	-1.5	1.2	5.2	8.1	6	3.5	-0.2	-4.3	-3.4
2017	-4.1	-3.2	-2.7	1	1.1	5.5	6.2	5	2	0.9	-0.7	-4.6
2018	-5.5	-4.5	-5.2	-3.2	1	5	6.5	4.2	0.4	-2.2	-2.3	0.3
2019	-3.4	-3.5	-1.1	0.3	-1.2	3.1	5.6	7.9	4.1	-2.7	-4.1	-1.9
2020	-3.9	-0.6	-2.4	-1.7	-1.7	3.2	5.2	4.4	-1.5	1.6	0.2	-3.5
2021	-7.4	-2.8	-1.3	-3.4	-1.9	3.8	9.5	5.3	5.4	2.4	-0.7	0.6
2022	-3.1	-0.8	-4.4	-2.3	3.1	4.9	9.1	7	3.3	2.9	-0.8	-7
2023	-6.1	-	-	-	-	-	-	-	-	-	-	-

Mean Maximum Air Temperature(°C)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2012	8.5	8.9	12.4	10.8	15	15.9	17.4	19.2	15.6	11.7	8.4	7.6
2013	7.1	7.3	5.9	10.8	13.6	17.9	22	18.8	16.5	14.3	8.9	9
2014	7.4	8.1	10.1	14	15.1	18.6	20.1	17.1	18	14.2	10.4	7.6
2015	7.4	7.2	9.6	13.1	13	17.1	17	17.6	15.5	13.8	11.2	11
2016	8.1	7.5	9.8	10.8	16.3	18.2	18.7	18.8	17.1	13.4	8	9.2
2017	8.3	8.7	11.3	12.2	17.2	17.7	18.7	17.9	15.7	14.2	9.4	7.8
2018	7.2	6.4	7.9	12	17	20.8	20.6	18.3	15.5	12.8	10.1	9.3
2019	7.5	10.4	10.4	12.5	14.8	16.7	20.1	18.9	16.8	12.1	8.3	7.9
2020	8.3	8.4	9.7	14.3	16.7	17.5	17	18.8	16.7	12.5	10.8	7
2021	6.1	8.2	10.4	11.8	14.3	18.2	21.6	19.1	18.2	14.4	10.6	8.8
2022	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5
2023	7.8	-	-	-	-	-	-	-	-	-	-	-

Mean Minimum Air Temperature(°C)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2012	3.2	4.6	3.8	2.3	6	9.2	10.2	11.8	8.3	4.3	2.9	2
2013	2.3	1	-0.2	2.3	6.1	8.4	12.8	11.9	9.5	8.2	3	3.9

2014	2.4	2.6	3.1	5.5	8.1	9.7	11.5	9.7	8.8	6.8	4.6	2.6
2015	1.2	1.1	1.8	2.3	5.5	8.4	9.9	10.1	8.1	6.1	4.6	4.7
2016	2.9	1	2.4	2.4	6.9	10.6	11.6	11.7	10.6	6.7	2	3.4
2017	2.8	2.9	4	4.9	6.8	10.4	10.5	10.3	8.1	7.9	3.3	2.6
2018	1.6	-0.3	1	4.7	7.1	10.2	11.5	11	7.7	5.6	4.5	5.4
2019	2.9	3.7	3.4	4.7	5.8	8.6	12.1	11.7	8.7	5.3	3	3.1
2020	3.4	1.9	2.1	4.3	6.3	9.8	10.3	11.4	8.9	6.4	5	2.1
2021	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
2022	2.9	3.3	1.6	3.6	8.4	9.7	12	10.6	9	8.2	5.6	0.3
2023	3	-	-	-	-	-	-	-	-	-	-	-

Monthly Precipitation (mm)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2012	99.2	52.5	22.9	65.6	43.7	185.1	104.8	92.5	84.3	93.1	83.8	103.1
2013	128.2	64	46.1	75.8	83.2	52.7	80.7	38.7	59.4	148.6	44.7	136.3
2014	127.4	151.9	71.8	45.1	103.7	71.1	77.4	107	10.8	-	139.7	91.3
2015	137.3	66.7	81.7	72.3	121.6	36.5	134.5	112.1	35.2	64.7	135.5	270.9
2016	106.7	98.5	67.9	62.4	-	77.6	92.5	74.6	91.9	41.5	55.6	72.9
2017	32.8	72.6	80.3	16.2	54.5	84.2	109.2	95.9	108.5	95.8	93.9	109.2
2018	171.3	78.4	72.3	70.1	49.9	40.9	69.2	99	38.5	53.3	89.8	104.4
2019	43.7	54.3	149.3	64.1	35.9	115.6	52.4	164.5	164.3	83.5	103	84.1
2020	59.2	212.8	77.8	32.8	26.2	99.5	129.7	138.4	60.4	113.3	100.7	111
2021	107.4	89.5	83.9	19.5	84.9	20.8	44.8	133.4	71.8	120.3	46.3	110
2022	43.7	122.9	32.7	62.6	76	76.2	39.5	52	135.8	205.2	118.1	84.2
2023	92.7	-	-	-	-	-	-	-	-	-	-	-

Grass Minimum Temperature(°C)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2012	-5.3	-	-4.5	-6.5	-4.3	0.5	2.7	2.9	-2.3	-6.1	-5.5	-6.6
2013	-5.6	-8.2	-7.9	-8	-1.9	1.8	7.4	5.6	-1.6	-2.6	-5.8	-2.2
2014	-4.7	-3.8	-5.8	-1.7	2.1	1.7	2.2	-0.5	0.3	-2.3	-5.1	-8.7
2015	-9.3	-8.9	-7.2	-6.3	-3.1	-1.3	1.7	3.5	0.2	-2.1	-4.7	-3.5
2016	-6.8	-6.8	-5.1	-5.5	-1.5	1.7	3.9	3.5	-1.1	-1.8	-7.3	-5.2
2017	-6.7	-6.7	-5.1	-2.4	-1.5	1.1	0.5	1.9	-0.6	-	-	-6.2
2018	-8.6	-9.3	-11.3	-8.4	-3.1	1.7	4.7	4.9	-3.9	-5.8	-5.8	-4.2
2019	-7.4	-9.3	-5.8	-3.3	-5.1	0.8	1.3	3.4	0.9	-6.5	-9.1	-7.4
2020	-8.6	-6.3	-5.8	-4.6	-7.3	-1.4	0.7	2.1	-5.5	-2.5	-5.2	-8.7
2021	-12.6	-6.5	-5.2	-9.6	-7.1	1	5.2	1.6	4.5	2.3	-2.6	-4.5
2022	-4.1	-1.7	-8.4	-7.2	-1.1	-0.6	6.2	2.8	0.1	0	-1.5	-10.8
2023	-11.7	-	-	-	-	-	-	-	-	-	-	-

Mean Wind Speed (knot)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2012	8.6	7	6.6	6.5	5.5	5.4	5.2	6.2	6.8	5.1	6.5	7.2
2013	7.2	6.3	7.3	8	7.5	5.3	4.5	5.8	5.7	6.2	5.5	9.9
2014	7.8	9.8	7.3	6.5	5.7	4.6	5.1	5.9	3.9	-	5.2	7.8
2015	8.9	6.5	7.9	5.7	7.3	6.5	5.9	5.8	5	5	8	9.6
2016	7.8	7.4	6.2	6.3	5.5	4.8	5.3	5.9	6.8	4.8	4.9	6.8
2017	6.1	8.1	7	5.6	5.7	6.4	5.5	5.6	6.1	7.3	5.6	6.4
2018	8.1	6.8	7.1	7.1	5.6	4.5	4.7	5.5	6.2	6	7.8	7.1

2019	5.5	8.2	7.4	6.8	4.9	5.7	5.4	6.1	5.3	6	5	7.3
2020	8	9.7	7.2	5.6	5.8	5.8	5.4	5.1	5.7	6.5	6.7	6.5
2021	5.3	8.8	6.8	4.8	5.5	5.3	3.5	4.3	4.4	6	5.8	6.4
2022	6.1	8.9	5.9	5.8	6.1	5.8	4.6	4.5	4.6	7	7.3	5.4
2023	6.6	-	-	-	-	-	-	-	-	-	-	-

Highest Gust (knot)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2012	52	33	45	34	38	33	25	32	34	26	37	50
2013	52	36	38	43	34	30	27	31	37	32	33	50
2014	45	47	38	38	31	26	28	30	23	39	38	41
2015	47	44	46	36	40	38	32	37	25	35	48	44
2016	47	45	40	36	34	28	28	33	38	30	29	41
2017	36	47	32	31	31	32	28	26	33	50	30	48
2018	63	39	38	44	30	41	31	26	57	36	42	41
2019	41	49	47	38	28	42	31	33	33	32	30	45
2020	50	49	42	36	49	34	34	51	35	42	37	44
2021	34	42	43	30	35	29	21	31	28	34	37	44
2022	41	42	36	38	32	41	26	26	34	35	39	34
2023	39	-	-	-	-	-	-	-	-	-	-	-

The information presented in Table 10.11 and Table 10.12 above provides an overview of the climatic conditions at the Site. Over the time period for which data is provided, the wettest months in terms of total rainfall for the period are January and December, shortly followed by February and August. High rainfall in these months provides natural dampening for potential dust emissions. The opposite impact occurs in windy months, with dust being carried further. The month with the highest mean wind speed according to Table 10.12 above is February, shortly followed by January and March. Similarly, dry weather can lead to greater potential for dust emissions. The data shown in Table 10.12 indicates that the driest month in the Site area is April, shortly followed by May and September. The monthly rainfall recorded at both the Kingscourt (Drummond) weather station and the Ballyhaise station have been compared, and it was found that both stations show the same seasonal rainfall trends.

An important meteorological parameter with regard to the dilution and dispersal of air pollutants is wind speed and direction. A wind-rose for the Ballyhaise station is presented in Figure 10.8 for the period January 2012 to January 2023. It is evident that the prevailing winds are from a southwesterly direction.

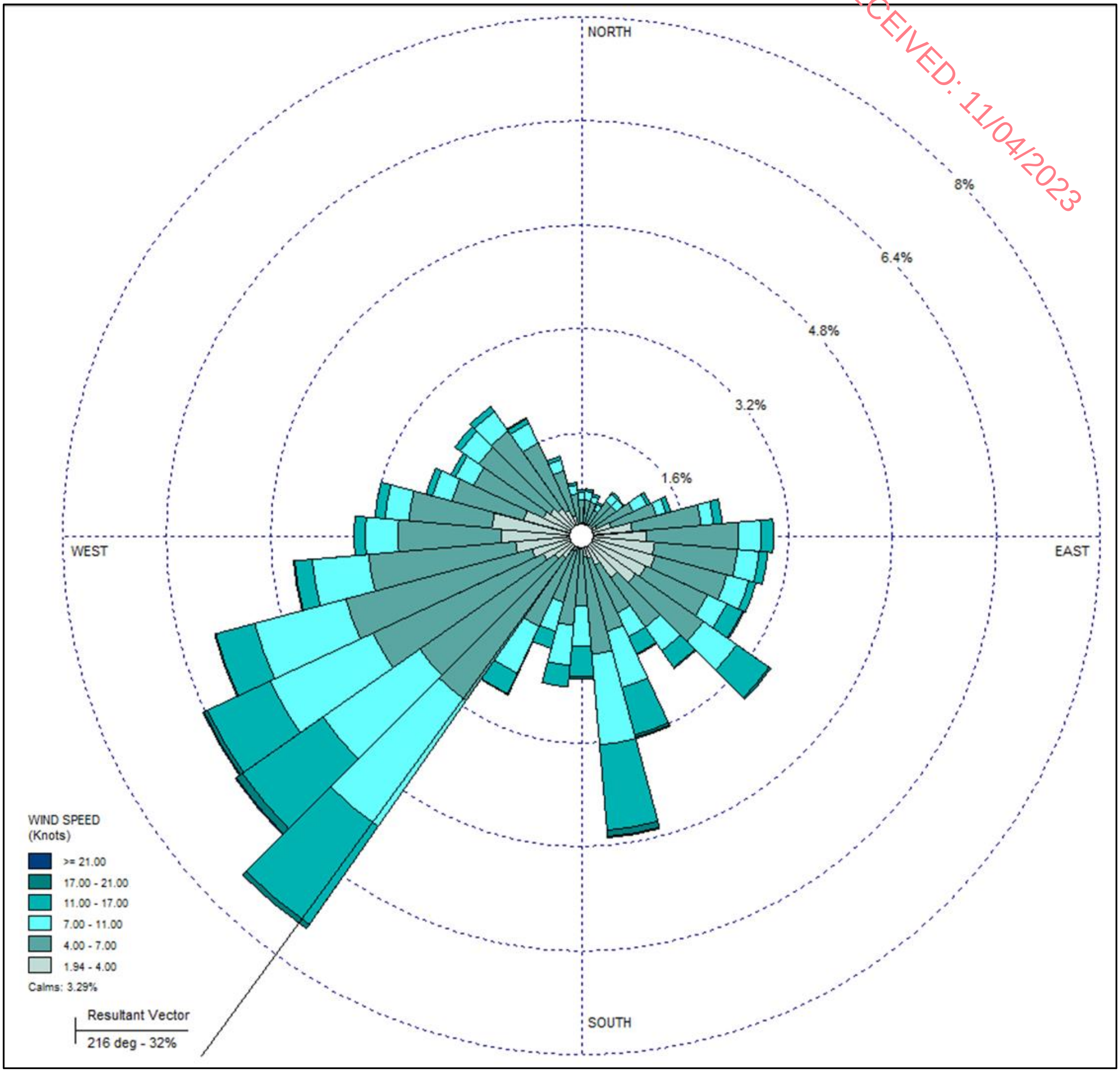


Figure 10.8: Dominant Wind Direction at Ballyhaise over ca. nine years, (Assessment Period January 2012 to January 2023)

10.4.5 Background Air Quality

Primary Data - Site Monitoring Data

Air quality monitoring data is available for the Site and surrounding area and covers periods during mining operations for the existing Knocknacran Site, and a baseline monitoring period for the Knocknacran West Site.

Dust Deposition Monitoring

Dust generation rates depend on the site activity, particle size, the moisture content of the material and weather conditions. Dust emissions are dramatically reduced where rainfall has occurred due to the cohesion created between dust particles and water and the removal of suspended dust from the air. It is typical to assume no dust is generated under "wet day" conditions where rainfall greater than 0.2 mm has fallen. Information collected from Met Éireann's Ballyhaise Station (January 2012 to July 2021) identified that 2,452 days during the eleven-year period were "wet" (approximately 60.6% of days in that period). In comparison, the Kingscourt (Drummond) weather station (January 2012 to October 2022) identified that 2,236 days during the ten-year period were "wet" (approximately 58.3 % of days in that period). It is noted that data for the Kingscourt (Drummond) weather station is currently only available to October 2022, whereas Met Éireann's Ballyhaise Station extends to January 2023, however the percentage of "wet" days at the two stations are very similar.

Large particle sizes (greater than 75 microns) fall rapidly out of atmospheric suspension and are subsequently deposited in close proximity to the source. Particle sizes of less than 75 microns are of particular interest as they can remain airborne for greater distances and give rise to the potential dust nuisance at the sensitive receptors. This size range would broadly be described as silt. Emission rates are normally predicted on a site-specific particle size distribution for each dust emission source.

In order to establish any future impacts from the mining and construction activities related to the Proposed Development on the surrounding area, the monitoring locations at and in the vicinity of the Site have been reviewed. Descriptions of the dust monitoring locations are presented in Table 10.13, and their locations are shown in Figure 10.9.

Table 10.13: Description of Dust Monitoring Locations

Location	Description
MS1	Located northeast of the existing Knocknacran Mine. Relocated formally in September 2021 due to there being trees surrounding the former location.
MS2	Located northwest of the existing Knocknacran Mine. Relocated formally in September 2021 as the former location is now part of the GAA site and outside the IE Licence for the mine.
MS3	Located east of the existing Knocknacran Processing Plant site and south of the existing Knocknacran Mine. Relocated formally in September 2021 due to agricultural activities (new chicken farm) adjacent to the former location.
MS4	Located west of the existing Knocknacran Processing Plant site and southwest of the existing Knocknacran Mine. Relocated formally in September 2021 due to forestry around the former location.
DMS5	Located to the southeast of the proposed Knocknacran West Mine.
DMS6	Located to the northwest of the proposed Knocknacran West Mine.
DMS7	Located on the boundary fence of the Mushroom Farm in Drumgoosat village to the northwest of the proposed Knocknacran West Mine.
DMS8	Located at the northeast boundary of the proposed Knocknacran West Mine.
DMS9	Located at the southeast boundary of the proposed Knocknacran West Mine adjacent to the R179 road.

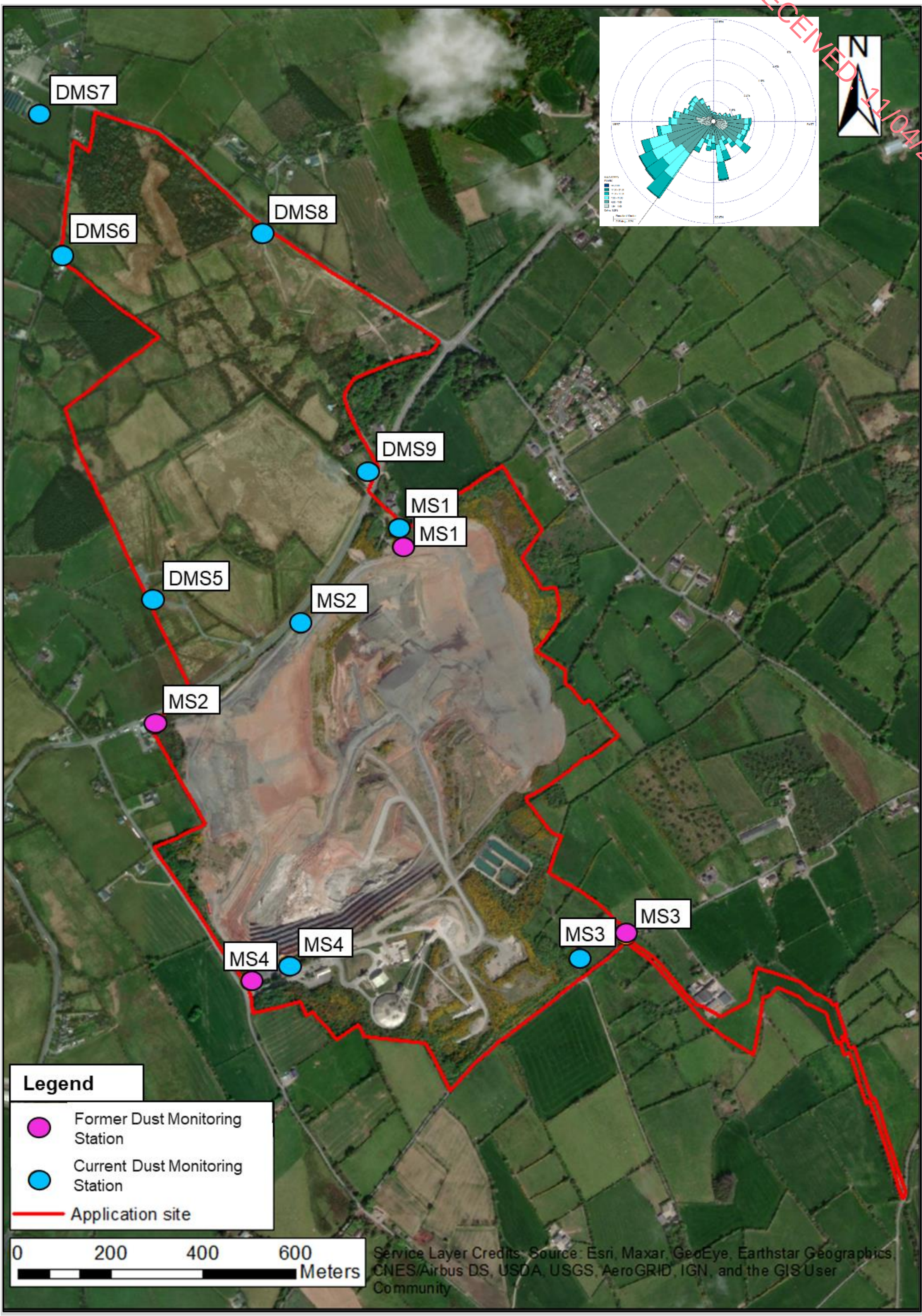


Figure 10.9: Plan Showing Dust Monitoring Locations

Monitoring locations MS1 – MS4 are locations used by the existing Knocknacran Site as part of the current environmental monitoring programme.

The current locations used for MS1-MS4 became the licenced locations in September 2021. The former locations for MS1 – MS4 were the licenced locations until September 2021. The relocation of MS4 and MS1 occurred due to tree cover around the jars and consist high organics being reported. MS3 was relocated due to a new agricultural industry (chicken farm) adjacent to the former location. MS2 was relocated as the former location was no longer in the IE Licence area and was instead part of the initial development of the Community Sports Complex. All relocations were trialled initially between February and September 2021, in consultation with the EPA and they were formalised with the EPA after the trial ended.

Locations DMS5 – DMS9 were set up in August 2019 to establish baseline conditions for the Knocknacran West Site, with the exception of DMS7 which was installed in September 2019 due to its third-party location.

The dust monitoring has been undertaken by an independent laboratory on a monthly basis, using standard Bergerhoff gauges, from January 2012 to present, at locations, MS1, MS2, MS3 and MS4. The monthly dust monitoring results for dust deposition rates at sampling locations MS1-MS4 up to August 2021 are presented as time series graphs in Figure 10.10, Figure 10.11, Figure 10.12 and Figure 10.13, with the 350 mg/m^2/day limit value shown. The results for the alternative locations MS1a, MS2a, MS3a and MS4a, which have been recorded from February 2021 up to December 2022, are presented together as a time series graph in Figure 10.14. Results for locations DMS5-DMS9 are shown in Figure 10.15 from August 2019 to December 2022.

It is noted that there is no data available for MS1 in September 2013, MS2 in July 2020, or DMS6 in November 2022 as the sample jars were broken or missing.

A total of 26 monitoring records were above the 350 mg/m^2/day dust deposition limit value adopted for this assessment, recorded at MS1 – MS4, leaving approximately 94% of the total samples below the limit value. The greatest concentration was 1,217 mg/m^2/day recorded in July 2012 at MS2, and this was approximately 3.5 times the dust deposition limit value. The high concentrations are generally accounted for by organic matter contamination un-associated with mining activities. It is likely that the high organic matter results are attributable to poor dust gauge placement, as MS1, MS2 and MS3 are situated along a hedgerow or surrounded by trees at a low height. The lowest concentrations recorded occurred during February 2016 at MS1, and November 2020 at MS3, when the concentrations were 1 mg/m^2/day.

A potential seasonal trend is observed in MS4, with higher concentrations prevalent during the Autumn. This may be attributable to the monitoring location being heavily surrounded by trees, which is likely to increase the amount of organic matter collected in the dust samples. The lowest concentrations recorded occurred during February 2016 at MS1, and November 2020 at MS3, when the concentrations were 1 mg/m^2/day.

All results at locations MS1a – MS4a on the existing Knocknacran Site were below the limit value. Data has been collected for a period of sixteen months at each alternative location. No exceedances are observed during this period at locations MS1 to MS4, apart from November 2022 at MS2 where an exceedance was reported but was attributed to a laboratory error (data not presented in the graphs due to laboratory error).

The baseline monitoring at locations DMS5 – DMS9 on the proposed Knocknacran West Site highlighted that some headroom exists between the current background and the dust deposition limit value. It is noted that higher concentrations of total dust (>350 mg/m^2/day) can occur in the baseline. Since April 2021 analysis has included the breakdown of percentage ash in the samples to provide a breakdown of the inorganic/organic component. When higher levels of total dust have been recorded on the Knocknacran West site, high levels of dust (both total and percentage ash) have not been recorded on the Knocknacran Mine site at any location. The following samples have had a total dust higher than 350 mg/m^2/day:

- DMS5 had higher total dust in June 2021, September 2021, January 2022, April 2022, May 2022, July 2022, August 2022 and September 2022. In all months, except January and May 2022, the percentage ash was below 350 mg/m^2/day. Percentage ash in January 2022 was 797.6 mg/m2/day and 540.1 mg/m2/day in May 2022;

- DMS6 had higher total dust in May 2021, the percentage ash was 106.8 mg/m^2/day;

- DMS7 had higher total dust in September 2022 (406.0 mg/m^2/day), the percentage ash was 87.7 mg/m^2/day);

- DMS8 had higher total dust between November 2019 and June 2020, and these could be attributed to site improvement and site remediation works related to drainage and crownhole remediation onsite, however, no percentage ash is available for these samples. For higher total dust in May 2021, September 2021, January 2022, May 2022 and December 2022, the percentage ash was below 350 mg/m2/day except for September 2021 (352.8 mg/m^2/day), January 2022 (523.6 mg/m^2/day) and December 2022 (358.2 mg/m^2/day); and

- DMS9 had higher total dust in June 2022 (percentage ash was 394.1 mg/m^2/day).

For the monitoring locations on the existing mine site (MS1 – MS4) it is noted that there is variability in the concentrations recorded across the monitoring months and locations. As such the existing open-cast mine's contribution from the deposited dust baseline cannot be clearly distinguished within the monitoring data. This suggests that deposited dust from the existing mining activities is deposited within the site or very close to the site, rather than being carried far off-site. The same limited impacts from deposited dust would be similarly expected to be the case for the proposed open-cast mine.

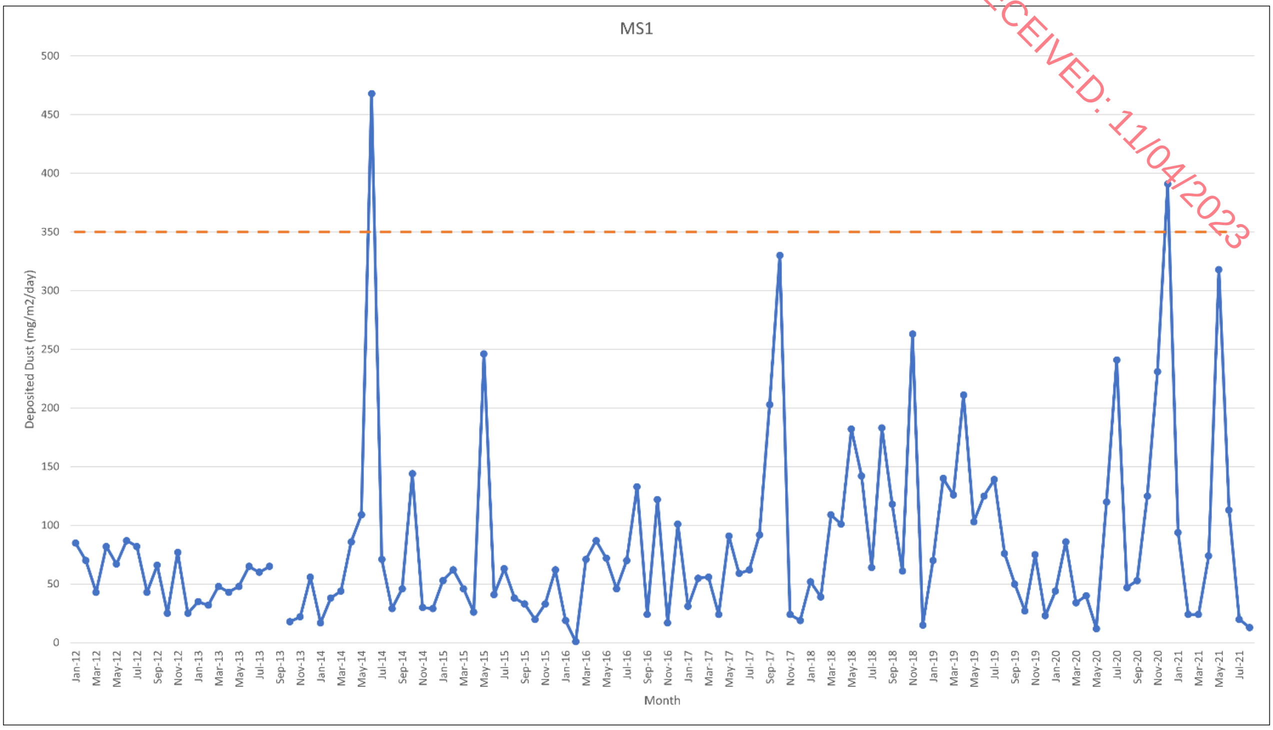


Figure 10.10: Time Series Graph showing Deposited Dust recorded at MS1 (January 2012 - August 2021). This is the former MS1 location.

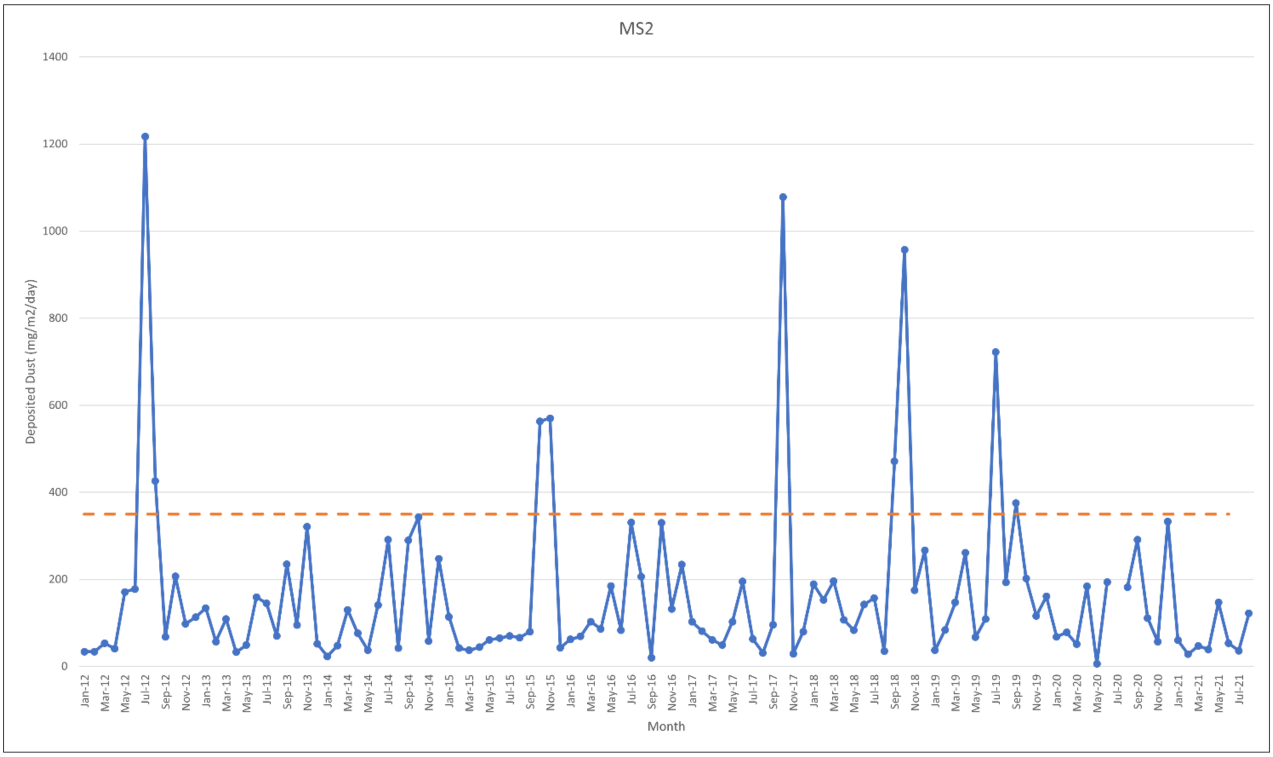


Figure 10.11: Time Series Graph showing Deposited Dust recorded at MS2 (January 2012 - August 2021). This is the former MS2 location.

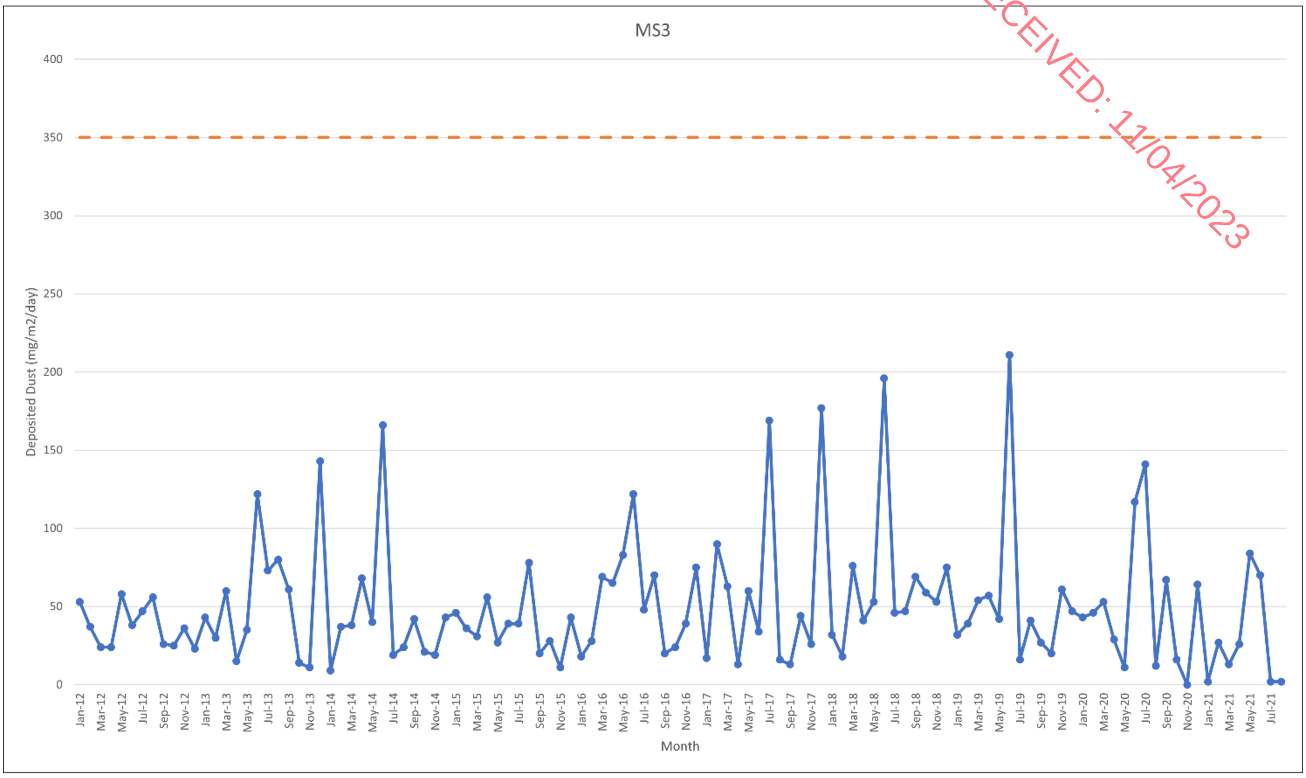


Figure 10.12: Time Series Graph showing Deposited Dust recorded at MS3 (January 2012 - August 2021). This is the former MS3 location.

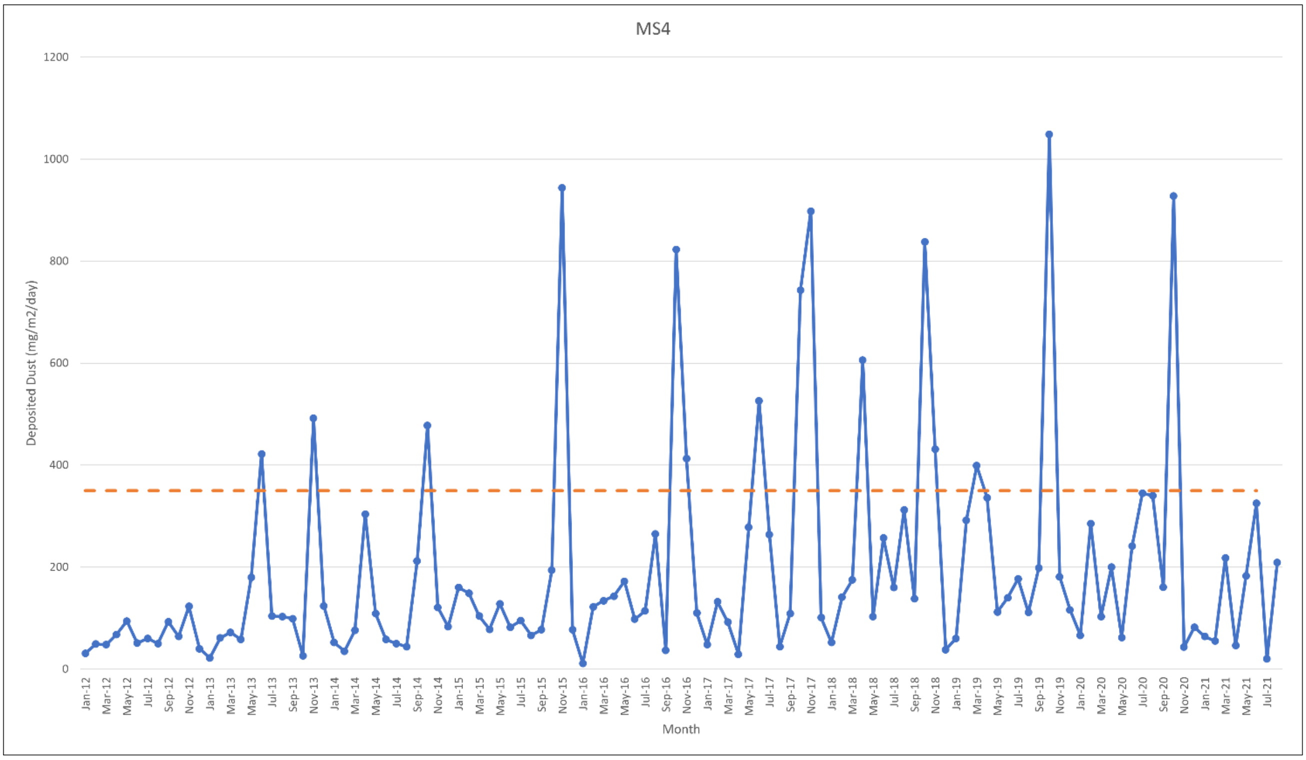


Figure 10.13: Time Series Graph showing Deposited Dust recorded at MS4 (January 2012 - August 2021). This is the former MS4 location

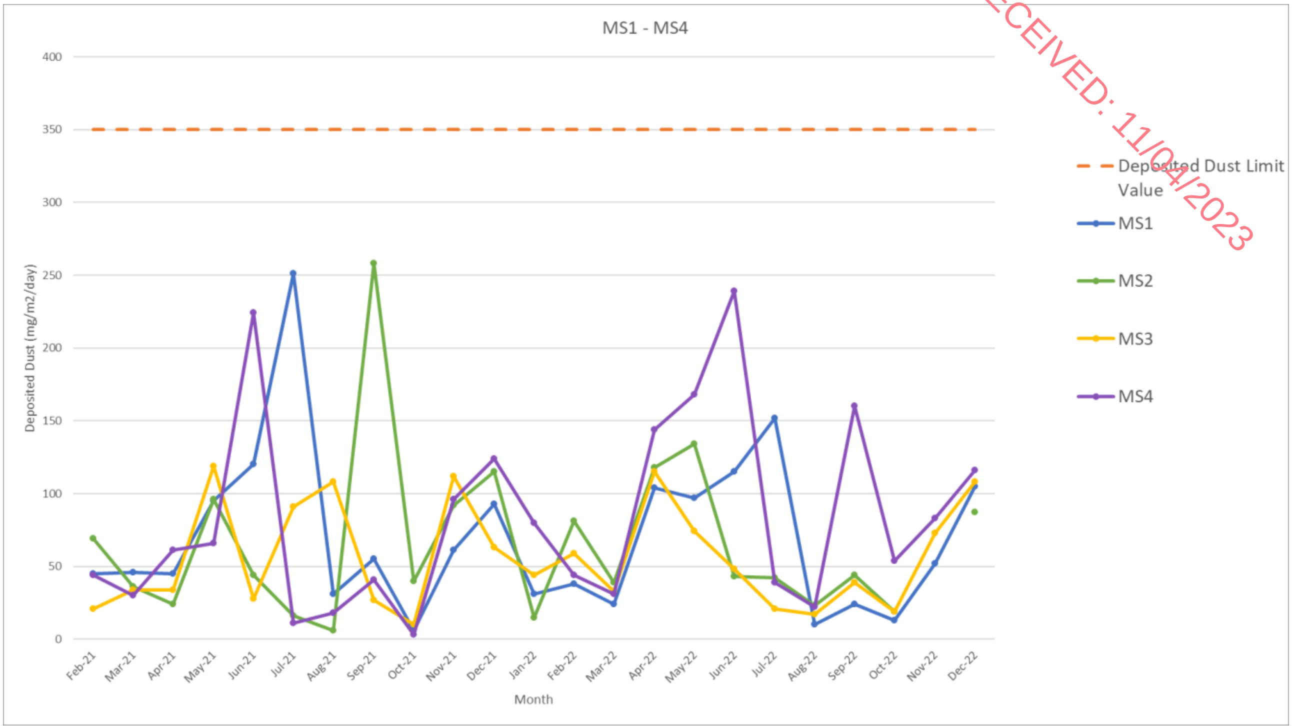


Figure 10.14: Time Series Graph showing Deposited Dust recorded at MS1, MS2, MS3 and MS4 (February 2021 – December 2022). These are the current locations monitored

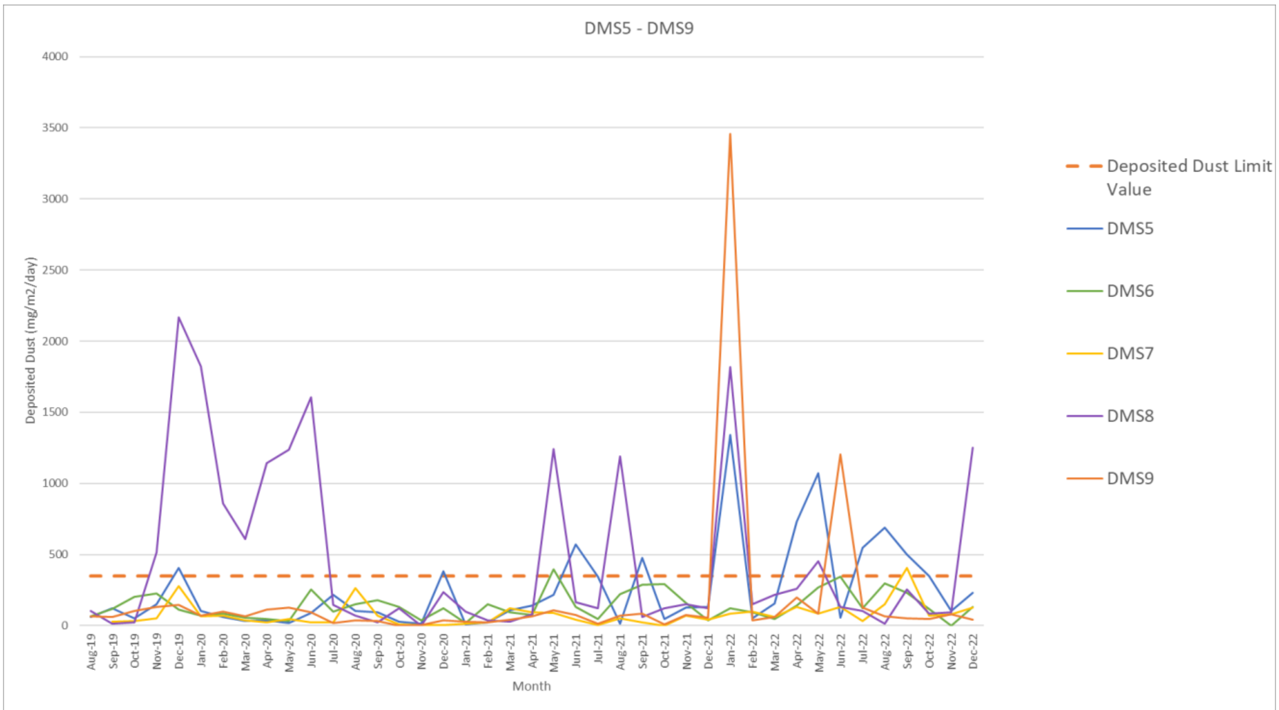


Figure 10.15: Time Series Graph showing Deposited Dust recorded at DMS5, DMS6, DMS7, DMS8 and DMS9 (August 2019 – December 2022)

Ambient Air Monitoring

Ambient air monitoring for background total particulates, PM_{10} and $PM_{2.5}$ was undertaken between 16th August and 13th September 201 at the monitoring location shown on Figure 10.16. The location was selected due to the downwind location from the current and the proposed pit areas and the need for a power supply to run the monitor. This monitoring was undertaken at 10-minute intervals for a continuous one-month period using an Osiris PM monitor. The results presented in Table 10.14 below shown the minimum, maximum and average recorded values for the duration of the monitoring period.

Figure 10.16: Plan showing locations of 2021 Ambient air Monitoring Location

Table 10.14: 2021 Ambient Particulate Monitoring Results

Date		Total Particles (ug/m³)	PM10 particles (ug/m³)	PM2.5 particles (ug/m³)
16/08/2021 – 13/09/2021	Minimum	1.8	1.0	0.3
	Average	13.1	7.8	3.7
	Maximum	392.2	256.1	21.2

The average values obtained during the 2021 ambient particulate monitoring are below the limit values mentioned in Section 10.2, although it is noted that only one month of data was obtained and that the limit values are for annual compliance.

It is noted that the monitoring location was in close proximity to a small lay-by on the R179. Elevated concentrations may potentially be attributed to idling vehicles in the lay-by.

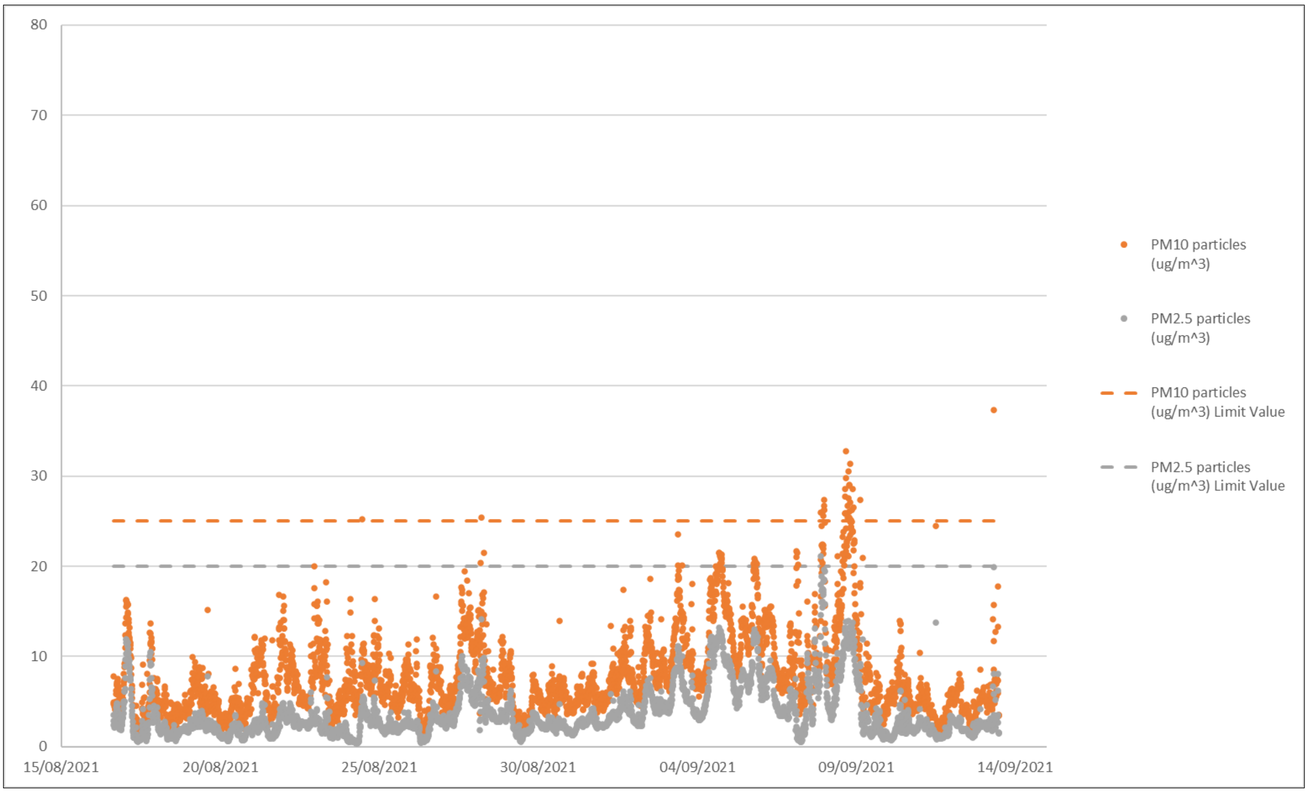


Figure 10.17: Graph showing 2021 Ambient Particulate PM_{10} and $PM_{2.5}$ Monitoring Results[2] compared to Limit Values

[2] Note that the two maximum results of 392.2 µg/m³ for total particulates and 256.1 µg/m³ for PM_{10} as noted in Table 10.14 are not included in Figure 10.17 as the axis would extend beyond a readable range.

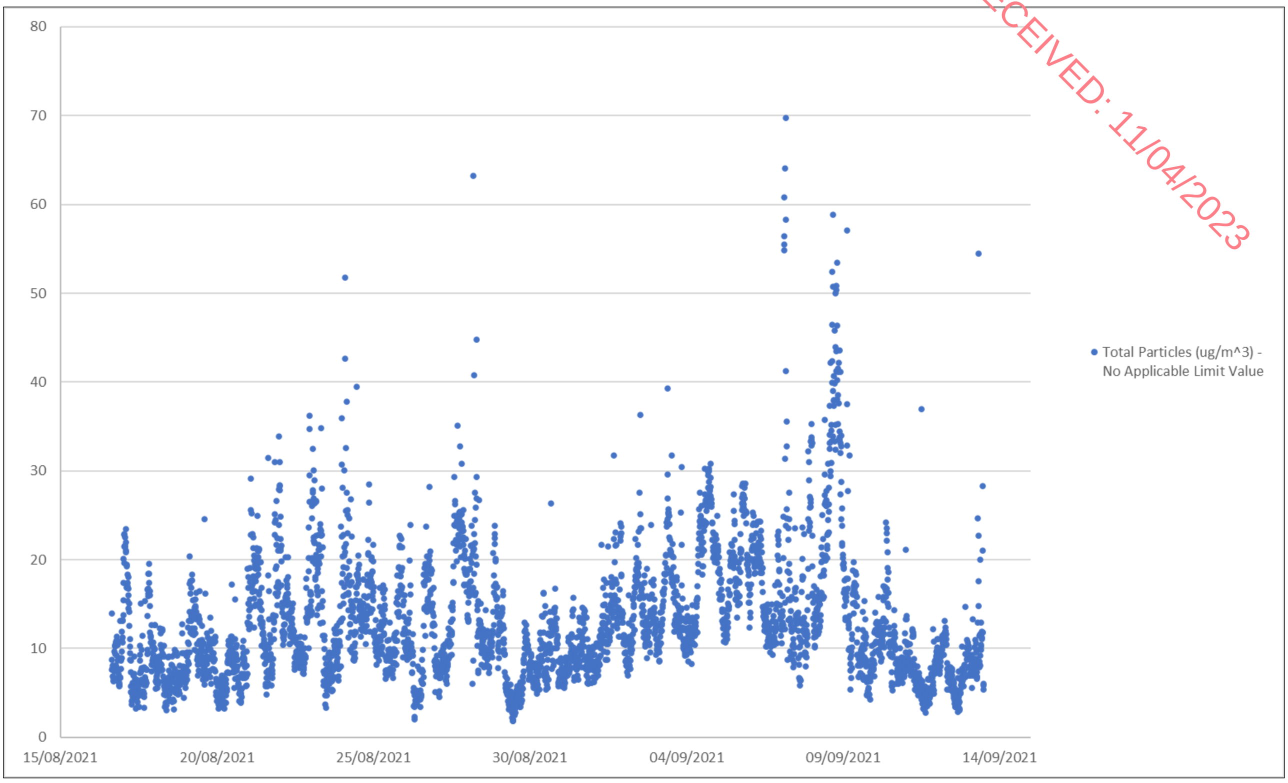


Figure 10.18: Graph showing 2021 Ambient Particulate Total Particulates Monitoring Results (no applicable limit value)

Figure 10.17 and Figure 10.18 above show the full ambient monitoring dataset compared to the Limit Values, with the exception of the maximum total particulates and PM_{10} readings as these would cause the axis to extend beyond a readable range. As shown, exceedances of the Limit Values are short-lived and generally uncommon. The exceedances in all monitoring pollutants shown during the monitoring period are likely attributed to activities outside to the Site boundary undertaken by external parties (e.g. vehicles idling in the nearby entrance to the former GAA site). The peak in concentrations seen around 8th and 9th September 2021 were also evident in a number of other monitoring stations (not related to or in the locality of the Site) e.g. Drogheda, Finglas and Ringsend, Tallaght and Monaghan (2021 Validated ambient air quality monitoring data CAFÉ directive parameters for Ireland). This would likely suggest a meteorological cause and not one linked to any Site related activity.

Calculated 1-hour Average PM_{10}

Using the 10-minute recorded PM_{10} values shown above, the 1-hour average values have been calculated and are shown in Figure 10.19 below.

Table 10.15: 2021 Ambient Particulate Monitoring PM10 calculated 1-hour averages statistics

Date		PM10 particles (ug/m^3)
16/08/2021 – 13/09/2021	Minimum	1.6
	Average	7.8
	Maximum	54.2

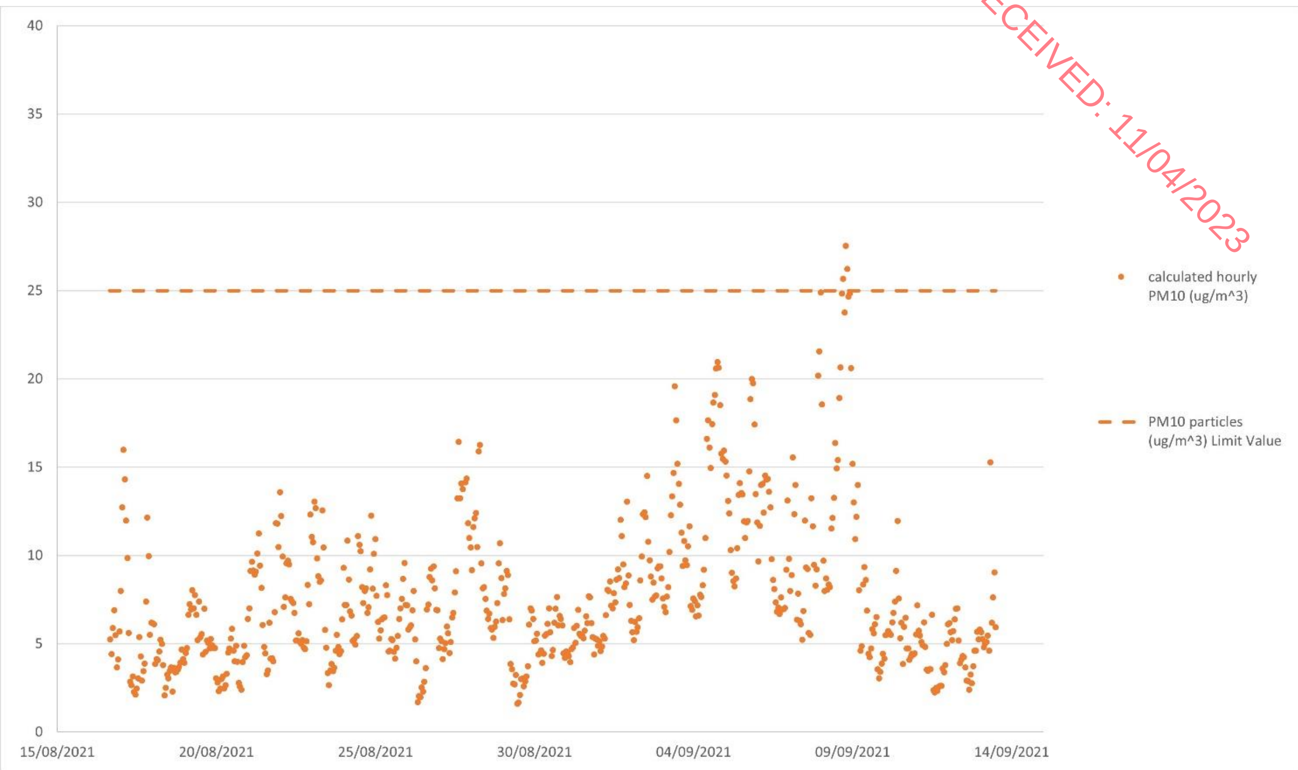


Figure 10.19: Graph showing 2021 Ambient Particulate PM10 calculated 1-hour averages compared to Limit Value

Baseline monitoring of on-Site ambient nitrogen dioxide (NO_2) at the proposed Knocknacran West Site was undertaken using diffusion tubes during six one-month periods in 2019 - 2020. Monitoring was undertaken at the seven locations shown in Figure 10.16, of which one was a triplicate location. The diffusion tube monitoring locations coincide with the baseline deposited dust monitoring locations on the proposed Knocknacran West Site. The results from this monitoring are presented in Table 10.16 below as both annual and hourly averages and are compared against the relevant Air Quality Standard (AQS).

The 1-hour concentrations have been calculated using methodology taken from *"UK Environment Agency Air Emissions Risk Assessment for Your Environmental Permit",* published in February 2016, updated and accessed in July 2022.

Monitoring was only initially undertaken for a six-month period due to travel restriction relating to COVID-19.

A further diffusion tube programme comprising of 3 monthly rounds was completed between July and October 2022, validate the findings of the previous diffusion programme, results are included in Figure 10.20, below, where they are compared to the original 2019 to 2020 monitoring results.

Table 10.16: 2019 - 2020 Annual Average Baseline Monitoring Results for NO_2 and calculated 1 hour concentration[3]

Monitoring Location	Averaging Period	Average Concentration (µg/m³)	AQS (µg/m³)	Concentration as % of AQS
DMS5	Annual	4.74	40	11.84
	1 hour	9.47	200	4.74
DMS6	Annual	3.71	40	9.27
	1 hour	7.41	200	3.71
DMS7a	Annual	6.30	40	15.76
	1 hour	12.61	200	6.30
DMS7b	Annual	6.78	40	16.94
	1 hour	13.55	200	6.78
DMS7c	Annual	5.88	40	14.69
	1 hour	11.75	200	5.88
DMS8	Annual	5.10	40	12.75
	1 hour	10.20	200	5.10
DMS9	Annual	12.19	40	30.47
	1 hour	24.37	200	12.19

The results presented in Table 10.16 above show that the annual and hourly average ambient concentrations of NO_2 in and around the proposed Knocknacran West Site are below the respective AQS limits. The greatest average concentrations were recorded at DMS9, with an annual average of 30.5% of the AQS limit, and an hourly average of 12.2% of the AQS limit. The results recorded at DMS9 are around twice those recorded at the remaining monitoring locations. This is likely to be attributed to the location of DMS9, as it is directly adjacent to the main R179 regional road, and as a result will account for traffic contributions of NO_2.

Figure 10.20 presents the average, min and max for each of the monitoring periods for NO^2. The results demonstrate that the additional monitoring undertaken during 2022, to confirm the validity of the previous 2019/2020 monitoring, is consistent. The 2022 averages are slightly lower than those monitored during 2019/2020 but the number of months included in the analysis is less.

The monitoring for both 2019/2020 and 2022 shows that there is headroom between the current ambient concentrations of NO_2, which includes the existing mining and agricultural activities in the area, and the specified limit values.

[3] The 1-hour concentrations in the EIAR have been calculated using methodology taken from "UK Environment Agency Air Emissions Risk Assessment for Your Environmental Permit", published in February 2016, updated and accessed in July 2022.

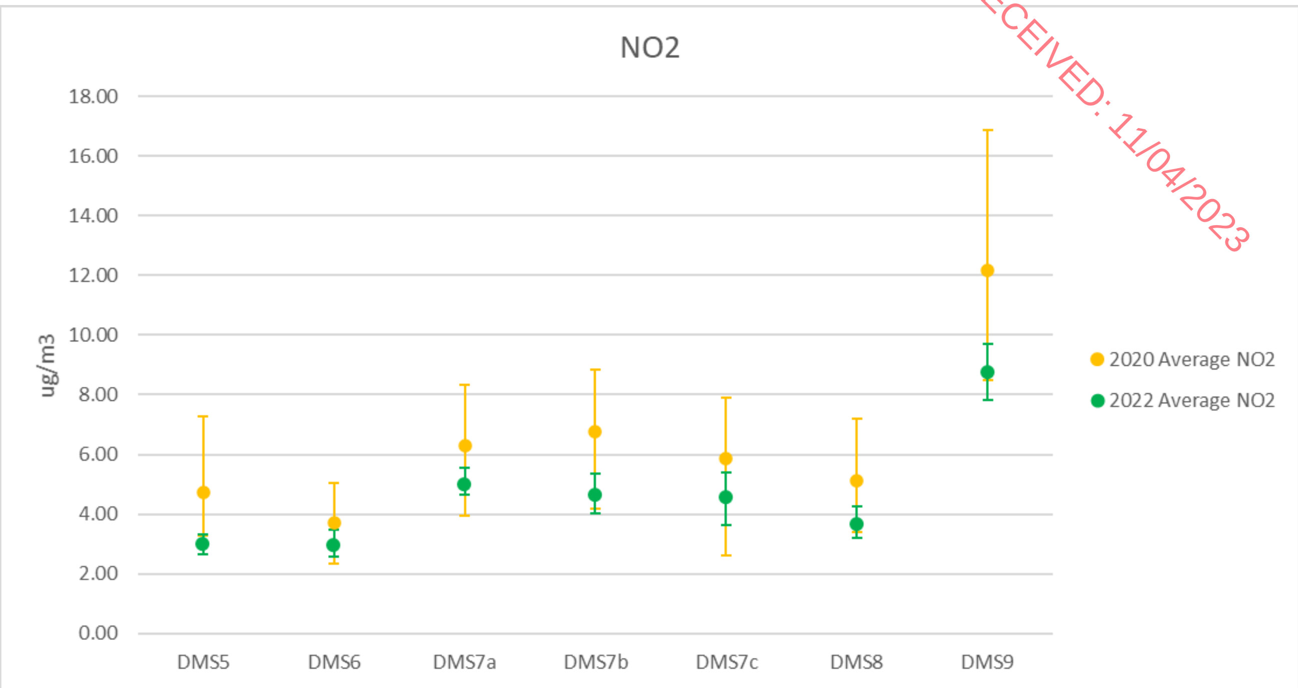


Figure 10.20: NO_2 average, min and max for each of the monitoring periods

1. **Average for the 3 x monthly monitoring rounds taken to be representative of the annual background to allow comparison with the data presented in Table 10.16**
2. **Error bars present the maximum and minimum concentrations monitored during any of the months**

10.1.1.1 Secondary Data - EPA Monitoring

There are 4 air quality zones in Ireland, defined for the purposes of air quality management and assessment. Highly populated areas are classified as Zone A, with sparsely populated areas as Zone D. The Site is located in a rural area, and it is therefore deemed reasonable to characterise the area as a Zone D area. A review of publicly available information identifies that the Irish EPA do not operate background air quality monitoring within Knocknacran, but there are three stations located in the surrounds of the Site.

The average hourly recorded NO_2 concentrations at three nearby EPA monitoring stations is presented below for comparison against the baseline monitoring data recorded at the Site.

Table 10.17: 2021 Hourly Average Monitoring Results for NO2 at nearby EPA Monitoring Stations (Home | AirQuality.ie)

Monitoring Location	Averaging Period	Average Concentration (µg/m³)	AQS (µg/m³)	Concentration as % of AQS
Dundalk (Zone C)	1 hour	11.24	200	5.62
Kilkitt (Zone D)	1 hour	2.37	200	1.19
Navan (Zone C)	1 hour	21.70	200	10.85

Dundalk – urban (town), approximately 24 km east of Site; Kilkitt – rural, approximately 18 km northwest of Site; Navan – urban (outskirts), approximately 33 km south of Site.

When comparing the baseline calculated hourly NO_2 data (monitored average multiplied by 2) monitored at the site between 2019 and 2020 (Table 10.16) to the EPA monitored hourly NO_2 data from 2021 (Table 10.17) (pre-2021 data was unavailable at the time of reporting), the results from the baseline monitoring are comparable to the EPA data from nearby stations. The baseline data ranges between 3.71% and 12.19% of the hourly EQS, and the EPA monitored data ranges between 1.19% and 10.85% of the hourly EQS. This verifies that the baseline results are representative of the area.

In the absence of long term local background data, the most recent annual mean data (2021 and 2020) for NO_2, NOx, PM_{10} and $PM_{2.5}$ for three stations in the surrounding area of the Site, and average historical data for NO_2, PM_{10} and $PM_{2.5}$ from monitoring locations in Zone D areas throughout Ireland are presented in Table 10.18 below. These locations are part of the EPA National Ambient Air Quality Monitoring Network and data is reported to Europe. The historical data is available as a Zone D average only.

Table 10.18: Annual Mean Monitoring Data for nearby and Zone D Stations, (2020: Microsoft Word - Summary Data Tables - 2020 (epa.ie), Monitoring & Assessment: Air Publications | Environmental Protection Agency (epa.ie)) and historical data: Air | Environmental Protection Agency (epa.ie), accessed July 2022)

Pollutant	Year	Monitoring Location	Concentration (µg/m3)
NO_2	2021	Dundaulk (Zone C)	10.7
		Kilkitt (Zone D)	2.4
		Navan (Zone C)	21.9
	2020	Dundaulk (Zone C)	10
		Kilkitt (Zone D)	2
		Navan (Zone C)	19
	2005	Zone D	9
	Average		**10.7**
NOx	2021	Dundaulk (Zone C)	17.6
		Kilkitt (Zone D)	3.1
		Navan (Zone C)	56.6
	2020	Dundaulk (Zone C)	17.8
		Kilkitt (Zone D)	2.5
		Navan (Zone C)	52
	Average		**24.9**
PM_{10}	2021	Dundaulk (Zone C)	11.7
		Kilkitt (Zone D)	7.8
	2020	Dundaulk (Zone C)	13
		Kilkitt (Zone D)	8
	2005	Zone D	17
	Average		**11.5**
$PM_{2.5}$	2021	Navan (Zone C)	8.2
	2020	Kilkitt (Zone D)	8
		Navan (Zone C)	8
	2011	Zone D	9
	Average		**8.3**

When compared, the EPA monitored annual average NO_2 data for the surrounding area is greater than the annual average NO_2 monitored at the Site, with an average of 10.7 µg/m^3 for the EPA data and 6.0 µg/m^3 as an average for all of the baseline monitored data from the Site.

10.5 Key Characteristics of the Proposed Development

10.5.1 Key Characteristics: Construction Phase: Community Sports Complex

The construction phase considerations for the Community Sports Complex development includes details for the following:

- The further development of a Community Sports Complex. The initial phase of this development has received planning permission (Reg. Ref.: 20/365), and the next phase will involve extending the Community Sports Complex by the construction of two further playing pitches, one with a perimeter running track, an all-weather pitch, a new club building, including a sports hall, a handball alley, changing rooms & toilets, a viewing gallery, a part-covered grandstand, additional parking and associated siteworks; and

- During the construction of Phase 2 of the Community Sports Complex development, the pitch, changing facilities and carpark constructed during Phase 1 will be in use. Access to the Community Sports Complex will be directly from the R179 Regional Road.

Appendix 10.1 of this report assesses the potential for dust emission associated with the construction activities at the Site.

The proposed timeline for the Community Sports Complex construction activities is summarised as follows:

- Month 2 – 24 Construction of the Community Sports Complex, which will occur simultaneously with all mine construction activities.

10.5.2 Key Characteristics: Construction Phase: Mine Development

The construction phase considerations for the Mine Development includes details for the following:

- The construction of screening berms and planting, perimeter fencing and the demolition of one residential house and three unoccupied houses and sheds on the Knocknacran West site;

- The construction of a temporary diversion of the R179 and a Cut-and-Cover Tunnel under the R179 for the transport of gypsum to the existing processing plant at the existing Knocknacran Mine, and for the transport of overburden and interburden to the existing Knocknacran Mine for restoration purposes;

- The construction of a new vehicular access to the existing Knocknacran Mine site from the L4816; and

- During construction, a temporary construction access to the site of the proposed Knocknacran West Open-Cast Mine will be provided via an existing emergency access on the L4900, ca. 240m north-west from the junction with the R179.

Appendix 10.1 of this report assesses the potential for dust emission associated with the construction activities at the Site.

10.5.3 Key Characteristics: Operational Phase: Community Sports Complex

The operational phase considerations for the Community Sports Complex includes details for the following:

- Traffic emissions relating to the operation of the Community Sports Complex.

10.5.4 Key Characteristics: Operational Phase: Mine Development

For quarrying/mining related activities, the most likely emission to the air environment is dust, which arises predominantly from the excavation, processing and transporting of material. These sources are generally dispersed sources rather than specific point sources and this dictates the measures required to mitigate dust related impacts. Appendix 10.2 of this report assesses the potential for dust emissions associated with the mining activities at the Site.

The operational phase considerations for the Mine Development includes details for the following:

- The proposed Knocknacran West Open-Cast Mine comprises ca. 54.3 ha; ca. 24.6 ha comprises the Knocknacran Processing Plant and ca. 51.5 ha will comprise the restoration area for the existing Knocknacran Open-Cast Mine.;

- The extraction of gypsum from the former (Drumgoosat) underground mine at Knocknacran West by open-cast mining methods.

- Production rates will be the same as the existing mine development (i.e. production rates between ca. 250,000 and 500,000 tonnes of gypsum per annum, depending on market conditions). Gypsum will be hauled to the existing factory site outside of Kingscourt on road haulage trucks. Excavations will proceed in a southerly direction to a depth of ca. 90 m below ground level;

- In terms of the detailed operation of the Knocknacran West Mine, drilling and blasting in conjunction with a rock breaker will be used to break-up the gypsum rock to a size not exceeding 800 mm. An excavator will then load the material onto dumper trucks, which will transport the material to the primary crusher which will be located in the open-cast. The primary crusher will reduce the rock to less than 150 mm. The <150 mm material will be transported from the primary crusher, out of the open-cast, through the Cut-and-Cover Tunnel and across the existing Knocknacran pit to a stockpile area adjacent to the existing processing plant by conveyor. A stockpile reclaim conveyor will transport the material onto the existing secondary crusher feed conveyor. The material will initially pass over a vibrating feeder with material less than 75 mm passing through the feeder and oversize directed to the secondary crusher. The secondary crusher reduces the oversize material (between 75 and 150 mm) to less than 75 mm. After crushing, the material will be conveyed to the existing homogeniser prior to being transported off-site to the Applicant's manufacturing facility at Kingscourt;

- The continued restoration of the existing Knocknacran Mine to modify the currently permitted restoration plan and return the existing Knocknacran Mine to near original ground levels. Overburden and interburden stripped as part of the gypsum extraction process in Knocknacran West will be used in the restoration of the existing adjacent Knocknacran Mine. The restoration material will be moved within the Knocknacran West and Knocknacran mine sites using the Cut-and-Cover Tunnel (there is no public road transport of this material);

- The continuation of use and refurbishment of the existing processing plant, water treatment facilities and associated infrastructure on the existing Knocknacran Mine site. Gypsum road haulage trucks exit and enter this part of the development; and

- The proposed hours of operation of the open-cast mine are between 08:00 hours and 20:00 hours on Monday to Saturday. Pump inspections will take place as required. Transport of gypsum from the Knocknacran Processing Plant will continue to take place between 06:00 hours and 21:00 hours Monday to Saturday. No blasting will take place on Saturdays, Sundays or Public Holidays, and the mine site will not be operated on Sundays or Public Holidays.

10.5.5 Key Characteristics: Restoration/Closure Phase: Community Sports Complex

There is no proposal to close the Community Sports Complex development and this phase is non-applicable.

10.5.6 Key Characteristics: Restoration/Closure Phase: Mine Development

During this phase:

- The new Knocknacran West site will be returned to grassland and a waterbody;

- The existing Knocknacran Plant site will be partially dismantled whereby mine plant is removed; and

- In line with the current CRAMP it is presented that here that a suitable developer would be sought to utilise the general buildings existing on the existing site for a light industrial usage into the future. This would be subject to a future developer seeking the necessary permits for continuation of use and change of use from mining to a non-mining use.

A Closure, Restoration and Aftercare Management Plan (CRAMP) has been prepared (Appendix 3.3), which sets out the closure and aftercare proposals following cessation of mine operations. The physical closure works will be followed by a period of monitoring, during which time the mining company must carry out monitoring and measurements to demonstrate that the closure works have been successful, and that all environmental metrics for the site are stable. This will be controlled by the EPA through the IE licencing procedure. Following this, it is envisaged that the former mining areas will transition to an aftercare period, which will be of reduced scope and intensity to the monitoring carried out during the closure works.

10.6 Potential Effects

10.6.1 Potential Effects: Construction Phase: Community Sports Complex

10.6.1.1 Potential Sources of Emissions to Air

Potential Sources of Emissions to Air: Construction Phase: Community Sports Complex: Particulates

Potential dust emissions associated with the Community Sports Complex are:

- The construction of the Community Sports Complex (including pitch laying) and associated material transport.

Potential Sources of Emissions to Air: Construction Phase: Community Sports Complex: Traffic Emissions

It is anticipated that the maximum number of HGVs (> 3.5 tonnes) movements per day during the construction period will be below the threshold for a quantitative construction phase assessment of vehicle emissions (100 movements per day or more over a year) referred to in the IAQM 2014 guidance. It is considered in Section 14.6.1.1 of Chapter 14.0 (Traffic) that 20 trips due to the delivery of materials to site may occur during this period.

No detailed assessment is required and therefore traffic emissions have been screened out of this assessment as **Not Significant**.

Potential Sources of Emissions to Air: Construction Phase: Community Sports Complex: Odour

There are no expected odours associated with this development, therefore, odour is not considered any further in this assessment and is screened out as **Not Significant**.

Potential Effects: Construction Phase: Community Sports Complex: Coarse Particulates

An assessment of the potential effects of deposited dust from the Community Sports Complex construction activities is provided in Appendix 10.1 of this report. This assessment has been undertaken in accordance with the IAQM Guidance on the Assessment of Mineral Dust Impacts for Planning (2016), as described in Section 10.3.2 above.

The assessment defined the potential dust emission magnitudes (relating to earthworks, construction and track-out), and the sensitivity of the area (relating to both people and property, and human health), and combined these to define the risk of unmitigated dust impacts in terms of dust soiling, human health and ecological impact. The assessment found that the unmitigated risk from the construction of the Sports Complex will be Low for construction and trackout, and Medium for earthworks activities, resulting in a negligible significance once proposed mitigation is in place.

Potential Effects: Construction Phase: Community Sports Complex: Fine Particulates

The IAQM recommend that if the PM_{10} background concentration is less than 17 µg/m^3 there is little risk that the process contribution (PC) from the Site would lead to an exceedance of the annual-mean objective. The background data monitored at the Site is detailed in Section 10.4.5 and from other equivalent Zone D areas in Section 10.4.5. The monthly average monitored concentration Is 7.8 µg/m^3 and the annual average of the local EPA stations is 10.7 µg/m^3, both of which are less than 17 µg/m^3. Based on this data, it is unlikely that the Community Sports Complex construction activities would lead to an exceedance of the AQS.

Guidance document, LAQM TG03, states that the likely PM_{10} contribution from fugitive dusts, stockpiles, quarries and construction is variable but up to 5 µg/m^3. Therefore, the likely concentration at the receptor locations can be estimated using the calculation considering the distance from source. As $PM_{2.5}$ is a sub-fraction of PM_{10}, the contribution of $PM_{2.5}$ will be lower but if it is conservatively assumed that all of the PM_{10} is $PM_{2.5}$.

When combining the likely concentration with the average local EPA monitored background value (10.7 µg/m^3) for Zone D areas (which is greater than the monitored monthly concentration), the maximum annual PM_{10} predicted environmental concentration (PEC) would be 12.2 µg/m^3 which is approximately 54% of the AQS and the annual $PM_{2.5}$ PEC would be 49% of the Stage 1 AQS and 61% of the Stage 2 AQS, at the closest receptor. The PEC would be less than this for all other receptors in the vicinity of the Site. The PEC is predicted to be below the annual AQS, with headroom. The impact from fine particle from the Community Sports Complex construction activities is considered to be a Negligible to Slight effect.

10.6.2 Potential Effects: Construction Phase: Mine Development

10.6.2.1 Potential Sources of Emissions to Air

Potential Sources of Emissions to Air: Construction Phase: Mine Development: Traffic Emissions

The predicted Annual Average Daily traffic (AADT) counts which would arise as a result of the proposed Mine Development are set out in Chapter 14.0 and comprise 40 trips per day associated with the delivery/removal of materials to the temporary road diversion site (the demolition of houses trips are included in this). There would be an expected 36 trips per day associated the delivery of material to the Cut-and-Cover tunnel site. Trips associated with the temporary diversion do not overlap with the Cut-and-Cover trips. Six trips per day would be associated with the perimeter fencing and screening berms. These vehicles counts are associated with the construction phase and therefore will occur within less than a year. No further additional LV or Heavy Duty Vehicle (HDV) movements are expected to arise as a result of the Proposed Development.

It is not anticipated that the maximum number of HGVs (>3.5 tonnes) movements per day during the construction period, are likely to be above the threshold for a quantitative construction phase assessment of vehicle emissions.

The EPUK & IAQM Land Use Planning Control: Planning for Air Quality (2017) guidance specifies an LDV screening criteria of a change of 500 AADT, and a HDV screening criteria of a change of 100 AADT. Considering that the expected change in traffic flows associated with the development falls below this screening criteria, no detailed assessment is required and therefore traffic emissions have been screened out of this assessment as **Not Significant**.

Due to their on-site nature and low number, exhaust emissions from vehicles used in earthworks on site have been screened out of the assessment of traffic emissions.

Potential Sources of Emissions to Air: Construction Phase: Mine Development: Odour

Inert materials are being excavated from the construction areas within the Mine Development, which are not odourous. Therefore, odour is not considered any further in this assessment and is screened out as **Not Significant**.

Potential Effects: Construction Phase: Mine Development: Coarse Particulates

An assessment of the potential effects of deposited dust from the demolition and construction activities at the Mine Development is provided in Appendix 10.1 of this report. This assessment has been undertaken in accordance with the IAQM 'Guidance on the assessment of dust from demolition and construction (IAQM 2014)as described in Section 10.3.2 above.

The assessment defined the potential dust emission magnitudes (relating to demolition, earthworks, construction and trackout), and the sensitivity of the area (relating to both people and property, and human health), and combined these to define the risk of unmitigated dust impacts in terms of dust soiling, human health and ecological impact. The risk of unmitigated dust impacts from the construction areas (mine development, road diversion, tunnel and site entrance) are predicted to be Negligible apart from earthworks activities associated with the road diversion and the tunnel, which are predicted to be Low and dust soiling impacts associated with the mine development earthworks, which are predicted to be Medium. With the application of the proposed mitigation, all impacts are predicted to be Not Significant.

During periods of simultaneous construction related works, the combined activities likely to generate the greatest impacts on human health are all low impacts which will occur for a maximum of 5 months, although it will only be applicable during simultaneous earthworks activities. The combined activities likely to generate the greatest impacts on dust soiling are medium impacts which will occur for a maximum of 5 months, although it will only be applicable during simultaneous earthworks activities. During the overlap of earthwork activities, there is the potential for up to a medium to large risk of unmitigated dust impacts. To manage this potential in combination impacts, mitigation will be applied, as detailed in Appendix 10.1.

10.6.3 Potential Effects: Operational Phase: Community Sports Complex

For the assessment of traffic emissions, the EPUK & IAQM Land Use Planning Control: Planning for Air Quality (2017) guidance specifies an LDV screening criteria of a change of 500 AADT, and a HDV screening criteria of a change of 100 AADT. The traffic flows associated with the operation of the sports complex are not yet defined, but due to the type and nature of the development the associated traffic flows are anticipated to be below this screening criteria, and therefore no detailed assessment is required, and traffic emissions have been screened out of this assessment as **Not Significant**.

10.6.4 Potential Effects: Operational Phase: Mine Development

10.6.4.1 Potential Sources of Emissions to Air

Potential Sources of Emissions to Air: Operational Phase: Mine Development: Particulates

The main potential impact on ambient air quality associated with mining activities is that associated with deposition of dust generated by the mineral extraction and material transfer operations from the following:

- Stripping of subsoil and overburden;
- Excavation of gypsum using methods including digging, blasting and rock-breaking equipment;
- Primary crushing of gypsum on the open-cast floor;
- Loading material onto trucks within the mine site, and onto conveyors for transport to the adjacent existing Knocknacran Site;
- The transportation of materials within the mine site on haul routes;
- Wind erosion at dump areas and exposed faces; and
- The phased restoration of the adjacent existing Knocknacran site and the movement of associated restoration materials from the Knocknacran West site.

Potential Sources of Emissions to Air: Operational Phase: Mine Development: Traffic Emissions

The predicted Annual Average Daily traffic (AADT) counts which would arise as a result of the Mine Development are set out in Section 14.6.4.1, Chapter 14.0 (i.e. 330 movements daily, 140 of which relate to

HGV's (52%)). No further additional LV or Heavy Duty Vehicle (HDV) movements are expected to arise as a result of the operational phase of the proposed Mine Development.

As the Proposed Development is a continuation of existing activities rather than an expansion in terms of capacity, the current LV and HV movements associated with the existing Knocknacran Mine will continue as they are and will serve the proposed Knocknacran West site as well.

The EPUK & IAQM Land Use Planning Control: Planning for Air Quality (2017) guidance specifies an LDV screening criteria of a change of 500 AADT, and a HDV screening criteria of a change of 100 AADT. Considering that the expected change in traffic flows associated with the development falls below this screening criteria, no detailed assessment is required and therefore traffic emissions have been screened out of this assessment as **Not Significant**.

Due to activities being restricted on-site and the low number of vehicles used in the soil and overburden movement on Site have been screened out of the assessment of traffic emissions.

Potential Sources of Emissions to Air: Operational Phase: Mine Development: Odour

Inert materials are being excavated from the Site, which are not odourous. Therefore, odour is not considered any further in this assessment and is screened out as **Not Significant**.

Potential Effects: Operational Phase: Mine Development: Coarse Particulates

An assessment of the potential effects of deposited dust from the continued operation of the Site is provided in Appendix 10.2 of this report. This assessment has been undertaken in accordance with the IAQM Guidance on the Assessment of Mineral Dust Impacts for Planning (2016), as described in Section 10.3.2 above.

The assessment defined residual source classifications to activities on Site and used these to assign a magnitude to the dust effects likely to be experienced at identified receptors. Consideration was given to mitigation measures, which are to be put in place, and will remain in place for the duration of the Site activities. Based on the magnitude of dust effects and the mitigation employed on Site, an overall significance of the effects of dust was assigned to key sources: excavation, transfer on haul roads, transfer on public roads, and dust from on-site processing. For each of these sources, the significance was defined as Slight Adverse. Dust from transfer on public roads was not considered, due to all material movement from the proposed Knocknacran West Site occurring via the Cut-and-Cover Tunnel.

It is noted that restoration of the existing Knocknacran Mine Site is scheduled with a west to east phasing. This means that the area of the mine closest to the Community Sports Complex will be restored first, thus covering any exposed gypsum and reducing the duration of potential dust nuisance arising at this receptor.

In the longer term, on completion of the Knocknacran Mine site restoration, the concentration of airborne dust would be expected to be reduced from operational levels as the result of covering and seeding of exposed, un-vegetated soil surfaces. This will most likely constitute a minor positive impact for the local environment.

Potential Effects: Operational Phase: Mine Development: Fine Particulates

The IAQM recommend that if the PM_{10} background concentration is less than 17 µg/m^3 there is little risk that the process contribution (PC) from the Mine Development would lead to an exceedance of the annual-mean objective. The background data monitored at the Mine Development is detailed in Section 10.4.5 and from other equivalent Zone D areas in Section 10.4.5. The monthly average monitored concentration Is 7.8 µg/m^3 and the annual average of the local EPA stations is 10.7 µg/m^3, both of which are less than 17 µg/m^3. Based on this data, it is unlikely that the PC from the Mine Development would lead to an exceedance of the AQS.

Fine particulate PC can also be assessed using the calculation of concentration with distance from source (for conservatism the site boundary is used) as detailed in LAQM TG03. The guidance document also states that the likely PM_{10} contribution from fugitive dusts, stockpiles, quarries and construction is variable but up to 5 µg/m^3. Therefore, the likely concentration at the receptor locations can be estimated using the calculation considering the distance from source. As $PM_{2.5}$ is a sub-fraction of PM_{10}, the contribution of $PM_{2.5}$ will be lower but if it is conservatively assumed that all of the PM_{10} is $PM_{2.5}$.

When combining the likely concentration with the average local EPA monitored background value (10.7 µg/m^3) for Zone D areas (which is greater than the monitored monthly concentration), the maximum annual PM_{10} predicted environmental concentration (PEC) would be 12.2 µg/m^3 which is approximately 54% of the AQS and the annual $PM_{2.5}$ PEC would be 49% of the Stage 1 AQS and 61% of the Stage 2 AQS, at the closest receptor. The PEC would be less than this for all other receptors in the vicinity of the Mine Development. The PEC is predicted to be below the annual AQS, with headroom. The impact from fine particle PC from the Mine Development is considered to be Negligible to Slight prior to mitigation which would reduce to Negligible due to the mitigation measures to be employed by the Site.

10.6.5 Potential Effects: Restoration/Closure Phase: Community Sports Complex

There is no proposal to close the Community Sports Complex development and this phase is non-applicable.

10.6.6 Potential Effects: Restoration/Closure Phase: Mine Development

10.6.6.1 Potential Sources of Emissions to Air

Potential Sources of Emissions to Air: Restoration/Closure: Mine Development: Particulates

The main potential impact on ambient air quality associated with the restoration is that associated with deposition of dust generated by the earthworks and decommissioning from the following:

- The final restoration of the Knocknacran site and the Knocknacran West site; and
- Decommissioning/demolition of plant and some buildings onsite.

Potential Sources of Emissions to Air: Restoration/Closure: Mine Development: Traffic Emissions

During the initial closure of the Mine Development, removal of plant and some buildings will occur onsite. Some plant may be sold and transported offsite to another location. However, this is expected to require less vehicles than those associated with the construction phase of the Mine Development. Material used in the final restoration of Knocknacran and Knocknacran West Mines will be transported within the site, no external road haulage is required.

It is not anticipated that the maximum number of HGVs (> 3.5 tonnes) movements per day during the construction period for all construction areas combined, are likely to be above the threshold for a quantitative construction phase assessment of vehicle emissions (100 movements per day or more over a year) referred to in the IAQM 2014 guidance.

No detailed assessment is required and therefore traffic emissions have been screened out of this assessment as **Not Significant**.

Potential Sources of Emissions to Air: Restoration/Closure: Mine Development: Odour

Inert materials are being moved moved within the Mine Development, which are not odourous. Therefore, odour is not considered any further in this assessment and is screened out as **Not Significant**.

Potential Effects: Operational Phase: Mine Development: Coarse Particulates

In the longer term, on completion of the site restoration, the concentration of airborne dust would be expected to be reduced from operational levels as the result of covering and seeding of exposed, un-vegetated soil surfaces. This will most likely constitute a minor positive impact for the local environment.

Potential Sources of Emissions to Air: Restoration/Closure: Mine Development: Fine Particulates

During the closure phase, the plant site at Knocknacran will no longer be in use for gypsum production, as such, the process contribution is no longer considered.

Guidance document (LAQM TG03) states that the likely PM_{10} contribution from fugitive dusts, stockpiles, quarries and construction is variable but up to 5 µg/m^3. Therefore, the likely concentration at the receptor locations can be estimated using the calculation considering the distance from source. As $PM_{2.5}$ is a sub-fraction of PM_{10}, the contribution of $PM_{2.5}$ will be lower but if it is conservatively assumed that all of the PM_{10} is $PM_{2.5}$.

When combining the likely concentration with the average local EPA monitored background value (11.5 µg/m^3) for Zone D areas (which is greater than the monitored monthly concentration), the maximum annual PM_{10} predicted environmental concentration (PEC) would be 13.0 µg/m^3 which is approximately 33% of the AQS and the annual $PM_{2.5}$ PEC would be 52% of the Stage 1 AQS and 65% of the Stage 2 AQS, at the closest receptor. The PEC would be less than this for all other receptors in the vicinity of the Site. The PEC is predicted to be below the annual AQS, with headroom. The impact from fine particle from closure activities is considered to be Negligible to Slight prior to mitigation which would reduce to Negligible due to the mitigation measures to be employed by the Site.

10.7 Mitigation and Management

10.7.1 Mitigation and Management: Construction Phase: Community Sports Complex

10.7.1.1 Embedded Mitigation Measures: Construction Phase: Community Sports Complex

Embedded design mitigation includes planting and screening berms around the perimeter of the development site, including those already constructed under Reg. Ref. 20/365.

10.7.1.2 Additional Mitigation Measures: Construction Phase: Community Sports Complex

Mitigation Measures that will be employed during construction activities includes:

- Works will be undertaken in line with any conditions set by the MCC;

- Display the name and contact details of person(s) accountable for air quality and dust issues on the Site boundary;
- Display the head or regional office contact information;
- Record all dust and air quality complaints, identify cause(s), take appropriate measures to reduce emissions in a timely manner and record the measures taken;
- Make the complaints log available to the local authority if requested;
- Record any exceptional incidents that cause dust and/or air emissions, either on-or off-site, and the action taken to resolve the situation in the log book.
- Carry out regular site inspections;
- Plan site layout so that machinery and dust causing activities including stockpiling are located away from receptors, as far as is possible;
- Erect solid screens or barriers around dusty activities or the site boundary which are at least as high as any stockpiles on site;
- Avoid site runoff of water or mud;
- Ensure all vehicles switch off engines when stationary – no idling vehicles;
- Avoid the use of diesel or petrol-powered generators and use mains electricity or battery powered equipment where practicable;
- Only use cutting, grinding or sawing equipment fitted or in conjunction with suitable dust suppression techniques such as water sprays or local extraction, e.g. suitable local exhaust ventilation systems;
- Ensure an adequate water supply on the site for effective dust/particulate matter suppression/mitigation, using non-potable water where possible and appropriate;
- Use enclosed chutes and conveyors and covered skips;
- Minimise drop heights from conveyors, loading shovels, hoppers and other loading or handling equipment and use fine water sprays on such equipment wherever appropriate;
- Re-vegetate earthworks and exposed areas/ stockpiles to stabilise the surface as soon as possible;
- Use hessian, mulches or trackifiers where it is not possible to revegetate or cover with topsoil
- Only remove the cover in small areas during work and not all at once;
- Avoid scabbling (roughening of concrete surfaces);
- Avoid bonfires and burning of waste materials;

- Use water-assisted dust sweeper(s) on the access and local roads for the Community Sports Complex, to remove, as necessary, any material tracked out of the site;
- Avoid dry sweeping of large areas at the Community Sports Complex site;
- Ensure vehicles entering and leaving sites are covered to prevent escape of materials during transport at the Community Sports Complex site; and
- Record all inspections of haul routes and any subsequent action in a site log book at the Community Sports Complex site.

10.7.2 Mitigation and Management: Construction Phase: Mine Development

10.7.2.1 Embedded Mitigation Measures: Construction Phase: Mine Development

- During the construction phase, a 2 m to 4 m-high screening berm will be constructed and completed on all sides of the Knocknacran West Open-Cast Mine site.

10.7.2.2 Additional Mitigation Measures: Construction Phase: Mine Development

Additional mitigation measures that will be employed during construction activities includes:

- Works will be undertaken in line with any conditions set by the MCC;
- Construction phase activities will take place in accordance with the Construction Environmental Management Plan;
- Dust monitoring will continue to be carried out monthly at the designated monitoring locations, and results will be reported to the local authority;
- Display the name and contact details of person(s) accountable for air quality and dust issues on the Site boundary;
- Display the head or regional office contact information;
- Record all dust and air quality complaints, identify cause(s), take appropriate measures to reduce emissions in a timely manner and record the measures taken;
- Make the complaints log available to the local authority if requested;
- Record any exceptional incidents that cause dust and/or air emissions, either on-or off-site, and the action taken to resolve the situation in the log book.
- Carry out regular site inspections;
- Plan site layout so that machinery and dust causing activities including stockpiling are located away from receptors, as far as is possible;
- Erect solid screens or barriers around dusty activities or the site boundary which are at least as high as any stockpiles on site;

- Avoid site runoff of water or mud;
- Ensure all vehicles switch off engines when stationary – no idling vehicles;
- Avoid the use of diesel or petrol-powered generators and use mains electricity or battery powered equipment where practicable;
- Only use cutting, grinding or sawing equipment fitted or in conjunction with suitable dust suppression techniques such as water sprays or local extraction, e.g. suitable local exhaust ventilation systems;
- Ensure an adequate water supply on the site for effective dust/particulate matter suppression/mitigation, using non-potable water where possible and appropriate;
- Use enclosed chutes and conveyors and covered skips;
- Minimise drop heights from conveyors, loading shovels, hoppers and other loading or handling equipment and use fine water sprays on such equipment wherever appropriate;
- Soft- strip buildings before demolition (retaining walls and windows in the rest of the building where possible to provide a dust screen);
- Ensure water supression is used during demolition operations. Hand-held sprays are the most effective method as the water can be directed to where it is most needed;Avoid blasting with explosives and use appropriate manual or mechanical alternatives;
- Bag and remove any biological debris or damp down such material before demolition;
- Re-vegetate earthworks and exposed areas/ stockpiles to stabilise the surface as soon as possible;
- Use hessian, mulches or trackifiers where it is not possible to revegetate or cover with topsoil;
- Only remove the cover in small areas during work and not all at once;
- Avoid bonfires and burning of waste materials.

10.7.3 Mitigation and Management: Operational Phase: Community Sports Complex

No mitigation measures are proposed for the operational phase of the Community Sports Complex.

10.7.4 Mitigation and Management: Operational Phase: Mine Development

10.7.4.1 Embedded Mitigation Measures: Operational Phase: Mine Development

A key objective of the construction phase is to ensure that screening berms and other screening measures (i.e. bolstering existing perimeter hedgerows) are carried out early on, and in advance of the operational phase of development where they will act as mitigation.

During the construction phase, a 2 m to 4 m-high screening berm will be constructed and completed on all sides of the Knocknacran West Open-Cast Mine site (Figure 10.21). As illustrated in Figure 10.21, the existing perimeter boundary hedgerow will be maintained and thickened.

In addition, forestry to the north of the Knocknacran West site, near Drumgoosat will be left largely intact to act as screening.

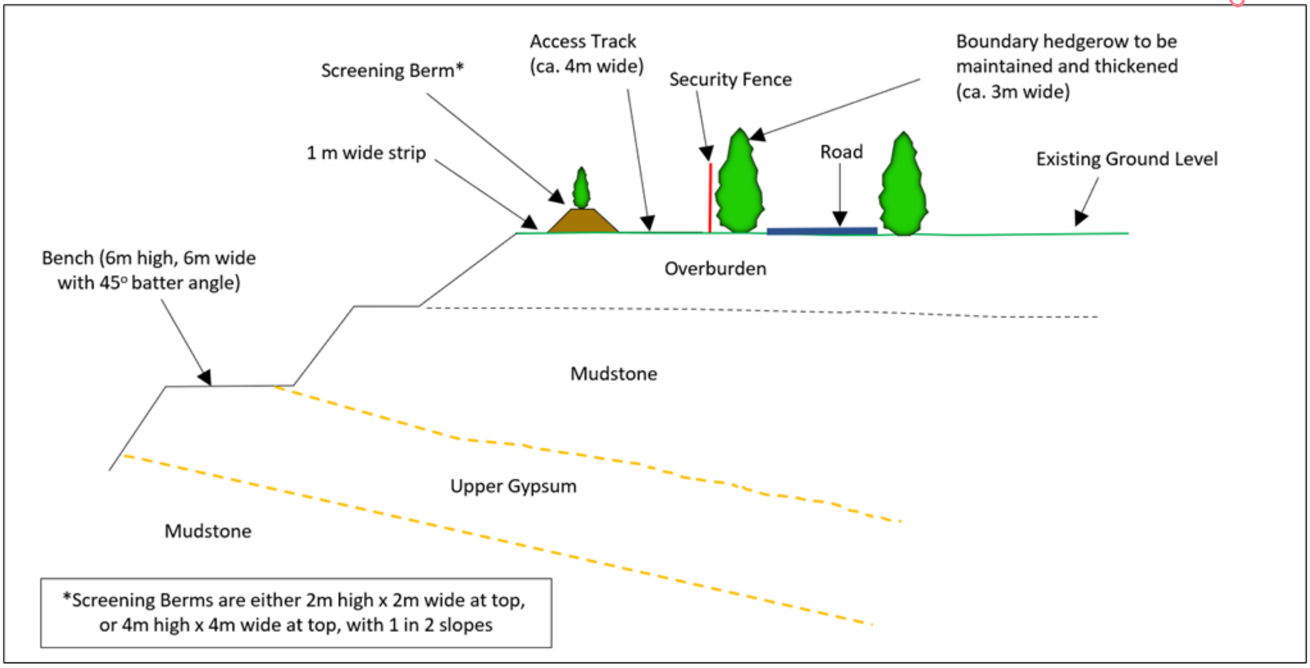


Figure 10.21: Schematic cross-section of generic boundary treatment for the Knocknacran West Mine site

10.7.4.2 Additional Mitigation Measures: Operational Phase: Mine Development

Details of mitigation measures that will be employed at the mine sites are summarised below:

- Works will be undertaken in line with any conditions set by the IE licence;
- Dust monitoring will continue to be carried out monthly at the designated monitoring locations, and results will be reported to the EPA in an annual monitoring report;
- An ambient monitoring station will be established on the Knocknacran West Mine site to record fine particulates, as part of the IE Licence;
- Display the name and contact details of person(s) accountable for air quality and dust issues on the Site boundary;
- Display the head or regional office contact information;
- The timing of operations will be optimised in relation to meteorological conditions;
- Overburden will be stripped in stages according to the mining schedule, reducing the risk of mass dust emissions;

- Material in outdoor stockpiling will be located within the mining void to take advantage of shelter from wind;
- Overburden mounds will be grass-seeded and planted to eliminate wind-blown dust;
- The existing hedgerow will be used as a means of screening, with a security fence and a vegetated berm for dust, noise and visual screening. Berms will be 2 m high and 2 m wide and planted, with a section of 4 m by 4 m berm along the southern part of the proposed pit (embedded mitigation);
- The woodland to the north of the proposed boundary will be kept (and enhanced with additional planting of native species), acting as a natural buffer (embedded mitigation);
- Plant will be regularly maintained;
- Equipment will be enclosed, such as the semi-mobile crusher and covered conveyor;
- Internal haul roads will be compacted and maintained (a water-bowser will be available at all times should haul roads need dampening to minimise dust blow during working hours);
- On site speed restrictions (<20 kph) will be maintained in order to limit the generation of fugitive dust emissions; and
- All vehicles exiting the existing site will exit through the existing wheel-wash, and the proposed Knocknacran West Site will operate as a closed site.
- No vehicles or plant will be left idling unnecessarily;
- Vehicles and plant will be well maintained. Should any emissions of dark smoke occur (except during start up) then the relevant machinery will be stopped immediately, and any problem rectified before being used;
- Engines and exhaust systems will be regularly serviced according to the manufacturer's recommendations and maintained to meet statutory limits/opacity tests; and
- All vehicles will hold a current Department of Environment certificate where required.

10.7.5 Mitigation and Management: Restoration/Closure Phase: Community Sports Complex

There is no proposal to close the Community Sports Complex development and this phase is non-applicable.

10.7.6 Mitigation and Management: Restoration/Closure Phase: Mine Development

Details of mitigation measures that will be employed at the mine sites are summarised below:

- Works will be undertaken in line with any conditions set by the IE licence;
- Dust monitoring will continue to be carried out monthly at the designated monitoring locations, and results will be reported to the EPA in an annual monitoring report, monitoring will be reduced or stopped in line with the IE Licence/EPA consultation; The timing of operations will be optimised in relation to meteorological conditions;

- Material in outdoor stockpiling will be located within the mining void to take advantage of shelter from wind;
- The existing hedgerow will be used as a means of screening, with a security fence and a vegetated berm for dust, noise and visual screening. Berms will be 2 m high and 2 m wide and planted, with a section of 4 m by 4 m berm along the southern part of the proposed pit (embedded mitigation);
- The woodland to the north of the proposed boundary will be kept (and enhanced with additional planting of native species), acting as a natural buffer (embedded mitigation);
- Plant will be regularly maintained;
- Internal haul roads will be compacted and maintained (a water-bowser will be available at all times should haul roads need dampening to minimise dust blow during working hours);
- On site speed restrictions (<20 kph) will be maintained in order to limit the generation of fugitive dust emissions; and
- All vehicles exiting the existing site will exit through the existing wheel-wash, and the proposed Knocknacran West Site will operate as a closed site.
- No vehicles or plant will be left idling unnecessarily;
- Vehicles and plant will be well maintained. Should any emissions of dark smoke occur (except during start up) then the relevant machinery will be stopped immediately, and any problem rectified before being used;
- Engines and exhaust systems will be regularly serviced according to the manufacturer's recommendations and maintained to meet statutory limits/opacity tests;
- All vehicles will hold a current Department of Environment certificate where required.
- Display the name and contact details of person(s) accountable for air quality and dust issues on the Site boundary for decommissioning operations on the plant site;
- Display the head or regional office contact information for decommissioning operations on the plant site;
- Record all dust and air quality complaints, identify cause(s), take appropriate measures to reduce emissions in a timely manner and record the measures taken for decommissioning operations on the plant site;
- Record any exceptional incidents that cause dust and/or air emissions, either on-or off-site, and the action taken to resolve the situation in the log book for decommissioning operations on the plant site;
- Carry out regular site inspections;
- Plan site layout so that machinery and dust causing activities including stockpiling are located away from receptors, as far as is possible;

- Erect solid screens or barriers around dusty activities or the site boundary which are at least as high as any stockpiles on site;
- Avoid site runoff of water or mud;
- Avoid the use of diesel or petrol-powered generators and use mains electricity or battery powered equipment where practicable;
- Only use cutting, grinding or sawing equipment fitted or in conjunction with suitable dust suppression techniques such as water sprays or local extraction, e.g. suitable local exhaust ventilation systems;
- Ensure an adequate water supply on the site for effective dust/particulate matter suppression/mitigation, using non-potable water where possible and appropriate;
- Use enclosed chutes and conveyors and covered skips;
- Minimise drop heights from conveyors, loading shovels, hoppers and other loading or handling equipment and use fine water sprays on such equipment wherever appropriate; and
- Avoid bonfires and burning of waste materials.

10.8 Monitoring

10.8.1 Monitoring: Construction Phase: Community Sports Complex

A record will be kept of all dust and air quality complaints, cause(s) identified, appropriate measures taken to reduce emissions in a timely manner and any exceptional incidents that cause dust and/or air emissions.

10.8.2 Monitoring: Construction Phase: Mine Development

Dust monitoring will continue to be carried out monthly at the designated monitoring locations on the mine sites, and results will be reported to Monaghan County Council during construction and for relevant jars within the construction area study areas in Figures 10.4 – 10.6, above.

10.8.3 Monitoring: Operational Phase: Community Sports Complex

There is no proposal to formally monitor the Community Sports Complex development.

10.8.4 Monitoring: Operational Phase: Mine Development

Dust monitoring will continue to be carried out monthly at the designated monitoring locations, and results will be reported to the EPA in an annual monitoring report.

An ambient monitoring station will be established on the Knocknacran West Mine site to record fine particulates, as part of the IE Licence.

10.8.5 Monitoring: Closure/Restoration Phase: Community Sports Complex

There is no proposal to close the Community Sports Complex development and this phase is non-applicable.

10.8.6 Monitoring: Closure/Restoration Phase: Mine Development

Dust monitoring will continue to be carried out monthly at the designated EPA licenced monitoring locations, and results will be reported to the EPA in an annual monitoring report, monitoring will be reduced or stopped in line with the IE Licence/EPA (including relevant statutory authority input) consultation during closure.

10.9 Residual Effects

10.9.1 Community Sports Complex

Residual impacts of the proposed Community Sports Complex on air quality are considered to be imperceptible. Air Quality impacts from the operation are expected to be unlikely if the above mitigation measures are implemented during the construction and extraction phases of the development. Residual effects are considered **Not Significant**.

10.9.2 Mine Development

Residual effects of the proposed mining activities on air quality are considered to be slight to imperceptible. Air Quality impacts from the operation are expected to be unlikely if the above mitigation measures are implemented during the construction and extraction phases of the development.

During long spells of dry weather, dust and fine particulate emissions can potentially be elevated. The overall impact from the proposed recommencement of mining, in terms of dust and ambient air emissions, is slight to imperceptible to the air environment. As mitigation measures will be implanted and adhered to at the proposed mine, there will be no detrimental effect from dust on the local environs.

In the longer term, on completion of the mine closure works which will include restoration to agricultural and light industrial/commercial use (depending on agreement with the relevant authorities), the concentration of airborne dust and fine particulates would be expected to return to pre-mining levels, similar to those recorded after the mine previously closed. Residual effects are considered **Not Significant**.

10.10 Cumulative Effects

10.10.1 The Project – Community Sports Complex and Mine Development

Construction Activities

Due to the construction timeline it is likely that a number of the construction activities may occur simultaneously, although will be located in different places. Where there is an overlap in timelines for activities, the durations are anticipated to be short. Based on the proposed Mine life framework, the following activities may occur simultaneously

- Construction of the sports complex simultaneously with both the perimeter landscaping berms (6 month duration), the road diversion (3 month duration) and the demolition of the houses (2 month duration) with incombination effects possible for a maximum period of 2 months; and

- Construction of the sports complex, perimeter berms (6 month duration) and construction of the tunnel (3 month duration) with incombination effects possible for a maximum period of 3 months.

During the periods of simultaneous works, the combined activities likely to generate the greatest impacts on human health are all low impacts which will occur for a maximum of 5 months, although it will only be applicable during simultaneous earthworks activities. The combined activities likely to generate the greatest impacts on dust soiling are medium impacts which will occur for a maximum of 5 months, although it will only be applicable during simultaneous earthworks activities. During the overlap of earthwork activities, there is the potential for up to a medium to large risk of unmitigated dust impacts. To manage this potential in combination impacts, mitigation will be applied, as detailed in Section 1.5 below.

Operational Activities

All of the operational mining activities have been considered in combination through the application of the IAQM guidance methodologies. The Site is due to become operational during the construction process for the Community Sports Complex, commencing in month 12. Due to the receptor locations and prevailing winds and neither of the predicted impacts being greater than Negligible, the combined impacts of the operational Mine Development and the Community Sports Complex construction is deemed to be negligible.

The requirement to continue monitoring at the mine sites is already included as a mitigation measure. There are no relevant ELVs for dust emissions but there are limits which can be applied to the dust monitoring results, as detailed in Section 10.2 Policy and legislation Context. The existing operations have a dust monitoring limit of 350 mg/m2/day using the Bergerhoff Method, this is proposed to continue for the proposed mine development. In addition, an ambient monitoring station will be established on the Knocknacran West mine site for the operational life.

Construction of the Community Sports Complex is due to occur at the same time as the majority of the mine construction activities, however given that the residual effects for both the mining and non-mining construction related activities have been determined as **Not Significant**, it is not anticipated that any significant combined effects will arise where an overlap in activities occurs as per the mining schedule.

10.10.2 The Project and other offsite projects (existing/reasonably foreseeable future)

The nearest extractive industry site to the Proposed Development which may have the potential to cumulatively effect the local air quality and climate include the underground Drummond Mine adjacent to the southern boundary of the existing Knocknacran Site. However, gypsum is transported by covered conveyor from the underground workings to the homogeniser on the Site, therefore greatly minimising the dust potential from the site. There are no further extractive industries within 1 km of the site boundary.

There are four extractive industry sites located within 5 km of the Proposed Development. These are; (i) Cormey Clay Pit, Breedon Brick Ltd's open-cast clay quarry, located ca. 1.5 km south of the Site. (ii) an associated site located ca. 4 km south of the Site, (iii) Limestone Industries Ltd limestone quarry, located ca. 2 km west of the Site, and (iv) Roadstone Barley Hill open-cast quarry located ca. 4 km southeast of the Site. Given the nature (open pit) and size of the activities at the Proposed Development, it is not anticipated that any noticeable cumulative effects will arise relating to air quality and the climatic environment that could be attributed to the interaction of several extractive industries in close proximity to each other.

Losset ADN Materials Ltd. have a planning application under consideration (Reg. Ref. 22/254) and are located ca. 1 km to the north of the Project site. Based on a review of the current planning file data (to date 10th February 2023), this development is not seeking to materially change their development or air quality impacts.

Other existing developments in the area include a mushroom farm, chicken farm, school and industrial/commercial facilities (e.g. car dealership). There will be no cumulative effect between the Project and these developments.

The cumulative effects are deemed **Not Significant** between the Project and other offsite Projects.

10.11 'Do-Nothing' Scenario

Without the further development of mining and further development of the Community Sports Complex at the Application Site, it is assumed that the baseline conditions would remain, as per the monitoring presented in Section 10.4.

10.12 Difficulties Encountered

The following difficulties were encountered during the assessment:

- Due to COVID 19, some primary monitoring was impacted by lockdowns. Collection of diffusion tubes by qualified persons could not be facilitated on site due to travel restrictions, validation sampling was then carried out post-COVID 19.

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APPENDIX 10.1

CONSTRUCTION DUST ASSESSMENT

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FIGURES

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SLR

CONSTRUCTION DUST ASSESSMENT

10.0 INTRODUCTION

10.1 Background

This appendix supports the Air Quality chapter of the EIAR and considers the potential impacts of the Proposed Development for the construction activities relating to the proposed Knocknacran West Mine and Community Sports Complex on the receiving environment (in particular dust and ambient air) in the vicinity of the Site.

The Proposed Development is for the recommencement of mining of gypsum in the former Drumgoosat Underground Mine by open-cast mining methods. The Proposed Development also includes the construction of a temporary diversion road (estimated six to nine month usage) to the north of the existing main R179 road, a Cut-and-Cover Tunnel under the main R179 road to connect the existing Knocknacran Mine Site and the proposed Knocknacran West Site, the construction of a new vehicular access point along the L4816 due to sightline issues, and the restoration of the existing Knocknacran Mine to original ground level. Further to this, the Proposed Development seeks the continued use of the existing Knocknacran Processing Plant (including water management facilities, and associated infrastructure, i.e. the water discharge pipeline and discharge point), and the further development of the Community Sports Complexon lands adjacent to the Knocknacran Mine.

10.2 Report Context

This report forms an Appendix to the Air Quality Assessment (EIAR Chapter 10.0) dated March 2023 and should be read in conjunction with that report.

The report sets out a qualitative assessment of construction dust impacts (coarse particles for deposited dust and fine particles for human health) and has been undertaken in line with IAQM 'Guidance on the assessment of dust from demolition and construction (IAQM 2014).

A separate qualitative assessment of dust impacts (coarse particles for deposited dust and fine particles for human health) from the operation of the Site, has been undertaken in line with IAQM 'Guidance on the assessment of Mineral Dust Impacts for Planning (IAQM 2016) and is provided in Appendix 9.1 to the Air Quality Assessment (EIAR Chapter 9.0).

10.3 Assessment Methodology

IAQM Demolition and Construction Dust Guidance

For the purpose of this assessment, dust is defined as solid particles that are suspended in air or have settled out onto a surface after having been suspended in air. In line with the IAQM 2014 guidance on the Assessment of Dust from Demolition and Construction (IAQM, 2014), the main air quality impacts potentially arising during construction are considered to be:

- Dust deposition, resulting in the soiling of surfaces;

- Visible dust plumes, which are evidence of dust emissions;
- Elevated PM_{10} concentrations, as a result of dust generating activities on the Site; and
- An increase in concentrations of airborne particles and nitrogen dioxide (NO_2) due to exhaust emissions from diesel powered vehicles and equipment used on site and vehicles accessing the Site.

Dust Soiling Effects

People and Property – Loss of Amenity

Loss of amenity may be caused by dust deposition resulting in the soiling of surfaces, which in turn causes annoyance and may result in complaints. The level at which soiling becomes an annoyance is highly subjective. Consequently, there are no universally agreed standards for assessing for example the risk of dust soiling. Mean rates of dust deposition, based upon gravimetric analysis, are generally used to indicate any potential impact, with guideline values suggesting a mean average rate of 350 mg/m^2/day is often an adequate criterion to assess dust deposition.

Damage to Sensitive Habitats

Dust soiling can also affect sensitive habitats. Direct impacts may occur on vegetation or aquatic ecosystems. For example, dust coating plant foliage during long dry periods may adversely affect photosynthesis and other biological functions. Indirect impacts may also occur on fauna (e.g. deterioration of foraging habitats).

Visible Dust Plumes

Visible dust plumes are evidence of dust emissions and have been known to be cited as causing loss of amenity. Plumes are often related to people making complaints, but not necessarily sufficient to be a legal nuisance.

Human Health Effects – Elevated PM_{10} Concentrations

While dust deposition will arise from the deposition of dust in all size fractions, the ambient dust relevant to human health outcomes will be that measured as PM_{10} and $PM_{2.5}$. PM_{10} concentrations in the vicinity of the development site may become elevated as a result of dust generating activities, including exhaust emissions from non-road mobile machinery and vehicles accessing the Site.

Exhaust Emissions

The IAQM 2014 guidance notes that “experience of assessing the exhaust emissions from on-site plant and site traffic suggests that they are unlikely to make a significant impact on local air quality, and in the vast majority of cases will not need to be quantitatively assessed.” Reference is made to a threshold of >200 heavy duty vehicles (HDVs) per day over a period of a year or more as being indicative of the need for quantitative assessment of construction vehicle emissions.

Methodology

Due to the separate locations and timelines for each of the construction areas, the magnitude has been defined separately for each. Activities on construction sites are classified into four types to reflect their different potential effects:

- Demolition;
- Earthworks;
- Construction; and
- Track-out.

The following steps, as defined in the IAQM 2014 guidance, were followed when assessing potential impacts:

- Step 1 – Screen the requirement for detailed assessment – Applicable human and ecological receptors were identified and the distance to the Proposed Development and relevant construction routes determined;
- Step 2 – Assess the risk of dust effects – The potential risk of dust impact occurring for each activity was determined, based on the magnitude of the potential dust emissions and the sensitivity of the receptors;
- Step 3 – Identify the need for site-specific mitigation. Based on the risk of impact occurring, site-specific mitigation measures were determined; and
- Step 4 – Define (residual) impacts and their significance. The significance of the potential residual dust effects (taking mitigation into account) for each activity was determined.

10.4 Assessment of Effects

10.4.1 Step 1: Screening

The IAQM 2014 guidance screening criteria have been applied to determine whether detailed assessment is required. A detailed assessment is deemed necessary if there is:

- A human receptor within 350 m of the boundary of the site or 50 m of the route(s) used by construction vehicles on the public highway, up to 500 m from the site entrance(s); or
- An ecological receptor within 50 m of the boundary of the site or 50 m of the route(s) used by construction vehicles on the public highway up to 500 m form the site entrance(s).

Some construction areas have no public road use associated with the works, therefore the 500 m along the public highway from the Site entrance has been excluded from these works.

A review of publicly available information indicates that there are no statutory (international or national) ecological receptors within 50 m of any of the construction areas or applicable construction routes. It can therefore be concluded, as there are no statutory receptors within the distance defined by the above criteria, that the level of risk to ecological sites is negligible, and any impacts will be not significant. Therefore, assessment of potential impacts on ecological receptors has been scoped out and is not considered further in this assessment. As such, a detailed assessment of potential impacts on ecological receptors is not required

10.4.1.1 Construction Area Screening

Community Sports Complex

The Community Sports Complex study area and identified receptors are included below in *Figure 1*. The construction area will be accessed via the existing road R179 and the temporary diversion once constructed. Both of these are included in the study area.

There are 12 residential and 2 non-residential receptors located within 350 m of the Site and construction route. As phase 1 of the sports complex will be constructed prior to the Proposed Development, the users of the complex will need to be considered as a further non-residential receptor. Residential receptors are mainly located to the west of the Site boundary. The nearest residential receptor to the Site is a property located adjacent to the western edge of the Sports Complex boundary. The closest non-residential receptor is a small shop located immediately adjacent to the west of the Sports Complex boundary. There is 1 additional residential receptor which has not yet been built but has planning permission, located to the south of the Site and there is one property located to the east which is owned by the operator.

Cut and Cover Tunnel and Road Diversion

The tunnel and road diversion study area and identified receptors is included below in Figure 2. The construction areas will be accessed from within the Site boundary and there will be no vehicles movements on the public road network, therefore this has not been included in the study area.

There are 4 residential and 1 non-residential receptors located within 350 m of the Site. As phase 1 of the sports complex will be constructed prior to the Proposed Development, the users of the complex will need to be considered as a further non-residential receptor. Residential receptors are mainly located to the west of the Site boundary, largely made up of farms and isolated dwellings. The nearest residential receptor to the Site is a property located adjacent to the eastern edge of the Site boundary. The closest non- residential receptor is a small shop located west of the tunnel and diversion. There is one additional residential receptor which has not yet been built but has planning permission, located to the east of the tunnel and diversion route.

Main Entrance

The main entrance study area and identified receptors is included below in Figure 3. The construction area will be accessed via the existing road which is included in the study area.

There are 4 residential receptors and 1 potential residential receptor (planning permission granted, house not built yet) located within 350 m of the Site and construction route. Residential receptors are mainly located to the west of the Site boundary, largely made up of farms and isolated dwellings. The nearest residential receptor to the Site is a property located adjacent to the western edge of the Site boundary. The closest non- residential receptor is a small shop located north of the entrance. There is one additional residential receptor which has not yet been built but has planning permission, located adjacent to the public highway.

Screening Berms and House Demolitions

The mine development area where the houses to be demolished and the berms will be located are included in Figure 4 below with the identified receptors.

There are 50 receptors located within 350 m of the Site. Receptors are mainly located to the north, southeast and southwest of the Site boundary. The nearest residential receptor to the Site is a property located adjacent to the northern boundary. The closest non-residential receptors are the community sports complex and a small shop located immediately adjacent to the west of the Sports Complex boundary. There is 1 additional residential receptor which has not yet been built but has planning permission, located to the south of the Site and there is one property located to the southeast which is owned by the operator.

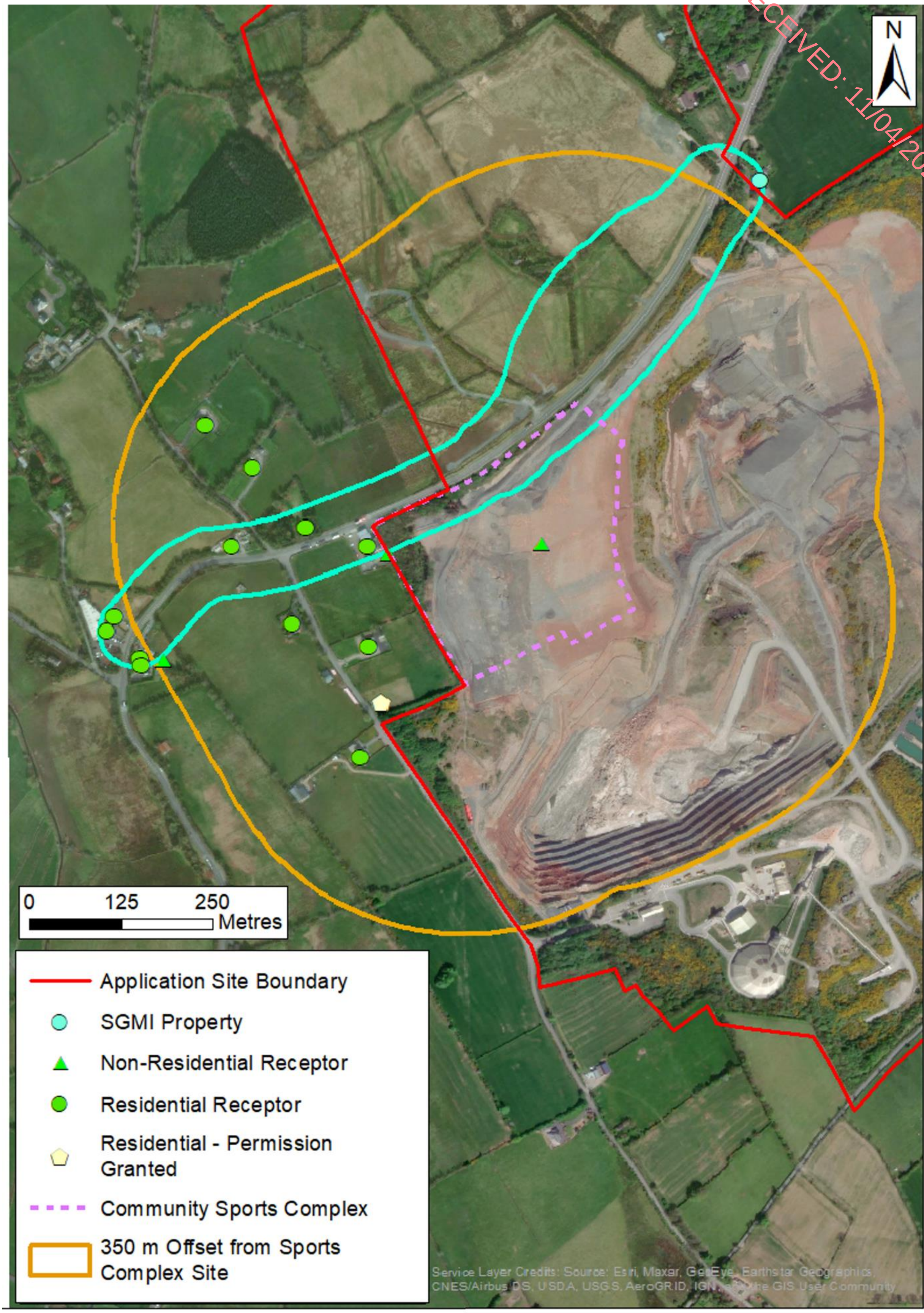

Figure 1: Community Sports Complex Construction Dust Assessment Study Area and Identified Receptors

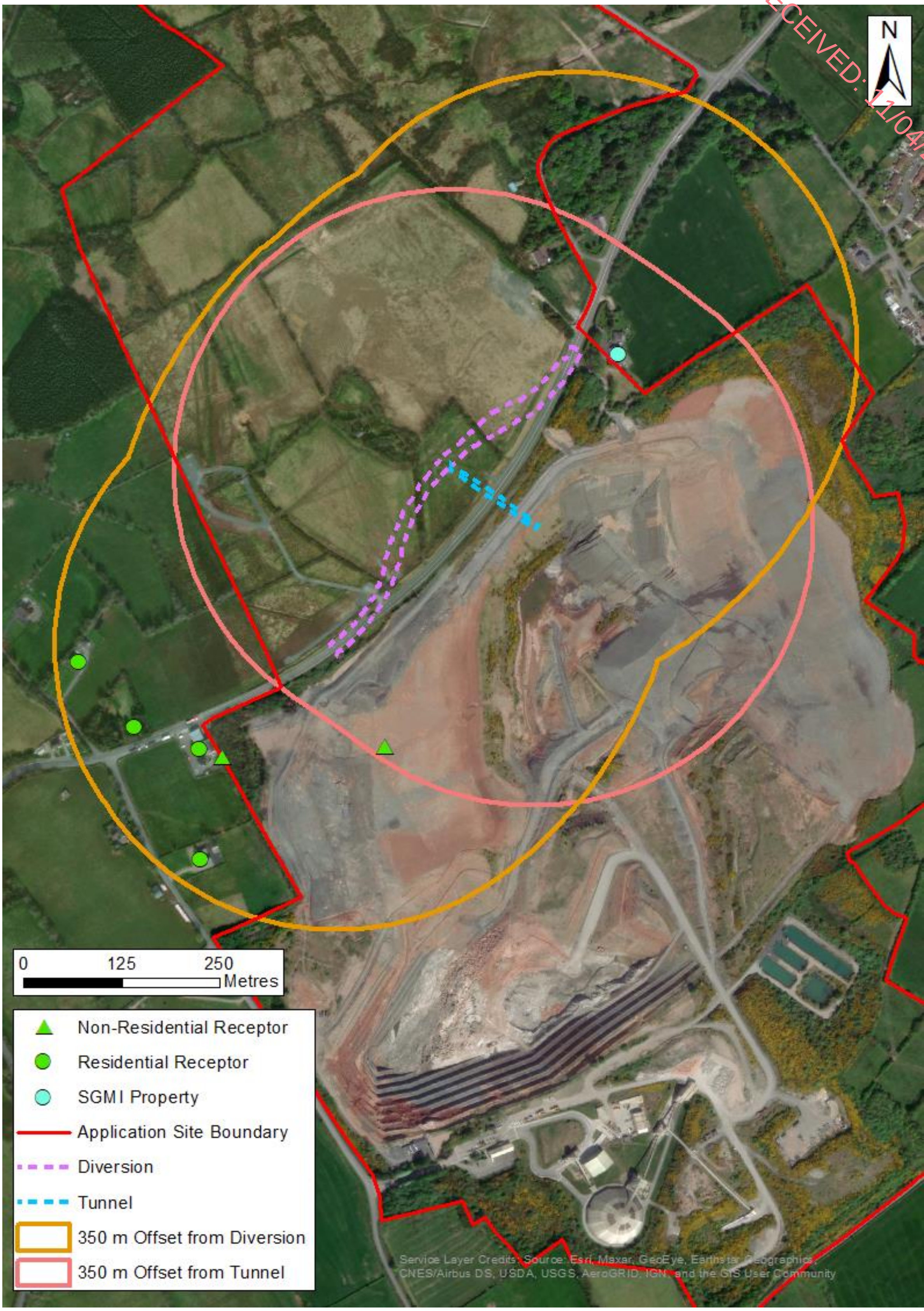

Figure 2: Cut-And-Cover Tunnel and Road Diversion Construction Dust Assessment Study Area and Identified Receptors

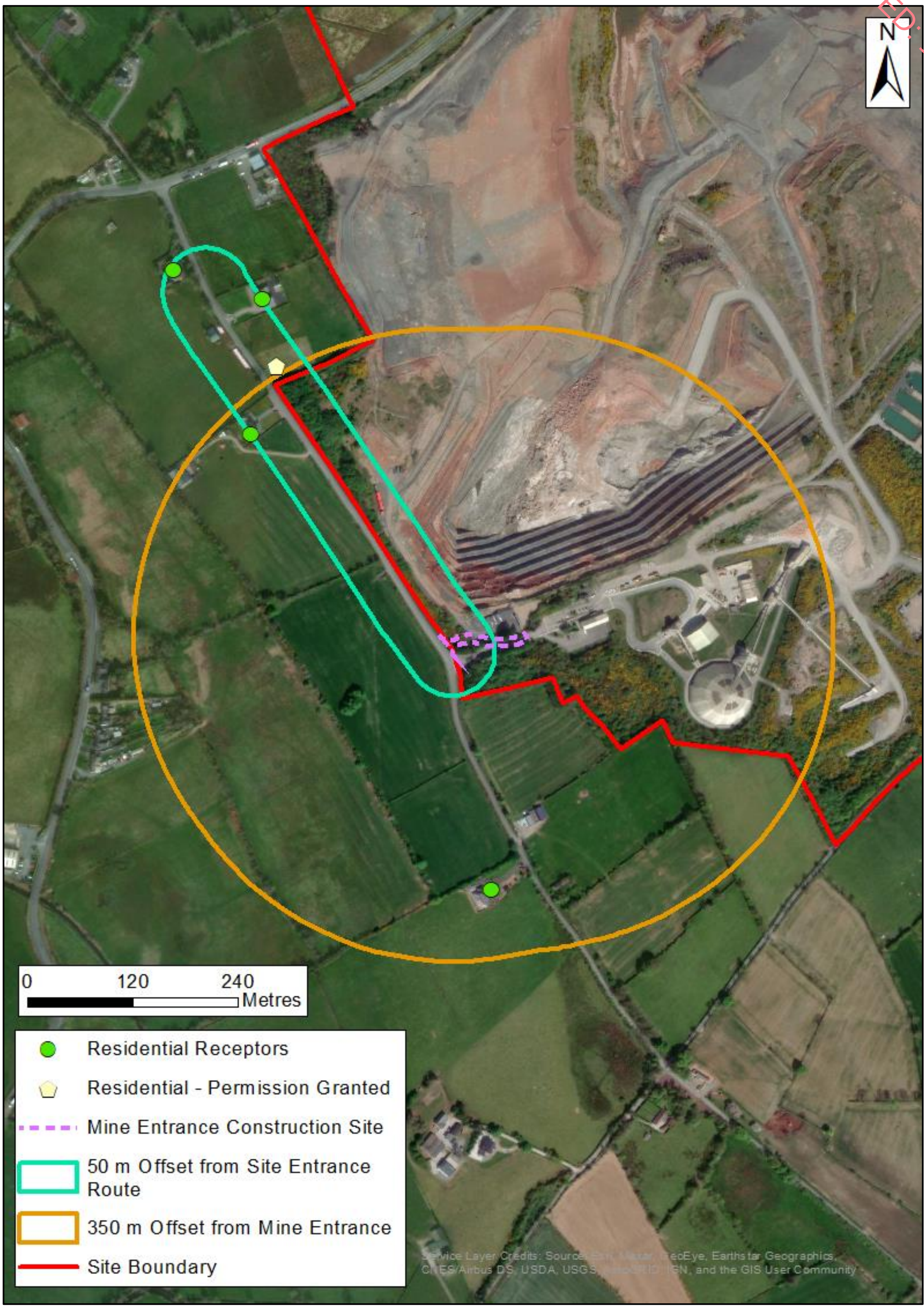

Figure 3: Mine Entrance Construction Dust Assessment Study Area and Identified Receptors

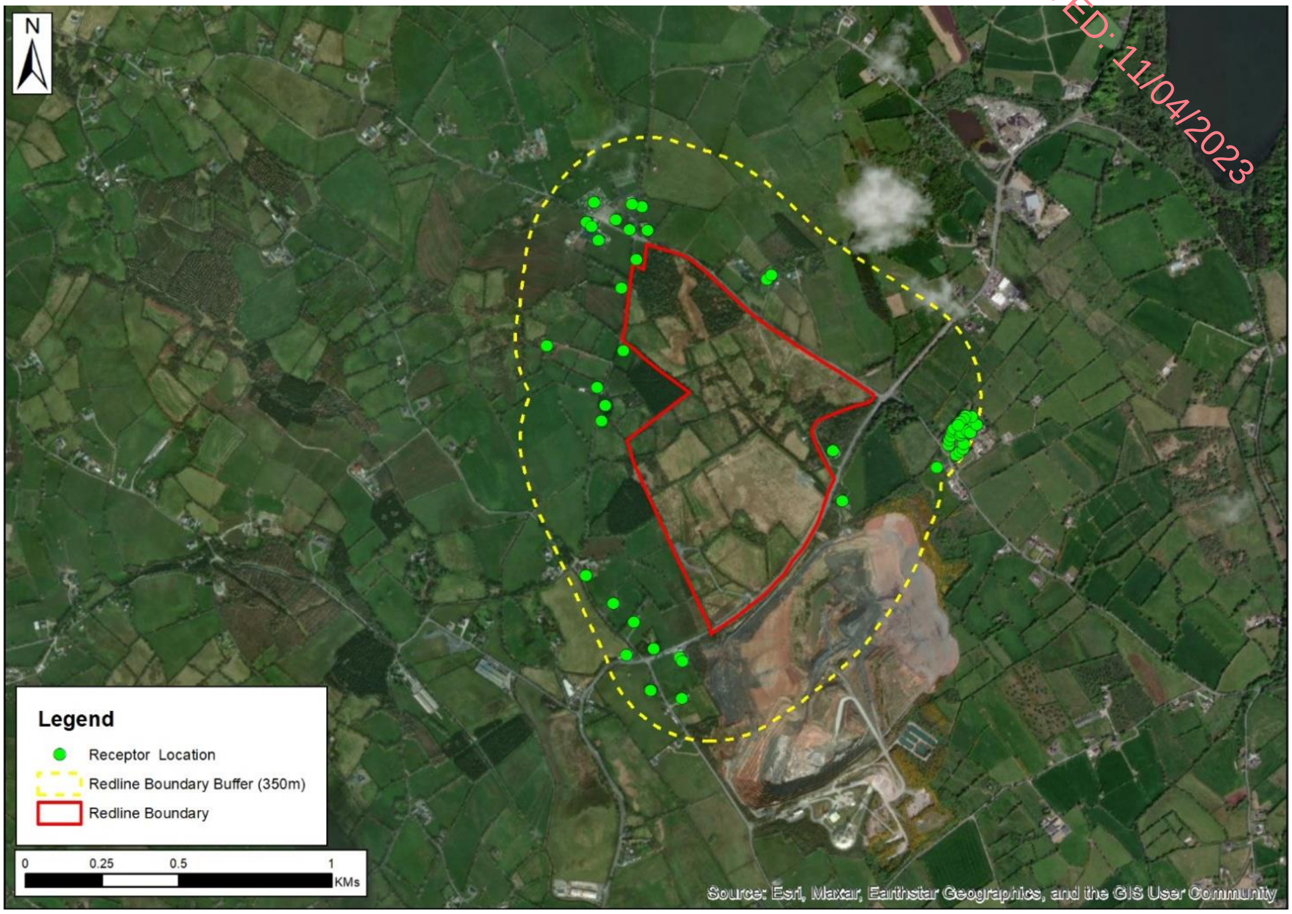

Figure 4: Receptors within 350 m of the screening berms and house demolitions

10.4.1.2 Traffic Screening

The number of construction vehicles have not yet been defined but due to the size of the development it is not anticipated that the maximum number of HGVs (> 3.5 tonnes) movements per day during the construction period for all construction areas combined, are likely to be above the threshold for a quantitative construction phase assessment of vehicle emissions (100 movements per day or more over a year) referred to in the IAQM 2014 guidance. Therefore, a quantitative assessment of construction vehicle emissions has not been undertaken and the emissions are considered not significant.

10.4.2 Step 2: Assess the Risk of Dust Impacts

In accordance with the IAQM 2014 guidance, the risk of dust arising in sufficient quantities to cause annoyance or health impacts has been determined using four risk categories: negligible, low, medium and high risk. The risk category allocation is undertaken independently for the four types of dust releasing activities: demolition , earthworks, construction and track-out.

A site is allocated a risk category based on two factors:

- The scale and nature of the works, which determines the potential dust emission magnitude as small, medium or large (Step 2A); and
- The sensitivity of the area of dust impacts, which is defined as low, medium or high (Step 2B).

These two factors are then combined in Step 2C to determine the risk of dust impact with no mitigation required.

10.4.2.1 2A: Defining Potential Dust Emission Magnitude

The potential dust emission magnitude is based on the scale of the anticipated works and associated activities and classified as small, medium or large, as defined in the IAQM 2014 guidance. There are no demolition activities associated with the construction phase of the Proposed Development. The demolition of two vacant houses and one unoccupied farmhouse as part of the mine expansion has been considered as part of the mineral dust assessment in Appendix 9.1. Therefore, demolition is not considered as part of the construction dust assessment. The dust emissions magnitude for each of the construction areas is defined below.

Community Sports Complex

Demolition

No demolition activities are associated with the community sports complex. This is therefore screened out of the assessment.

Earthworks

The earthworks activities expected at the Site in conjunction with construction have been classified as medium based on the following:

- The total development gross external area is anticipated to be greater than 10,000 m^2;
- There will likely be between 5 and 10 heavy earth moving vehicles active at any one time during the soil stripping phase; and
- The total amount of material to be moved will be greater than 20,000 tonnes.

Construction

The construction activities expected at the Site have been classified as small based on the following:

- The total building volume being constructed is likely to be less than 25,000 m^3;
- Construction materials may include potentially dusty materials, such as concrete and brickwork, as well as steel, metal cladding and glazing; and
- There will be no on-Site concrete batching.

Track-out

The track-out activities expected at the Site have been classified as medium based on the following:

- The number of outward movements associated with the construction phase are not yet known but due to the size of the development it would be anticipated to average between 10 and 50 HDV movements per day; and
- The maximum length of unpaved roads on Site will likely be greater than 100 m.

Road Diversion

Demolition

No demolition activities are associated with the road diversion. This is therefore screened out of the assessment.

Earthworks

The earthworks activities expected at the Site in conjunction with construction have been classified as medium based on the following:

- The total development gross external area is anticipated to be less than 10,000 m^2;
- There will likely be between 5 and 10 heavy earth moving vehicles active at any one time; and
- The total amount of material to be moved will be greater than 20,000 tonnes.

Construction

The construction activities expected at the Site have been classified as small based on the following:

- There is no build volume, only road construction; and
- There will be no on-Site concrete batching.

Track-out

- Not applicable as there will be no outward HDV movements onto the public highway

Cut and Cover Tunnel

Demolition

No demolition activities are associated with the cut and cover tunnel. This is therefore screened out of the assessment.

Earthworks

The earthworks activities expected at the Site in conjunction with construction have been classified as medium based on the following:

- The total development gross external area is anticipated to be greater than 2,500 m^2;

- There will likely be less than 5 heavy earth moving vehicles active at any one time during the soil stripping phase; and
- The total amount of material to be moved will likely be greater than 20,000 tonnes.

Construction

The construction activities expected at the Site have been classified as small based on the following:

- The total building volume being constructed is likely to be less than 25,000 m^3;
- Construction materials may include some potentially dusty materials;
- There will be no on-Site concrete batching.

Track-out

Not applicable as there will be no outward HDV movements onto the public highway

Site Entrance

Demolition

No demolition activities are assoiated with the site entrance. This is therefore screened out of the assessment.

Earthworks

The earthworks activities expected at the Site in conjunction with construction have been classified as small based on the following:

- The works will be of a very short duration;
- The total development gross external area is anticipated to be less than 2,500 m^2;
- There will likely be less than 5 heavy earth moving vehicles active at any one time during the soil stripping phase; and
- The total amount of material to be moved will likely be less than 20,000 tonnes.

Construction

The construction activities expected at the Site have been classified as small based on the following:

- There is no build volume, only road construction; and
- There will be no on-Site concrete batching.

Track-out

The track-out activities expected at the Site have been classified as small based on the following:

- The number of outward movements associated with the construction phase are not yet known but due to the size of the development it would be anticipated to be less than 10 HDV movements per day; and
- The maximum length of unpaved roads on Site will likely be less than 50 m.

Screening Berms and House Demolitions

Demolition

The activities associated with the demolition of four houses at the Proposed Development in conjunction with construction of the mine development have been classified as small based on the following:

- The total building volume to be demolished is less than 20,000 m^3;
- Demolition activities will occur at a maximum height of <10 m above ground level.

Earthworks

Activities relating to the construction of earth berms on the mine development are classified as medium, based on the following:

- The screening berms will be approximately 2 to 4 m high; and
- Less than 10 heavy plant will be operational at any one time

Construction

No specific construction activities are associated with the mine development during the construction phase. This is therefore screened out of the assessment. The operation of the mine development and associated activities is assessed as part for the mineral dust assessment in Appendix 10.2.

Trackout

No trackout activities are associated with the mine development during the construction phase. This is therefore screened out of the assessment. The operation of the mine development and associated activities is assessed as part for the mineral dust assessment in Appendix 10.2.

A summary of the anticipated dust emission magnitude for each activity is provided in Table 1.

Table 1: Dust Emission Magnitude

Activity	Dust Emissions Magnitude
Community Sports Complex	
Demolition	Not applicable
Earthworks	Medium
Construction	Small
Track-out	Medium

Road Diversion	
Demolition	Not applicable
Earthworks	Medium
Construction	Small
Track-out	N/A
Cut and Cover Tunnel	
Demolition	Not applicable
Earthworks	Medium
Construction	Small
Track-out	N/A
Site Entrance	
Demolition	Not applicable
Earthworks	Small
Construction	Small
Track-out	Small
Screening Berms and House Demolitions[1]	
Demolition	Small
Earthworks	Medium
Construction	N/A
Track-out	N/A

1. See Appendix 10.2 – Air Quality Mineral Dust Assessment

10.4.2.2 2B: Defining the Sensitivity of the Area

The following were taken into consideration when determining the sensitivity of the area to dust soiling and the human health impacts of fine particulates.

- The Site is located close to residential receptors, which are considered to have a high sensitivity to dust soiling effects;
- The number of residential and non-residential receptors present in the study areas, as defined in Section 1.4.1
- PM_{10} and $PM_{2.5}$ monitoring is undertaken by the EPA[1] at stations from equivalent Zone D areas. The annual average concentrations of the historic Zone D stations for PM_{10} is 11.5 µg/m^3, and for $PM_{2.5}$ is 8.3 µg/m^3 as detailed in Table 10.17 of the main Air Quality EIAR chapter. The 2021 background data monitored at the Site, detailed in Table 10.14 of the main Air Quality EIAR Chapter (Chapter 10), gives a monthly average monitored PM_{10} concentration of 7.8 µg/m^3, and a $PM_{2.5}$ concentration of 3.7 µg/m^3; and
- There are some significant natural shelters (trees and hedgerows) found in the study area, the majority of which will be retained.

[1] http://erc.epa.ie/safer/iso19115/display?isoID=69#files

The sensitivity of the area has been assessed independently for potential dust soiling effects on people and property and the potential human health impacts from elevated fine particulate concentrations.

Dust Soiling Effects on People and Property

The specific sensitivity of receptors in the area can be classified as high, medium and low. Examples for high sensitivity receptors with regard to dust soiling effects include residential dwellings, museums and other culturally important collections, as well as medium and long-term car parks. Medium sensitivity receptors include parks and places of work. Indicative examples for low sensitivity receptors include playing fields, farmland, footpaths, short-term car parks and roads. The sensitivity of the area to dust soiling effects has been derived based on receptor sensitivity, number of receptors and distance from the Site, as shown in Table 2.

Table 2: Sensitivity of the Area to Dust Soiling Effects on People and Property

Receptor Sensitivity	Number of Receptors	Distance from the Source (m)			
		<20	**<50**	**<100**	**<350**
High	>100	High	High	Medium	Low
	10-100	High	Medium	Low	Low
	1-10	Medium	Low	Low	Low
Medium	>1	Medium	Low	Low	Low
Low	>1	Low	Low	Low	Low

Based on the above assessment criteria and using the number of receptors identified, the sensitivity of the area to dust soiling effects on people and property has been determined as detailed in Table 3.

Table 3: Derived sensitivity to dust soiling effects for each construction area

Construction Area	Demolition	Sensitivity - Earthworks	Sensitivity - Construction	Sensitivity - Trackout
Sports Complex	N/A	Medium	Medium	Medium
Road Diversion	N/A	Low	Low	N/A
Tunnel	N/A	Low	Low	N/A
Site Entrance	N/A	Low	Low	Low
Mine Development	Medium	Medium	N/A	N/A

Human Health Impacts

The specific sensitivity of receptors in the area can been classified as high, medium and low. Examples for high sensitivity receptors, with regard to human health impacts, include residential properties. Medium sensitivity receptors include office and shop workers. Indicative examples for low sensitivity receptors include public footpaths, playing fields, parks and shopping streets. The sensitivity of the area to human health impacts has been derived based on receptor sensitivity, number of receptors, annual mean PM_{10} concentration and distance from the Site, as shown in Table 4.

Table 4: Sensitivity of the Area to Human Health Impacts

Receptor Sensitivity	Annual Mean PM10 Concentration	Number of Receptors	Distance from the Source (m)				
			<20	<50	<100	<200	<350
High	>32 µg/m³	>100	High	High	High	Medium	Low
		10-100	High	High	Medium	Low	Low
		1-10	High	Medium	Low	Low	Low
	28-32 µg/m³	>100	High	High	Medium	Low	Low
		10-100	High	Medium	Low	Low	Low
		1-10	High	Medium	Low	Low	Low
	24-28 µg/m³	>100	High	Medium	Low	Low	Low
		10-100	High	Medium	Low	Low	Low
		1-10	Medium	Low	Low	Low	Low
	<24 µg/m³	>100	Medium	Low	Low	Low	Low
		10-100	Low	Low	Low	Low	Low
		1-10	Low	Low	Low	Low	Low
Medium	<24 µg/m³	>10	Low	Low	Low	Low	Low
		1-10	Low	Low	Low	Low	Low
Low	-	>1	Low	Low	Low	Low	Low

Publicly available EPA background data[2] has been reviewed from equivalent zone D areas (this is used rather than the average of the on-Site monitoring data to provide a more conservative assessment). The data gives an average annual PM_{10} concentration of 11.5 µg/m³. The sensitivity of the study area to human health impacts has therefore been determined as low for demolition, earthworks, construction and track-out activities associated with each of the construction areas at the Site.

2C: Defining the Risk of Impacts

To define the risk of impacts from either dust soiling effects and human health impacts, the dust emission magnitude has been combined with the sensitivity of the area to determine the potential risk of dust impacts with no mitigation applied. **Error! Reference source not found.**

Table 5: Risk of Dust Impacts Matrix - Track-out

Sensitivity of Area	Dust Emission Magnitude		
	Large	**Medium**	**Small**
High	High Risk	Medium Risk	Low Risk
Medium	Medium Risk	Low Risk	Negligible
Low	low Risk	Low Risk	Negligible

Taking into consideration the conclusions from steps 2A and 2B, the risk of unmitigated dust impacts for each activity are provided in Table 6.

[2] http://erc.epa.ie/safer/iso19115/display?isoID=69#files

Table 6: Risk of Unmitigated Dust Impacts

	Risk			
	Demolition	Earthworks	Construction	Track-out
Sports Complex				
Dust Soiling	N/A	Medium	Low	Low
Human Health	N/A	Low	Negligible	Low
Road Diversion				
Dust Soiling	N/A	Low	Negligible	N/A
Human Health	N/A	Low	Negligible	N/A
Tunnel				
Dust Soiling	N/A	Low	Negligible	N/A
Human Health	N/A	Low	Negligible	N/A
Site Entrance				
Dust Soiling	N/A	Negligible	Negligible	Negligible
Human Health	N/A	Negligible	Negligible	Negligible
Screening Berms and House Demolitions				
Dust Soiling	Low	Medium	N/A	N/A
Human Health	Negligible	Low	N/A	N/A

10.4.2.3 In Combination Effects

Due to the construction timeline it is likely that a number of the construction activities may occur simultaneously, although will be located in different places. Where there is an overlap in timelines for activities, the durations are anticipated to be short. Based on the proposed Mine life framework, the following activities may occur simultaneously

- Construction of the sports complex simultaneously with both the perimeter landscaping berms (6 month duration), the road diversion (3 month duration) and the demolition of the houses (2 month duration) with incombination effects possible for a maximum period of 2 months.

- Construction of the sports complex, perimeter berms (6 month duration) and construction of the tunnel (3 month duration) with incombination effects possible for a maximum period of 3 months.

During the periods of simultaneous works, the combined activities likely to generate the greatest impacts on human health are all low impacts which will occur for a maximum of 5 months, although it will only be applicable during simultaneous earthworks activities. The combined activities likely to generate the greatest impacts on dust soiling are medium impacts which will occur for a maximum of 5 months, although it will only be applicable during simultaneous earthworks activities. During the overlap of earthwork activities, there is the potential for up to a medium to large risk of unmitigated dust impacts. To manage this potential in combination impacts, mitigation will be applied, as detailed in Section 1.5 below.

10.5 Mitigation

The dust risk categories prescribed to each of the assessed construction activities have been used to define an appropriate, site-specific mitigation scheme, as detailed in Table 7. No mitigation is proposed for the Site entrance works as the predicted risk of impacts is Negligible.

Table 7: Required Site-Specific Mitigation Measures to be included in the CEMP

Activity	Mitigation Measure	Applicable Construction Area
Communication	Display the name and contact details of person(s) accountable for air quality and dust issues on the Site boundary.	Sports Complex and Mine Development
	Display the head or regional office contact information.	Sports Complex, Road Diversion, Tunnel and Mine Development
Site Management	Record all dust and air quality complaints, identify cause(s), take appropriate measures to reduce emissions in a timely manner and record the measures taken.	Sports Complex, Road Diversion, Tunnel and Mine Development
	Make the complaints log available to the local authority when asked.	Sports Complex, Road Diversion, Tunnel and Mine Development
	Record any exceptional incidents that cause dust and/or air emissions, either on-or off-site, and the action taken to resolve the situation in the log book.	Sports Complex, Road Diversion, Tunnel and Mine Development
Monitoring	Carry out regular site inspections, record inspection results, and make an inspection log available to the local authority if requested.	Sports Complex, Road Diversion, Tunnel and Mine Development
	Plan site layout so that machinery and dust causing activities including stockpiling are located away from receptors, as far as is possible.	Sports Complex, Road Diversion, Tunnel and Mine Development

	Erect solid screens or barriers around dusty activities or the site boundary which are at least as high as any stockpiles on site.	Sports Complex, Road Diversion, Tunnel and Mine Development
Preparing and Maintaining the Site	Avoid site runoff of water or mud.	Sports Complex, Road Diversion, Tunnel and Mine Development
	Ensure all vehicles switch off engines when stationary – no idling vehicles.	Sports Complex, Road Diversion, Tunnel and Mine Development
	Avoid the use of diesel or petrol-powered generators and use mains electricity or battery powered equipment where practicable.	Sports Complex, Road Diversion, Tunnel and Mine Development
Operating vehicle/machinery and sustainable travel	Only use cutting, grinding or sawing equipment fitted or in conjunction with suitable dust suppression techniques such as water sprays or local extraction, e.g. suitable local exhaust ventilation systems.	Sports Complex, Road Diversion, Tunnel and Mine Development
	Ensure an adequate water supply on the site for effective dust/particulate matter suppression/mitigation, using non-potable water where possible and appropriate.	Sports Complex, Road Diversion, Tunnel and Mine Development
Operations	Use enclosed chutes and conveyors and covered skips.	Sports Complex, Road Diversion, Tunnel and Mine Development

	Minimise drop heights from conveyors, loading shovels, hoppers and other loading or handling equipment and use fine water sprays on such equipment wherever appropriate.	Sports Complex, Road Diversion, Tunnel and Mine Development
	Avoid bonfires and burning of waste materials.	Sports Complex, Road Diversion, Tunnel and Mine Development
Demolition	Soft- strip buildings before demolition (retaining walls and windows in the rest of the building where possible to provide a dust screen)	Mine Development
	Ensure water supression is used during demolition operations. Hand-held sprays are the most effective method as the water can be directed to where it is most needed.	Mine Development
	Avoid blasting with explosives and use appropriate manual or mechanical alternatives	Mine Development
	Bag and remove any biological debris or damp down such material before demolition	Mine Development
Earthworks	Re-vegetate earthworks and exposed areas/ stockpiles to stabilise the surface as soon as possible	Sports Complex and Mine Development
	Use hessian, mulches or trackifiers where it is not possible to revegetate or cover with topsoil	Sports Complex and Mine Development
	Only remove the cover in small areas during work and not all at once	Sports Complex and Mine Development
Construction	Avoid scabbling (roughening of concrete surfaces)	Sports Complex
	Ensure sand and aggregates are stored in bunded areas and not allowed to dry out unless this is required for a particular process.	Sports Complex

Trackout	Use water-assisted dust sweeper(s) on the access and local roads, to remove, as necessary, any material tracked out of the site.	Sports Complex
	Avoid dry sweeping of large areas.	Sports Complex
	Ensure vehicles entering and leaving sites are covered to prevent escape of materials during transport.	Sports Complex
	Record all inspections of haul routes and any subsequent action in a site log book.	Sports Complex

These recommended measures will be included in the Construction Environmental Management Plan (CEMP) and agreed with the local authority Environmental Health Officer prior to construction works commencing.

10.6 Residual Impacts

In relation to residual impacts of construction generated dust, the IAQM 2014 guidance states that "in the case of construction it is assumed that mitigation (secured by planning conditions, legal requirements or required by regulations) will ensure that a potentially significant adverse effect will not occur, so the residual effect will normally be 'not significant'".

Following the application of the site-specific mitigation measures set out in Section 10.5, where required, it is therefore considered that the residual effects associated with the construction phase of the Proposed Development will be **not significant**.

10.7 Cumulative Effects

Due to the construction timeline a number of the Community Sports Complex and Mine Development construction activities will occur simultaneously, although these will be located in different places across the Site. As detailed in Section 10.3.1 (Chapter 10.0), it has been found that deposited dust does not generally travel beyond 400 m (IAQM, Appendix 2, 2016). Therefore, due to the spatial extent of the Site, even when activities are occurring simultaneously, the dust is unlikely to impact a greater distance. As discussed in

Section 1.4.3.4, there is the potential for some incombination effects due to simultaneous construction activities, but this should be minimal and any increase in dust concentrations, will be managed by the mitigation measures focused on the potential sources of dust as detailed in Section 10.7 of Chapter 10.0. Considering this, a conservative consideration of potential impacts of in combination effects has been undertaken.

The nearest extractive industry site to the Proposed Development which may have the potential to cumulatively effect the local air quality and climate include the underground Drummond Mine adjacent to the southern boundary of the existing Knocknacran Site. However, gypsum is transported by covered conveyor from the underground workings to the homogeniser on the Site, therefore greatly minimising the dust potential from the site. There are no further extractive industries within 1 km of the site boundary.

There are four extractive industry sites located within 5 km of the Proposed Development. These are; (i) Cormey Clay Pit, Breedon Brick Ltd's open-cast clay quarry, located ca. 1.5 km south of the Site. (ii) an associated site located ca. 4 km south of the Site, (iii) Limestone Industries Ltd limestone quarry, located ca. 2 km west of the Site, and (iv) Roadstone Barley Hill open-cast quarry located ca. 4 km southeast of the Site. Given the nature (open pit) and size of the activities at the Proposed Development, it is not anticipated that any noticeable cumulative effects will arise relating to air quality and the climatic environment that could be attributed to the interaction of several extractive industries in close proximity to each other.

Losset ADN Materials Ltd. have a planning application under consideration (Reg. Ref. 22/254) and are located ca. 1 km to the north of the Project site. Based on a review of the current planning file data (to date 27th March 2023), this development is not seeking to materially change their development or air quality impacts.

The cumulative effects are deemed **Not Significant** between the Project and other offsite Projects.

CONSTRUCTION DUST ASSESSMENT 10.1

APPENDIX 10.2

MINERAL DUST ASSESSMENT

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SLR

MINERAL DUST ASSESSMENT

10.0 INTRODUCTION

10.1 Background

This appendix supports the Air Quality chapter of the EIAR and considers the potential impacts of the Proposed Development for the continuation of mining of gypsum at the proposed Knocknacran West Mine and associated activities on the receiving environment (in particular dust and ambient air) in the vicinity of the Site.

The Proposed Development is for the recommencement of mining of gypsum in the former Drumgoosat Underground Mine by open-cast mining methods. The Proposed Development also includes the construction of a Cut-and-Cover tunnel under the main R179 road to connect the existing Knocknacran Mine Site and the proposed Knocknacran West Site, the construction of a new vehicular access point along the L4816, and the restoration of the existing Knocknacran Mine to original ground level. Further to this, the Proposed Development seeks the continued use of the existing Knocknacran Processing Plant (including water management facilities, and associated infrastructure, i.e. the water discharge pipeline and discharge point), and the further development of the Community Sports Complex on lands adjacent to the Knocknacran Mine.

10.2 Report Context

This report forms an Appendix to the Air Quality Assessment (EIAR Chapter 9.0) dated March 2023 and should be read in conjunction with that report.

The report sets out a qualitative assessment of dust impacts (coarse particles for deposited dust and fine particles for human health) from the proposed operation of the Site, which has been undertaken in line with IAQM 'Guidance on the assessment of Mineral Dust Impacts for Planning (IAQM 2016).

A separate qualitative assessment of dust impacts (coarse particles for deposited dust and fine particles for human health) from the construction of a Cut-and-Cover Tunnel beneath the R179 and a new vehicular access point along the L4816, the relocation of the Community Sports Complex, and the demolition of existing houses and the construction of berms within the mine development area has been undertaken in line with IAQM 'Guidance on the assessment of dust from demolition and construction (IAQM 2014) and is provided in Appendix 10.1 to the Air Quality Assessment (EIAR Chapter 10.0).

10.3 Assessment Methodology

The following section details the IAQM methodology used for assessing the impacts of deposited dust and fine particulates from the extraction activities. It follows a standard source-pathway-receptor methodology. The residual source emissions are characterised based on the scale of the operations and the Site activities and are classified as either small, medium or large. Guidance on the appropriate scale of the residual source is provided in the IAQM guidance, Appendix 4 (2016). This source characterisation includes consideration of the routine management and mitigation measures which will be undertaken at the Site.

The pathway from the source to the receptor is assessed considering the distance and direction of receptors to the source relative to the prevailing wind and local meteorology. The local meteorological data is also used to assess the frequency of the winds in each direction. It has been found that deposited dust does not generally travel beyond 400 m (IAQM, Appendix 2, 2016), therefore all receptors within 500 m of the Site boundary are conservatively considered. The guidance states that it is commonly accepted that the greatest impacts will occur within 100 m of the source, with the potential for travel up to 400 m.

For full consideration of the effects of the access road, in the absence of any methodology within the IAQM minerals guidance, the IAQM Guidance on the Assessment of Dust from Demolition and Construction (2016) has been considered. This guidance states that human receptors within 50 m of the routes used by vehicles for 350 m from the site exit point should be considered. For this reason, the haul road will be subject to a 50 m buffer, which will then extend 350 m out onto the L4816 road in a southerly direction to account for the possibility of trackout from exiting vehicles. A 350 m length buffer has been applied from the point at which the Site exits onto the L4816 public road. HGVs will only enter and exit the Site using the southerly section of the L4816, therefore, the northbound section has not been included in the assessment.

The criteria for the categorisation of the frequency of potentially dusty winds (Table 1) and the receptor distance from source (Table 2) is used to define the pathway effectiveness (Table 3).

The residual source emissions and the pathway effectiveness are combined to predict the Dust Impact Risk as shown in Table 4.

Table 1: Categorisation of Potentially Dusty Winds

Pathway Effectiveness	Criteria
Infrequent	Frequency of winds (>5 m/s) from the direction of the dust source on dry days are less than 5%
Moderately Frequent	Frequency of winds (>5 m/s) from the direction of the dust source on dry days are between 5% and 12%
Frequent	Frequency of winds (>5 m/s) from the direction of the dust source on dry days are between 12% and 20%
Very Frequent	Frequency of winds (>5 m/s) from the direction of the dust source on dry days are greater than 20%

Table 2: Categorisation of Receptor Distance from Source

Category	Criteria
Distant	Receptor is between 200 m and 400 m from the dust source
Intermediate	Receptor is between 100 m and 200 m from the dust source
Close	Receptor is less than 100 m from the dust source

Table 3: Pathway Effectiveness

		Frequency of Potentially Dusty Winds			
		Infrequent	**Moderately Frequent**	**Frequent**	**Very Frequent**
Receptor Distance Category	**Close**	Ineffective	Moderately Effective	Highly Effective	Highly Effective
	Intermediate	Ineffective	Moderately Effective	Moderately Effective	Highly Effective

	Distant	Ineffective	Ineffective	Moderately Effective	Moderately Effective

Table 4: Estimation of Dust Impact Risk

		Residual Source Emissions		
		Small	**Medium**	**Large**
Pathway Effectiveness	**Highly Effective Pathway**	Low Risk	Medium Risk	High Risk
	Moderately Effective Pathway	Negligible Risk	Low Risk	Medium Risk
	Ineffective Pathway	Negligible Risk	Negligible Risk	Low Risk

The final step is to assess the likely magnitude of the dust effects (Table 5). This is determined using both the dust impact risk and the receptor sensitivity. Receptor sensitivity is classified as either low, medium or high based on the receptor type.

Table 5: Descriptors for Magnitude of Dust Effects

		Receptor Sensitivity		
		Low	**Medium**	**High**
Dust Impact Risk	**High Risk**	Slight Adverse Effect	Moderate Adverse Effect	Substantial Adverse Effect
	Medium Risk	Negligible Effect	Slight Adverse Effect	Moderate Adverse Effect
	Low Risk	Negligible Effect	Negligible Effect	Slight Adverse Effect
	Negligible Risk	Negligible Effect	Negligible Effect	Negligible Effect

10.4 Sources

The mining activities associated with the Proposed Development that are the most likely dust generating sources are listed below:

- Stripping of subsoil, overburden and interburden;
- Excavation of gypsum using methods including blasting, rock-breaking and digging;
- Primary crushing and screening of the rock into specific fragment sizes on the open-cast floor;
- Loading material onto trucks within the open-cast pit, and onto the conveyor for transport to the adjacent existing Knocknacran Site;
- The transportation of materials within the mine site on haul routes;
- Wind erosion at dump areas and exposed faces; and
- The phased restoration of the adjacent existing Knocknacran site and subsequently the Knocknacran West site.

The following residual source classifications can be attributed based on the identified sources and management and assessment methodology outlined above and in Appendix 4 of the IAQM guidance (2016).

Mineral extraction is classified as a **medium** magnitude source due to the annual extraction rate of up to ca. 300,000 t/yr of gypsum within a medium working area (based on the whole extraction area), there will be one hydraulic excavator operational at any one time and material will be subject to natural dust suppression only.

Materials handling is classified as a **small** magnitude source as there will be <10 heavy plant, including 1 loader which will only operate in the mobile crushing area.

On-site transportation is classified as a **small** magnitude source as there will be less than 30 on-site vehicle trips per day which will be less than 850 m in length (i.e. trips to and from the working face and the semi-mobile crusher on the pit floor). Transport of materials for processing to the existing Knocknacran Site will be via the Cut-and-Cover Tunnel and covered conveyor.

Mineral processing is classified as a **small** magnitude source due to up to ca. 300,000 t/yr of material being processed with low moisture content and primary crushing occurring on the pit floor with a semi-mobile crusher. Secondary crushing will occur at the existing Knocknacran Processing Plant.

Stockpiles (of gypsum) and exposed surfaces are classified as a **small** magnitude source due to the annual mine production of up to 300,000 t per annum, and due to the stockpile size and the fact that they will be temporary and located within the pit on the pit floor.

Off-site transportation is classified as a **small** magnitude source as there will be no additional road transportation of unprocessed materials off Site. A tunnel and covered conveyor will be used to transport materials to the Knocknacran Processing Plant at the adjacent existing Knocknacran Mine Site. Once processed, outgoing materials will be transported via covered HGVs, which will exit through the existing wheel wash from the existing Knocknacran Mine Site. There is no proposed increase in the number of outgoing HGV movements compared to the existing operations. The Knocknacran West Site will therefore operate as a Closed Site.

10.5 Assessment

10.5.1 Site Parameters

The risks of potential dust emissions associated with the Site being transported off-site are largely determined by the local atmospheric conditions surrounding the Site and distance from the source to the receptor.

The conditions considered in the assessment include:

- Wind speed, to determine the likely occurrence of particles travelling beyond the site boundary; and
- Wind direction, to identify the areas over which particles are likely to travel.

As detailed in the main Air Quality Chapter 9, the closest Met Éireann station to the Site recording wind data is located at Ballyhaise, Co. Cavan, ca. 40 km west of the Site. Wind speed and wind direction are measured hourly by the station and a wind-rose has been presented in Figure 1 covering the period January 2012 to August 2021.

The prevailing wind direction is from the southwest, with a large portion of low wind speeds between 4 – 7 knots (approximately 2 – 3.6 m/s), and some mid wind speeds between both 7 – 11 knots (approximately 3.6 – 5.6 m/s) and 11 – 17 knots (approximately 5.6 – 7.2 m/s).

The receptors identified in Table 6 and presented in Figure 1, with their associated distance and direction, are located within 500 m of the Site boundary. This is a conservative approach to the assessment as Site activities will not be undertaken directly at the boundary in all directions. The Site boundary includes an underground pipeline located to the southeast which has been included in the assessment for conservatism, although there will be no emissions to air from this. Residential receptors have been categorised as high sensitivity receptors. The remaining non-residential receptors have been categorised as medium sensitivity receptors, except for the Drumgoosat National School which is located within ca. 100 m of the Application Site boundary to the northwest (the proposed gypsum extraction area is located within ca. 230 m of the school and will be screened by maintaining the existing woodland between the school and extraction area (see Chapters 3.0 and 12.0 for details on phasing and landscaping respectively), which has been defined as high sensitivity. The category of receptor distance is defined based on the criteria in Table 2 of the methodology and the frequency of dusty winds is determined based on the criteria in Table 1 of the methodology.

The receptor distance category and the frequency of dusty winds are then combined using Table 3 of the methodology to define the pathway effectiveness.

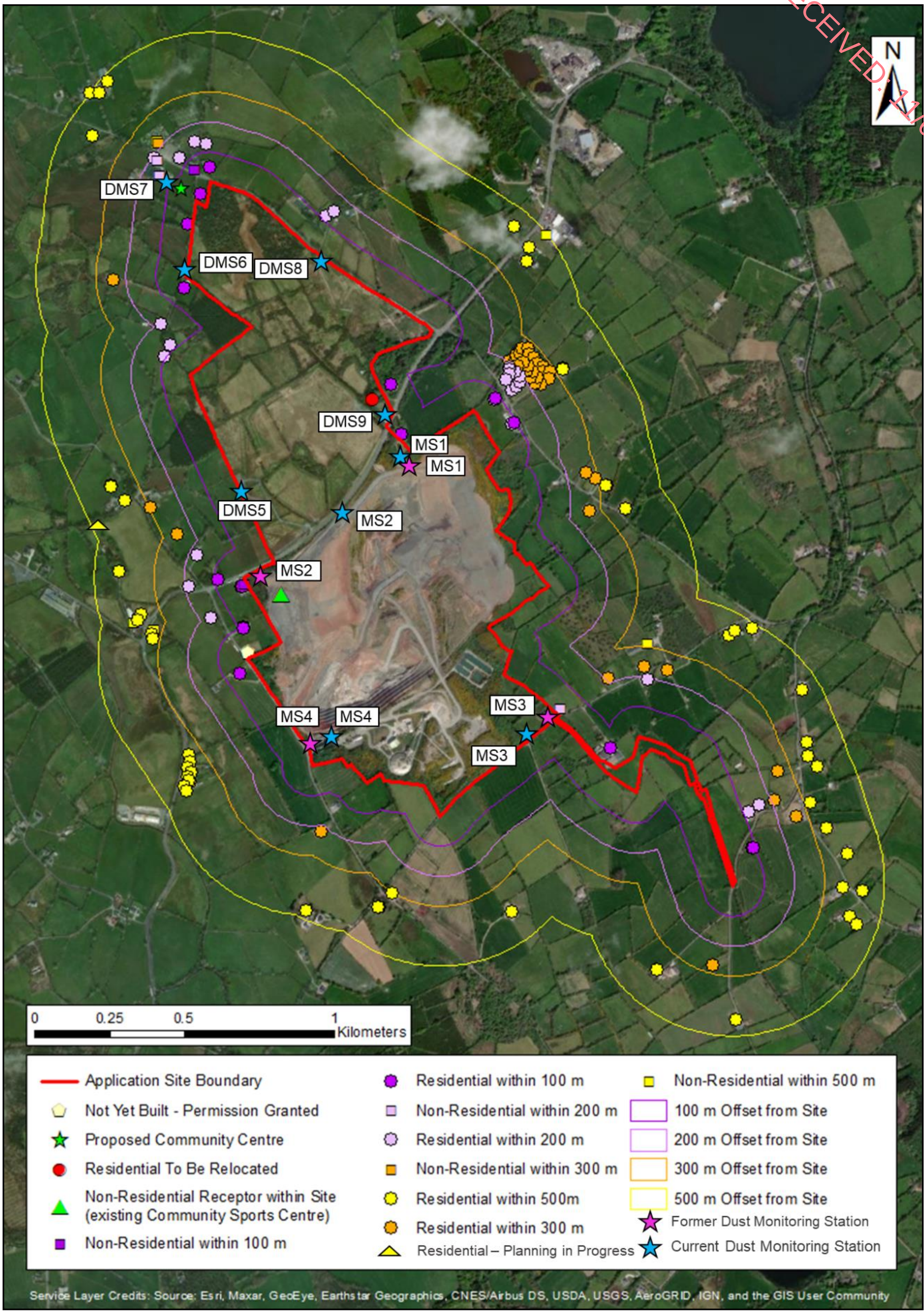

Figure 1: Location of Receptors within 500 m of the mining activities and within 50 m of the Haulage Route (extending 350 m from the point of exit of the Site Boundary)

Table 6: Receptors within 500 m of the Site[a] (Proposed and Current Operational Boundary)

Receptor Type and Distance Band	Number of Receptors in Group	Percentage of Receptors Occupied	Category of Receptor Distance	Number of Receptors in Prevailing Wind Direction (NE of Boundary)	Frequency of Dusty Winds[c]	Pathway Effectiveness[c]
Residential within 100 m	12[b]	93%	Close	4	Infrequent	Ineffective
Residential within 200 m	26		Intermediate	12	Infrequent	Ineffective
Residential within 300 m	33		Distant	27	Infrequent	Ineffective
Residential within 500 m	39		Distant	5	Infrequent	Ineffective
Non-Residential within 100 m	3	100%	Close	1	Infrequent	Ineffective
Non-Residential within 200 m	2		Intermediate	0	Infrequent	Ineffective
Non-Residential within 300 m	2		Distant	1	Infrequent	Ineffective
Non-Residential within 500 m	3		Distant	1	Infrequent	Ineffective

[a] Does not include the single receptor currently located within the Site boundary (as shown on Figure), as resident is to be relocated prior to commencement of works.
[b] Includes 1 receptor for which permission has been granted but is not yet built.
[c] Accounts for those identified receptors in the prevailing wind direction only.

10.5.2 Assessment of Coarse Particles

Assessment of the dis-amenity dust associated with the Proposed Development is summarised for each receptor in Table 7. Following the IAQM guidance, the nature of the activities at the Site and the existing mitigation measures (outlined in Section 10.6) suggest that the magnitude of any deposited dust effects at the identified receptors will be ‘**negligible’** effects.

Table 7: Assessment of Dust Dis-amenity Effects at Receptors

Receptor Type and Distance Band from Site Boundary	Maximum Residual Source Emissions	Pathway Effectiveness	Dust Impact Risk	Receptor Sensitivity	Magnitude of Dust Effects
Residential within 100 m	Small	Ineffective	Negligible Risk	High	Negligible effect
Residential within 100 m - 200 m	Small	Ineffective	Negligible Risk	High	Negligible effect
Residential within 200 m - 300 m	Small	Ineffective	Negligible Risk	High	Negligible effect
Residential within 300 m - 500 m	Small	Ineffective	Negligible Risk	High	Negligible effect
Non-Residential within 100 m	Small	Ineffective	Negligible Risk	Medium	Negligible effect
Non-Residential within 200 m	Small	Ineffective	Negligible Risk	Medium	Negligible effect
Non-Residential within 300 m	Small	Ineffective	Negligible Risk	Medium	Negligible effect
Non-Residential within 500 m	Small	Ineffective	Negligible Risk	Medium	Negligible effect

10.5.3 Assessment of Fine Particles

The IAQM recommend that if the PM_{10} background concentration is less than 17 µg/m^3 there is little risk that the process contribution (PC) from the Site would lead to an exceedance of the annual-mean objective. The background data monitored at the Site is detailed in Section 10.4.1 of the EIAR Chapter. The monthly average monitored concentration is 7.8 µg/m^3 and the annual average of the local EPA stations stations is 10.7 µg/m^3, both of which are less than 17 µg/m^3. Based on this data, it is unlikely that the PC from the Site would lead to an exceedance of the AQS.

Fine particulate PC can also be assessed using the calculation of concentration with distance from source (for conservatism the site boundary is used) as detailed in LAQM TG03. The guidance document also states that the likely PM_{10} contribution from fugitive dusts, stockpiles, quarries and construction is variable but up to 5 µg/m^3. Therefore, the likely concentration at the receptor locations can be estimated using the calculation considering the distance from source. As $PM_{2.5}$ is a sub-fraction of PM_{10}, the contribution of $PM_{2.5}$ will be lower but if it is conservatively assumed that all of the PM_{10} is $PM_{2.5}$.

When combining the likely concentration with the average local EPA monitored background value (10.7 µg/m^3) for Zone D areas (which is greater than the monitored monthly concentration), the maximum annual PM_{10} predicted environmental concentration (PEC) would be 12.2 µg/m^3 which is approximately 54% of the AQS and the annual $PM_{2.5}$ PEC would be 49% of the Stage 1 AQS and 61% of the Stage 2 AQS, at the closest receptor. The PEC would be less than this for all other receptors in the vicinity of the Site. The PEC is predicted to be below the annual AQS, with headroom. The impact from fine particle PC from the Site is considered to be **Negligible** to **Slight** prior to mitigation which would reduce to **negligible** due to the mitigation measures to be employed by the Site.

Table 8: Assessment of Fine Particulates at Closest Downwind Receptors

Receptor Type and Distance Band	Number of Receptors in Distance Band	Number of Receptors in Prevailing Wind Direction	Distance from Source	Relative Concentration (with fallout from source)	Estimated Concentration (µg/m^3) at Receptor Band, assuming Source Emission of 5 µg/m^3
Residential within 0 m - 100 m of source	13	4	10	30%	1.5
Residential within 100 m - 200 m	26	12	100	18%	0.9
Residential within 200 m - 300 m	33	27	200	8%	0.4
Non-Residential within 0 m - 100 m of source	3	1	10	30%	1.5
Non-Residential within 100 m - 200 m	2	0	100	18%	0.9
Non-Residential within 200 m - 300 m	2	1	200	8%	0.4

10.6 Mitigation

Details of mitigation measures that will be employed at the Application Site are summarised below:

- Dust monitoring will continue to be carried out monthly at the designated monitoring locations, and results will be reported to the local authority;
- The timing of operations will be optimised in relation to meteorological conditions;
- Overburden will be stripped in stages according to the mining schedule, reducing the risk of mass dust emissions;
- Material in outdoor stockpiling will be located within the mining void to take advantage of shelter from wind;
- Overburden mounds will be grass-seeded and planted to eliminate wind-blown dust;
- The existing hedgerow will be used as a means of screening, with a security fence and a vegetated berm for dust, noise and visual screening. Berms will be 2 m high and 2 m wide and planted, with a section of 4 m by 4 m berm along the southern corner of the proposed pit;
- The woodland to the north of the proposed boundary will be kept (and enhanced with additional planting of native species), acting as a natural buffer.
- Plant will be regularly maintained;
- Equipment will be enclosed, such as a semi-mobile crusher and covered conveyor;

- Internal haul roads will be compacted and maintained (a water-bowser will be available at all times should haul roads need dampening to minimise dust blow during working hours);
- On site speed restrictions (<20 kph) will be maintained in order to limit the generation of fugitive dust emissions; and
- All vehicles exiting the existing site will exit through the existing wheel-wash, and the proposed Knocknacran West Site will operate as a closed Site.

Table 9 assesses the potential impacts from the Proposed Development on the local air quality both with and without the establishment of appropriate mitigation measures detailed above based on the IAQM, 2016 guidance and the application of expert judgement. The duration of these effects will occur in the medium term during the extraction operations. Definitions of effect significance are as defined in the EPA's 2022 'Guidelines on the information to be contained in environmental impact assessment reports'.

Without mitigation measures it is considered that dust impacts from extraction activities may not affect the character of an environment but would have noticeable changes. Through the implementation of the environmental management programme it is likely that the dust from various activities will have an effect capable of measurement but without noticeable consequences to the environment.

Table 9: Assessment of Impacts to Local Air Quality and Mitigation Measures Employed (based on IAQM 2016 guidance and expert judgement)

Impact	With / Without the establishment of Mitigation Measures	Type of Effect	Quality of Effects	Significance of Effects	Duration of Effects
Dust from excavation	Without	Direct	Negative	Slight adverse	Medium Term (7-15 years)
Dust from excavation	With	Direct	Negative	Negligible	Medium Term (7-15 years)
Dust from transfer on haul roads	Without	Direct	Negative	Slight adverse	Medium Term (7-15 years)
Dust from transfer on haul roads	With	Direct	Negative	Negligible	Medium Term (7-15 years)
Dust from transfer on public roads	Without	Direct	N/A	N/A	Medium Term (7-15 years)
Dust from transfer on public roads	With	Direct	N/A	N/A	Medium Term (7-15 years)
Dust from on-site processing (crushing and screening)	Without	Direct	Negative	Slight adverse	Medium Term (7-15 years)
Dust from on-site processing (crushing and screening)	With	Direct	Negative	Negligible	Medium Term (7-15 years)

10.7 Residual Impacts

Residual impacts of deposited dust and particulates generated during the proposed Site activities on air quality are considered to be **negligible** to **slightly adverse**. During long spells of dry weather, particulate emissions can potentially be elevated, however dust nuisance or fine particulate impacts from the operation are expected to be unlikely if the above mitigation measures are implemented during operation and restoration. The overall impact from the operation of the Site, in terms of dust emissions and fine particulates, and considering mitigation, is considered '**negligible'** to the air environment and **Not Significant**.

It is noted that restoration of the existing Knocknacran Mine Site is scheduled with a west to east phasing. This means that the area of the mine closest to the Community Sports Complex will be restored first, thus covering any exposed gypsum and reducing the duration of potential dust nuisance or particulate impacts arising at this receptor.

In the longer term, on completion of the site restoration, the concentration of airborne dust would expect to be reduced from operational levels as the result of covering and seeding of exposed, un-vegetated soil surfaces. This will most likely constitute a minor positive impact for the local environment.

Following the application of the site-specific mitigation measures set out in Section 10.6, it is considered that the residual effects associated with the mining operations of the Proposed Development will be **not significant**.

10.8 Cumulative EFFECTS

Research has shown that the greatest proportion of dust predominantly deposits within the first 100 m away from the source (The Environmental Effects of Dust from Surface Mineral Workings, Volume 1 DETR, HMSO 1995) as dust has a higher deposition velocity than finer particles (i.e. PM_{10} and $PM_{2.5}$). The finer particles of less than 10 microns aerodynamic diameter may remain airborne for longer and therefore travel larger distances, although a large proportion may still deposit within 200 m of the source.

All of the operational mining activities have been considered in combination through the application of the IAQM guidance methodologies. The Site is due to become operational during the construction process for the Community Sports Complex, commencing in month 12. Due to the receptor locations and prevailing winds and neither of the predicted impacts being greater than Negligible, the combined impacts of the operational Mine Development and the Community Sports Complex construction is deemed to be negligible.

The requirement to continue monitoring at the mine sites is already included as a mitigation measure. There are no relevant ELVs for dust emissions but there are limits which can be applied to the dust monitoring results, as detailed in Section 10.2 Policy and legislation Context. The existing operations have a dust monitoring limit of 350 mg/m2/day using the Bergerhoff Method, this is proposed to continue for the proposed mine development. In addition, an ambient monitoring station will be established on the Knockancran West mine site for the operational life.

Construction of the Community Sports Complex is due to occur at the same time as the majority of the mine construction activities, however given that the residual effects for both the mining and non-mining construction related activities have been determined as **Not Significant**, it is not anticipated that any significant combined effects will arise where an overlap in activities occurs as per the mining schedule.

The nearest extractive industry site to the Proposed Development which may have the potential to cumulatively effect the local air quality and climate include the underground Drummond Mine adjacent to the southern boundary of the existing Knocknacran Site. However, gypsum is transported by covered conveyor from the underground workings to the homogeniser on the Site, therefore greatly minimising the dust potential from the site. There are no further extractive industries within 1 km of the site boundary.

There are four extractive industry sites located within 5 km of the Proposed Development. These are; (i) Cormey Clay Pit, Breedon Brick Ltd's open-cast clay quarry, located ca. 1.5 km south of the Site. (ii) an associated site located ca. 4 km south of the Site, (iii) Limestone Industries Ltd limestone quarry, located ca. 2 km west of the Site, and (iv) Roadstone Barley Hill open-cast quarry located ca. 4 km southeast of the Site. Given the nature (open pit) and size of the activities at the Proposed Development, it is not anticipated that any noticeable cumulative effects will arise relating to air quality and the climatic environment that could be attributed to the interaction of several extractive industries in close proximity to each other.

Losset ADN Materials Ltd. have a planning application under consideration (Reg. Ref. 22/254) and are located ca. 1 km to the north of the Project site. Based on a review of the current planning file data (to date 17th March 2023), this development is not seeking to materially change their development or air quality impacts.

The cumulative effects are deemed **Not Significant** between the Project and other offsite Projects.

10.9 References

- Environmental Protection UK / Institute of Air Quality Management (EPUK/IAQM, 2017) Land-Use Planning and Development Control: Planning for Air Quality,v1.2, 2017.
- Institute of Air Quality Management (IAQM, 2014) Guidance on the assessment of dust from demolition and construction.
- Institute of Air Quality Management (IAQM, 2016) Guidance on the assessment of mineral dust for Planning.
- The Environmental Effects of Dust from Surface Mineral Workings, Volume 1 DETR, HMSO 1995.

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APPENDIX

11.0 NOISE

11.1 Introduction

This chapter of the EIAR assesses the impacts of noise associated with the Proposed Development (both the Mine Development and the Community Sports Complex) on sensitive receptors that have been identified in accordance with legislation and guidance as set out within this assessment. This chapter will assess potential impacts of noise arising from the Proposed Development and mitigation measures considered, as necessary.

As part of this assessment noise levels associated with the proposed construction, operation and restoration of the Knocknacran West Mine have been predicted with noise modelling software CadnaA and the potential impact on noise sensitive receptors (NSRs) surrounding the proposed Knocknacran West Mine site has been assessed. In addition, predictive modelling has been used in the assessment of likely noise levels arising from the construction of the proposed Community Sports Complex site on adjacent NSRs.

11.1.1 Site Location and Setting

The Site is located in the townlands of Knocknacran (East & West), Drumgoosat, Drummond, Derrynascobe, Enagh, Derrynaglah and Clontrain Co. Monaghan, to the north and south of the R179, a regional road which runs between Carrickmacross and Kingscourt.

The Site is accessed via a public road (L4816) which runs south-eastwards from the R179. The town of Kingscourt is located ca. 7 km south of the Site along the R179, and the town of Carrickmacross is located ca. 7 km north of the Site also along the R179.

11.2 Legislative and Policy Context

11.2.1 Relevant Legislation

Legislative references considered specifically for the assessment of noise and vibration from mining activities and relevant statutory instruments in a planning context include:

- Directive 2014/52/EU of the European Parliament and of the Council, (amending Directive 2011/92/EU);
- European Union (Planning and Development) (Environmental Impact Assessment) Regulations 2018, S.I. 296 of 2018;
- Environment Noise Regulations 2018 S.I. 549 of 2018; and
- Planning and Development Regulations 2001 (as amended).

EU Directive 2002/49/EC

The Directive provides a basis for developing and completing the Community measures concerning noise emitted by the major sources, in particular; road and rail vehicles and infrastructure, aircraft, outdoor and industrial equipment and mobile machinery. The Directive applies to environmental noise to which humans are exposed, in particular built-up areas, in public parks or quiet areas in an agglomeration, in quiet areas in open country, near schools, hospitals and other noise-sensitive buildings and areas.

"Environmental noise" is defined within the Directive as "unwanted or harmful outdoor sound created by human activities, including noise emitted by means of road traffic, and from site of industrial activity…".

Member states (of the EU) are required to implement the Directive, by making and approving noise maps and action plans for agglomerations, major roads, major railways and major airports.

Noise indices specified by the Directive include L_{den} and L_{night}, however, supplementary noise indicators are permitted where these are used to express relevant limit values in Member State legislation.

11.2.2 Relevant Guidance

This assessment has been made with guidance from the 'Guidelines on the information to be contained in environmental impact assessment reports', published in draft by the EPA in August 2017. Guidance related specifically to noise and relevant to this assessment has been identified below.

NG4: Guidance Note for Noise: Licence Applications, Surveys and Assessment in Relation to Scheduled Activities

With regard to noise, the most recent Irish guidance document in relation to noise was published in 2016 by the Environmental Protection Agency (EPA), Office of Environmental Enforcement (OEE), entitled 'Guidance Note for Noise: Licence Applications, Surveys and Assessments in Relation to Scheduled Activities (NG4)'.

NG4 sets methods for addressing noise from operations that fall under IPPC and Waste Licensing functions of the Environmental Protection Agency Office of Environmental Enforcement (OEE).

NG4 provides detailed consideration of a range of noise related issues including basic background to noise issues, various noise assessment criteria and procedures, noise reduction measures, Best Available Techniques (BAT) and the detailed requirements for noise surveys. NG4 identifies typical limit values for noise from licensed sites as: Daytime (07:00 to 19:00) – 55dB $L_{Ar,T}$; Evening (19:00 to 23:00) – 50dB $L_{Ar,T}$; and, Night-time (23:00 to 07:00) – 45dB $L_{Aeq,T}$.

NG4 states that existing background noise levels measured during the environmental noise survey should be examined to determine if they satisfy the following criteria:

- Average daytime background noise level <40 dB L_{AF90};
- Average evening background noise level <35 dB L_{AF90}, and;
- Average night-time background noise level <30 dB L_{AF90}.

If all three of the above criteria are satisfied for any of the measurement locations, then those locations are deemed to be in areas of low background noise, and the following reduced noise limits are applicable at those locations:

- Daytime – 45 dB $L_{Aeq,T}$
- Evening – 40 dB $L_{Aeq,T}$

- Night-time – 35 dB $L_{Aeq,T}$

NG4 identifies the following guidance as potentially appropriate for assessing noise, subject to the use of the methodology being considered and justified by a competent person:

- BS 4142:2014+A1:2019: Methods for rating and assessing industrial and commercial sound – evaluation of industrial and commercial noise sources at residential properties;
- BS 8233:2014 Guidance on sound insulation and noise reduction for buildings – outline guidance on noise matters and deals specifically with noise within buildings; and
- BS 5228-1:2009+A1:2014 Code of practice for noise and vibration control on construction and open sites – Part 1: Noise – outline guidance on prediction and control of noise from construction and open sites.

British Standard BS 5228-1:2009+A1:2014 Code of Practice for Noise and Vibration Control on Construction and Open Sites, Part 1 – Noise ('BS5228')

BS5228 (BSI, 2014) provides a procedure for the estimation of construction noise and vibration levels and for the assessment of the significance of the predicted effects at the nearest sensitive receptors. Annex D of the Standard includes measured typical noise levels for a range of construction plant and activities.

Part 1 of the Standard provides several methods for the evaluation of the significance of construction noise effects. The ABC method considers significance by comparison to the measured baseline $L_{Aeq,T}$ noise level, rounded to the nearest 5 dB. Three categories of threshold values are provided; A, B and C, in increasing 5 dB bands, for the periods "daytime and Saturdays", "evenings and weekends" and "night-time". Where the measured baseline exceeds the highest category (C), a 3 dB increase over baseline is considered significant. The evaluation periods are defined as follows:

- Daytime: 07:00 – 19:00 on weekdays and 07:00 – 13:00 on Saturdays;
- Evenings and weekends: 19:00 – 23:00 weekdays, 13:00 – 23:00 Saturdays and 07:00 – 23:00 Sundays; and
- Night-time: 23:00 - 07:00 (all days).

BS 5228 describes several methods for assessing noise impacts during construction projects. Of these methods, the approach utilised in this assessment is the threshold-based 'ABC' method. The method specifies a construction noise limit based on the existing ambient noise level and for different periods of the day.

The predicted construction noise levels were assessed against noise limits derived from advice within Annex E of BS 5228. Table 11.1, reproduced from BS 5228 Table E.1, presents the criteria for selection of a noise limit for a specific receptor location.

Table 11.1: Construction Noise Threshold Levels Based on the ABC Method (BS 5228:2009+A1:2014)

Assessment category and threshold value period (L_{Aeq})	Threshold value, in decibels (dB)		
	Category A[A)]	Category B[B)]	Category C[C)]
Night time (23.00 – 07.00)	45	50	55
Evenings and weekends (D)	55	60	65
Daytime (07.00 – 19.00) and Saturdays (07.00 – 13.00)	65	70	75
A) Category A: threshold values to use when ambient noise levels (when rounded to the nearest 5 dB) are less than these values.			
B) Category B: threshold values to use when ambient noise levels (when rounded to the nearest 5 dB) are the same as category A values.			
C) Category C: threshold values to use when ambient noise levels (when rounded to the nearest 5 dB) are higher than category A values.			
D) 19.00–23.00 weekdays, 13.00–23.00 Saturdays and 07.00–23.00 Sundays.			

The ABC method described in BS 5228 establishes that where construction noise levels meet the relevant ABC threshold noise effects are not significant.

BS 5228 states:

> *"If the site noise level exceeds the appropriate category value, then a potential significant effect is indicated. The assessor then needs to consider other project-specific factors, such as the number of receptors affected and the duration and character of the impact, to determine if there is a significant effect."*

BS7445-1:2003 Description and Measurement of Environmental Noise. Guide to Quantities and Procedures.

BS7445 provides guidance on appropriate environmental noise monitoring, including specification of equipment and appropriate calibration intervals, suitable weather conditions and observations to note regarding the nature of the noise environment.

11.2.3 Other relevant guidance

Other guidance reviewed as part of the assessment process include:

- The EPA's Environmental Management Guidelines: Environmental Management in the Extractive Industry (Non-Scheduled Minerals; April 2006);

- As well as the EPA's NG4 guidance, noise monitoring at the mine is based on procedures outlined in ISO 9613 (1996): Attenuation of sound during propagation outdoors Part 1 and Part 2, and BS4142:2014+A1:2019: Method for rating and assessing industrial and commercial sound;

- Guidelines for Environmental Noise Impact Assessment, Institute of Environmental Management and Assessment, 2014;

- 'Guidelines on the information to be contained in environmental impact assessment reports', published by the EPA in May 2022, and 'Advice notes for preparing Environmental Impact Statements', (Draft, 2015);

- Department of the Environment, Heritage and Local Government – Quarries and Ancillary Activities: Guidelines for Planning Authorities, 2004;

- Environmental Management in the Extractive Industry (Non-Scheduled Minerals) (2006) Environmental Protection Agency. This guidance outlines primary sources of noise associated with mining and offers guidance in relation to the correct approach to be followed in respect of assessment and mitigation. Recommended noise limit values are 55dB $L_{Aeq,1hr}$ and 45dB $L_{Aeq,15min}$ for daytime and night-time respectively; and

- EPA's Guidance Note for Noise Action Planning, 2006 – 2018.

Design Manual for Roads and Bridges (DMRB)

DMRB provides standards and advice regarding the assessment, design and operation of roads in the UK and sets out screening criteria, by which percentage changes in traffic flow can be related to a predicted change in road traffic noise and vibration. The guidance also provides significance criteria, by which the percentage of people adversely affected by traffic noise can be related to the total noise or vibration level due to road traffic, or the increase over an existing level.

DMRB provides a method for predicting the Basic Noise Level (BNL), a measure of the source noise level of a road. The BNL is a function of the composition, flow and speed of traffic and the quality of the road surface. Changes in the BNL, arising from changes in traffic flow, may be used as a means of determining the significance of operational noise effects.

The following scoping criteria are provided for the evaluation of operational noise from a road:

- Is the project likely to cause a change in the BNL of 1dB $L_{A10,18hr}$ in the do-minimum opening year (DMOY) compared to the do-something opening year (DSOY)?;

- Is the project likely to cause a change in the BNL of 3dB $L_{A10,18\ hr}$ in the do-something future year (DSFY) compared to the DMOY?;

- Does the project involve the construction of new road links within 600 m of noise sensitive receptors?; and

- Would there be a reasonable stakeholder expectation that an assessment would be undertaken?

With regard to a 'reasonable stakeholder expectation' for an operational noise assessment, DMRB notes an example where works involve changes to infrastructure but are not expected to give rise to significant environmental effect, such as smart motorway projects.

Where the response to any of the above scoping questions is 'yes' the scoping assessment shall make a recommendation on the scope of further assessment.

11.2.4 Relevant Planning Objectives and Plans

The Monaghan County Development Plan 2019-2025 acknowledges that mineral resources make an important contribution to the economy and that it is important that they be safeguarded for future use whilst also ensuring that impacts on the environment and communities are acceptable.

To address this the Council notes that planning applications for mineral extraction must account for several potential environmental impacts including noise impacts as it can impact on people's quality of life and health.

Monaghan County Council has adopted policies with the 2019-2025 County Development plan in relation to the protection of environs from noise from planned projects.

Monaghan County Council policies relevant to the assessment of noise include:

- NP1 – To promote the implementation of the Noise Directive 2002/49/EC and associated Environmental Noise Regulations 2006;

- AQP2 – To contribute towards compliance with air quality legislation; greenhouse gas emission targets; management of noise levels; and reductions in energy usage;

- ICP1 (d) - The provision of a buffer zone up to 15 m in width, or as otherwise determined by the Planning Authority according to the proposed operations, where industrial and other sensitive land uses adjoin, to ensure amenities of adjacent properties are not adversely affected and that there is no significant amenity loss by way of noise, smell or other nuisance to immediate neighbours or the area in general as a result of the proposed development, lighting and the amount of traffic generated or the servicing arrangements; and

- DM2 - To assess proposals for development in terms of, inter alia, potential impact on existing adjacent developments, existing land uses and/or the surrounding landscape. Where proposed developments would be likely to have a significant adverse effect on the amenities of the area through pollution by noise, fumes, odours, dust, grit or vibration, or cause pollution of air, water and/or soil, mitigation measures shall be implemented to eliminate adverse environmental impacts or reduce them to an acceptable operating level.

11.3 Assessment Methodology and Significance Criteria

11.3.1 Scope of Assessment

The scope of this assessment has included the following:

- Analysis of noise survey data;

- Derivation of applicable noise criteria;
- Prediction of operational phase noise impacts;
- Prediction of construction phase impacts associated with the mine;
- Prediction of construction phase impacts associated with the Community Sports Complex;
- Evaluation of predicted noise levels against agreed criteria; and
- Specification of appropriate mitigation, if required.

Effects scoped out – HGV Contribution to Road Traffic Noise

DMRB provides scoping criteria for the evaluation of operational noise from a road. With reference to the DMRB scoping criteria provided in Section 11.2.2 and traffic data provided, the contribution of HGVs to traffic noise does not meet 'reasonable stakeholder expectation' for an operational noise assessment. For the level of traffic expected (refer to Chapter 14.0), the mine will not cause a change in the BNL of greater than or equal to 1dB $L_{A10,18hr}$ in the do-minimum opening year (DMOY) compared to the do-something opening year (DSOY). The mine will also not cause a change in the BNL of greater than or equal to 3 dB $L_{A10,18hr}$ in the do-something future year (DSFY) compared to the DMOY. The mine also does not involve the construction of new road links within 600 m of Noise Sensitive Receptors (NSRs). Operational phase changes in traffic noise levels will therefore be not significant and have been scoped out of this assessment. Traffic data for the surrounding road network is provided in Appendix 14.1.

HGV movements associated with the construction of the Community Sports Complex will be sporadic and will therefore provide a negligible contribution to overall traffic flows. These traffic movements have therefore also been scoped out of further assessment.

A temporary road diversion is proposed on the R179 during the construction of the Proposed Development. Traffic flows are not expected to change significantly during the duration of diversion and therefore this aspect has also been scoped out of further assessment.

11.3.2 Study Area and NSRs

The Site is composed of the existing Knocknacran Mine site which operates under IE Licence P0519-04 in addition to the Knocknacran West Mine site further north and the Community Sports Complex site to the west.

The study area considered in this assessment comprises an areaextending 450 m beyond the boundary of the Site (Figure 11.1). The number of NSRs in the study area is based on a review of the aerial photograph identified by Department of Communications, Climate Change and Environment mapping resources and Eircode mapping in addition to site visits in the area.

The study area includes the identified NSRs for the proposed Knocknacran West Mine and proposed Community Sports Complex, Figure 11.2. Following a review of proposed site operations, which include surface drilling, plant activities, blasting and process plant, a selection of representative NSRs has been carried forward in this assessment; these are listed in Table 11.2. The selected NSRs are the closest to proposed surface activity areas and compliance with noise limits at these NSRs will entail compliance at other NSRs that are a greater distance from proposed mining activities.

As part of the current IE Licence, three noise monitoring locations (MS1 - MS3) are monitored monthly on the Knocknacran Mine site; these are proximal to the nearest NSRs. These locations are shown in Figure 11.3. As part of the baseline monitoring for the Proposed Development five noise monitoring locations (NMP1 - NMP5) were monitored in September 2021 and March 2023 (Figures 11.1 and 11.3).

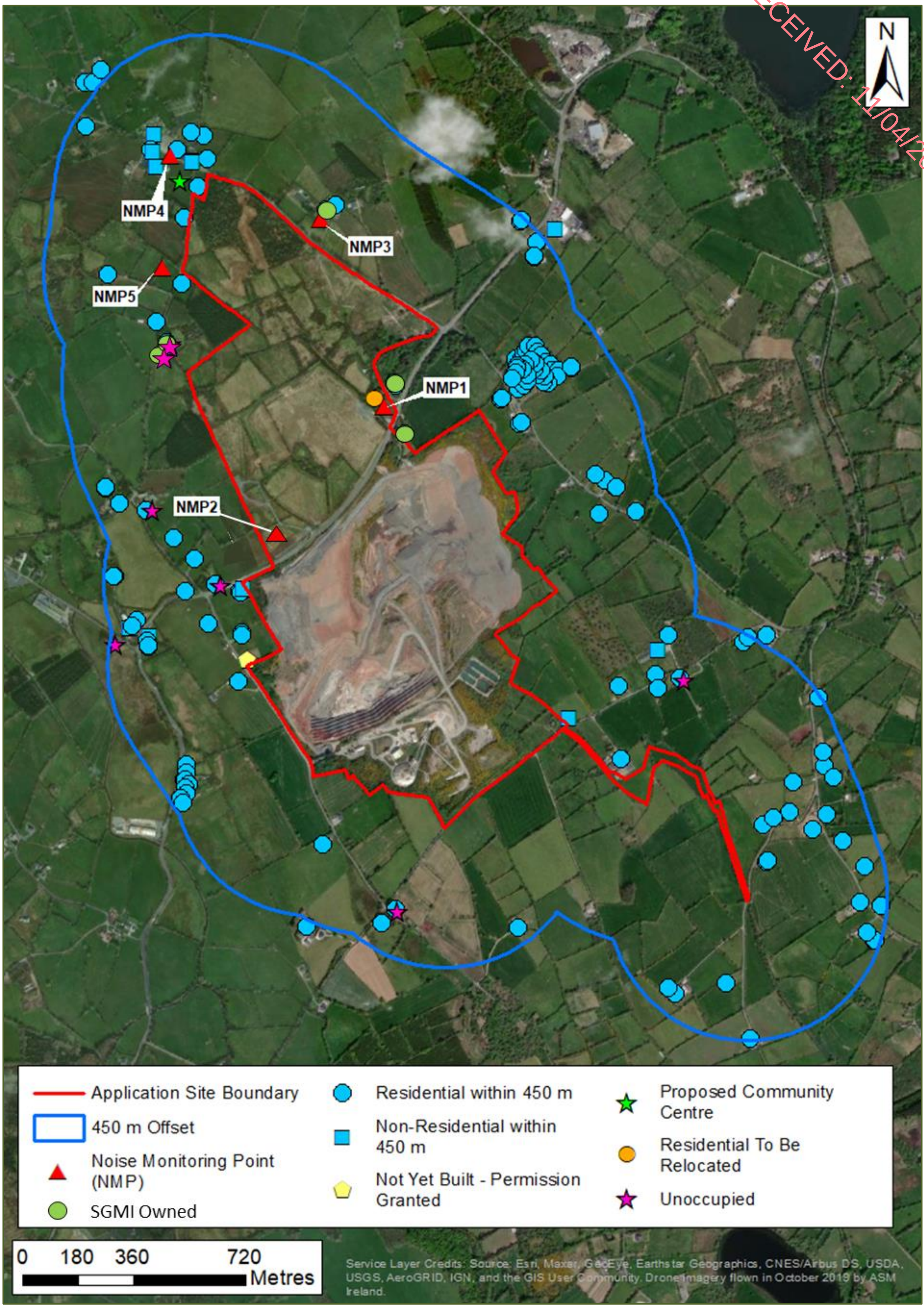

Figure 11.1: Receptors and NMPs within 450 m of the Application Site

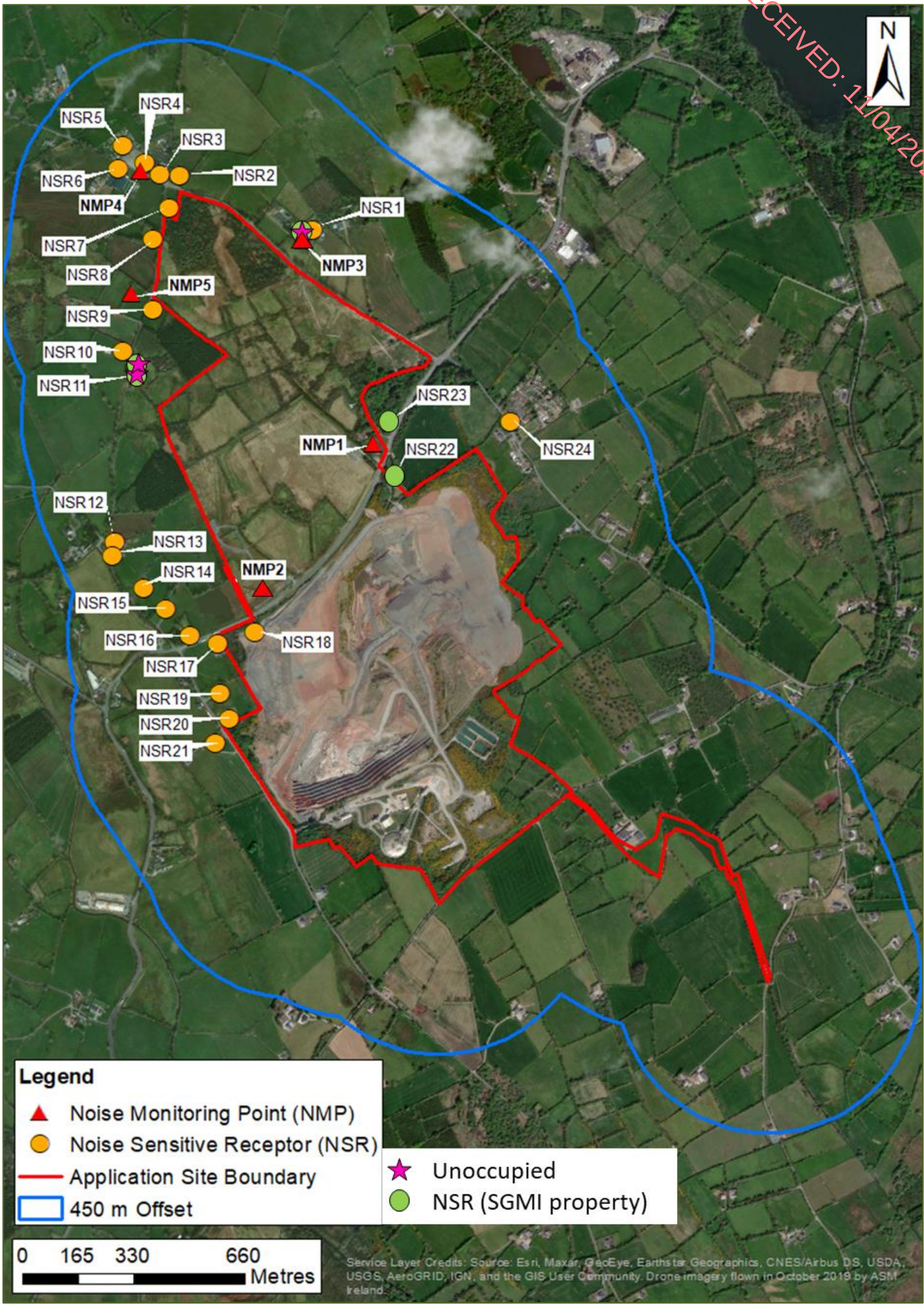

Figure 11.2: NSRs around the Proposed Development

Figure 11.3: Location of baseline noise monitoring locations MS1 - MS3 and NMP1 - NMP5

Table 11.2: Identified representative NSRs

Receptor ID and rationale for selection	X (Irish Grid)	Y (Irish Grid)
NSR1 2 residential dwellings, 1 owned by SGMI, considered for the mine development	280763	300808
NSR2 residential dwelling, proximal dwelling in Drumgoosat village to the development, considered for the mine development	280369	300968
NSR3 Drumgoosat National School, considered for the mine development	280311	300973
NSR4 residential dwelling, considered for the mine development	280266	301006
NSR7 residential dwelling, proximal dwelling in Drumgoosat village to the development, considered for the mine development	280336	300872
NSR9 residential dwelling, considered for the mine development	280289	300569
NSR10 residential dwelling, considered for the mine development	280200	300444
NSR15 residential dwelling, considered for the mine development	280326	299678
NSR17 residential and commercial dwelling, considered for the mine development and Community Sports Complex	280482	299575
NSR18 existing Community Sports Complex, considered for the mine development and Community Sports Complex	280593	299609
NSR19 residential dwelling, considered for the mine development and Community Sports Complex	280489	299425
NSR22 residential dwelling owned by SGMI, considered for the mine development	281010	300074
NSR23 residential dwelling owned by SGMI, considered for the mine development	280989	300236

11.3.3 About the Author

This noise assessment has been prepared by Gregor Massie MSc BEng AMIOA. Gregor is an associate member of the UK Institute of Acoustics (IoA) and has more than 5 years' experience in environmental noise assessment. He has completed the IoA postgraduate diploma in Acoustics and Noise Control and also the Certificate of Competence in Environmental Noise Measurement.

This section of the EIAR has been reviewed by Simon Waddell BSc. (Hons), MSc., MIOA. Simon is an Associate Consultant at ITPEnergised and has over 10 years of experience in environmental acoustics. Simon has completed the IoA Diploma in Acoustics and Noise Control and is a corporate member of the IoA.

ITPEnergised has considerable experience in the assessment of noise impacts and has compiled EIA studies ranging from quarries, mines, retail development, housing developments and renewable energy infrastructure.

11.3.4 Receptor Sensitivity

This assessment considers that human receptors, including residential dwellings and Drumgoosat School, have a high sensitivity to noise. Commercial and industrial receptors, comprising buildings and businesses, are considered to have a low sensitivity to noise. The assumed sensitivity of identified representative existing NSRs are provided in Table.11.3.

Table.11.3: Representative receptor sensitivity

Receptor	Type of receptor	Sensitivity
NSR1, NSR2, NSR3, NSR4, NSR7, NSR9, NSR10, NSR15, NSR17, NSR18, NSR19, NSR22, NSR23 –existing dwellings, Community Sports Complex and Drumgoosat National School	Residential/amenity/school	High

11.3.5 Impact Magnitude Criteria

Appropriate criteria have been adopted using relevant guidance for the derivation of impact magnitude and these are provided in Table 11.4. The adopted criteria considers a scale whereby compliance with the noise limits results in impacts of low magnitude, while exceedance of the limits results in impacts of medium to high magnitude.

Table 11.4*:* Impact magnitude criteria

Predicted level relative to noise limit dB	Impact Magnitude
>10	High Adverse
>0, ≤10	Medium Adverse
<0, ≤-5	Low Adverse
<-5	No change / none

The Proposed Development will introduce additional anthropogenic noise sources to the study area during both the construction and occupation phases, therefore all impacts are assumed to be adverse.

The criteria in Table 11.4 have been used to determine the significance of noise effects for receptors of different sensitivities, as shown in Table 11.5.

Table 11.5: Significance of Effect

Magnitude	Level of significance, relative to sensitivity of receptor		
	Low	Medium	High
High	Moderate	Moderate/Large	Large
Medium	Slight	Moderate	Moderate
Low	Neutral	Slight	Slight
No change / none	Neutral	Neutral	Neutral

All residential NSRs are considered to be of 'high' sensitivity to noise.

This assessment considers that effects of moderate and large significance are significant, and that effects of neutral and slight significance are not significant.

11.3.6 Target Noise Levels – Mining Operational Phase and Restoration Phase

Noise criteria have been adopted from appropriate guidance, as provided in Section 11.2. The adopted criteria are provided below.

The applicable guidance which dictates noise thresholds is the EPA's 'Environmental Management in the Extractive Industry (Non-Scheduled Minerals)' (2006). As noted above, the recommended noise limit values for the mine are 55 dB $L_{Aeq,1hr}$ and 45 dB $L_{Aeq,15min}$ for the daytime and night-time periods, respectively. The guidance specifies that the daytime and night-time periods comprise the hours 08:00 - 20:00 and 20:00 - 08:00, respectively.

More recent Irish guidance in relation to noise was published in 2016 by the EPA and OEE, although applicable to EPA licenced facilities, the NG4 guidance identifies typical limit values for noise from such sites as: Daytime (07:00 to 19:00) – 55 dB $L_{Ar,\,T}$; Evening (19:00 to 23:00) – 50 dB $L_{Ar,T}$; and Night-time (23:00 to 07:00) – 45 dB$L_{Aeq,\,T}$.

NG4 states that NSRs can be classified as 'low noise' when measured background levels are below 40 dB (daytime), 35 dB (evening) and 30 dB (night-time). If this applies to all three periods, then the noise limits at these locations are: Daytime (07:00 to 19:00) – 45 dB $L_{Ar,\,T}$; Evening (19:00 to 23:00) – 40 dB $L_{Ar,T}$; and Night-time (23:00 to 07:00) – 35 dB$L_{Aeq,\,T}$.

Noise monitoring in 2021 and 2023 confirmed that some NSRs can be classified as 'low noise' receptors. Table 11.6 presents the target noise levels for NSRs that are considered 'low noise' and NSRs which are not.

Table 11.6: Target Noise Levels

NSR	Daytime dB $L_{Ar,T}$	Evening dB $L_{Ar,T}$
NSR1, NSR2, NSR3, NSR4, NSR7, NSR9, NSR10 – NSRs situated in areas of low background noise	45	40
NSR15, NSR17, NSR18, NSR19, NSR22, NSR23	55	50

This assessment adopts the more recent guidance published by the EPA and OEE for the daytime and evening periods, this is also in line with the existing IE Licence's (Reg. Ref. P0519-04) definition of daytime and evening hours.

This assessment is not seeking to amend the existing IE Licence noise levels for the Knocknacran Mine and Processing Plant site, the noise limits at MS1, MS2 and MS3 are proposed to remain at 55 dB $L_{Ar,T}$ (Daytime), 50 dB $L_{Ar,T}$ (evening) and 45 dB $L_{Ar,T}$ (night).

Night-time operations associated with the mine are minimal and consist of the transport of gypsum from the Knocknacran Processing Plant which takes place between 06:00 hours and 21:00 hours Monday to Saturday. A one-hour period from 06:00 to 07:00 falls within EPA night-time hours. A separate modelling exercise has been undertaken to assess noise from road haulage a the closest NSR (NSR20). The results are presented in Section 11.7.4.

The noise index $L_{Ar,T}$ is defined in the guidance as the rated noise level, equal to the $L_{Aeq,}$ during a specified time interval (T), plus adjustments for tonal character and/or impulsiveness of the sound.

The guidance further notes that in quiet areas, such as remote or rural settings, lower noise limits may be applicable, however whilst the proposed Knocknacran West Mine site is in a rural area, the presence of existing industrial noise sources (existing mining activities) means that the development location would not be classified as a quiet area.

Ambient noise levels at baseline NMPs have been used to derive appropriate noise limits at representative NSRs.

11.3.7 Target Noise Levels – Construction of Mine and Community Sports Complex

This assessment provides an evaluation following guidance contained in BS5228 ABC Method and provides noise limits applicable to construction activities for the nearest off-site NSRs. Ambient noise levels at NMPs have been used to derive appropriate noise limits at NSRs.

Based on measured ambient levels at all NMPs, all receptors fall within Category A of the ABC Method.

11.3.8 Operating Hours

Mine Related Operations

The proposed operating and maintenance hours for the proposed Knocknacran West Mine will be from 08:00 hours to 20:00 hours Monday to Saturday. Pump inspections will take place as required. Transport of gypsum from the Knocknacran Processing Plant will continue to take place between 06:00 hours and 21:00 hours Monday to Saturday.

No blasting will take place on Sundays or Public Holidays. Mining operations will not take place on Sundays or Public Holidays, unless due to exceptional circumstances.

Construction operations related to the temporary diversion of the R179, cut and cover tunnel, mine entrance relocation and screening berm construction shall only be carried out between the hours of 07:00 and 20:00 hours Monday to Friday and works may take place on Saturday mornings between 07:00 and 13:00. No works shall be carried out on Sundays or Bank Holidays.

Community Sports Complex

Construction works which are audible at the site boundary shall only be carried out between the hours of 07:00 and 20:00 hours Monday to Saturday. No works shall be carried out on Sundays or Bank Holidays.

11.3.9 Phasing

The Knocknacran West Mine will be developed in a series of phases, based on process plant blending requirements in conjunction with optimised overburden/interburden stripping to ensure a consistent supply of high-quality gypsum. There are seven phases, which are described in detail in Chapter 3.0.

Worst case noise levels are represented by Phase 1, Phase 4, Phase 5, Phase 6 and Phase 7; these phases have been modelled. Phases 1, 4, 5 and 6 are operational mining phases. Phase 7 is the restored phase when the topography has been re-established in the north using the material stored in Phases 5 and 6. These include the shallowest and nearest surface activities, which have the most potential for noise generation at NSRs. The number of plant in operation during Phase 7 will have reduced as operations have wound down and little material is left to be moved.

11.3.10 Method of Baseline Characterisation

Baseline noise measurements were undertaken over two days, in September 2021 and March 2023. Monitoring was undertaken at 5 NMPs shown in Figure 11.3.

Multiple samples were obtained at each NMP during the daytime, evening and night-time period. Each sample was 15 minutes in duration, in accordance with EPA guidance.

Monitoring was undertaken in accordance with BS7445 guidance, using a Norsonic Nor-140 Class I sound level meter (SLM). The SLM was mounted on a tripod at a height of 1.2 - 1.5 m above ground level. The SLM was field calibration tested at the start of each measurement, with no significant drift noted. The SLM and calibrator were within their laboratory calibration period. SLM calibration certificates are presented in Appendix 11.1.

Weather conditions during the survey were in accordance with the requirements of BS7445, with no rain and wind speeds below 5 m/s throughout. The temperature was generally within the range 10 - 17°C in 2021 and between 1-4 °C in 2023.

The following noise indices were recorded:

- $L_{Aeq,T}$ – the equivalent continuous level is the constant noise level that would result in the same sound energy over a given period and is used to represent varying noise levels over a time, T, as a single number. Typically referred to as the 'ambient' noise level;

- $L_{A90,T}$ – the 'background', i.e. the noise level that is exceeded for 90 percent of a time, T. Representative of the quieter moments experienced at a location, this index is unaffected by short-duration noisy events;

- $L_{A10,T}$ –the noise level that is exceeded for 10 percent of a time, T. Typically used to characterise road traffic noise; and

- $L_{Amax,T}$ – the maximum noise level recorded over a time, T.

Details of observations made during monitoring are provided in Appendix 11.2.

11.3.11 Method of Prediction

Multiple 3D models of the mine representing each phase and construction of the community sports complex were constructed within noise prediction software CadnaA and noise levels were predicted at the representative NSRs. The software enables prediction of noise levels under atmospheric conditions using the method provided in ISO9613. Full modelling results are presented in Appendix 11.3.

Operational Phase

Appropriate source noise terms from BS5288 and measured data held on file by ITPEnergised were applied to plant items within the noise model. Conservative assumptions on effective on-times for items of plant were agreed with SGMI. Table 11.7 presents the noise sources and applied sound power data included in the noise model.

Table 11.7: Source noise terms – Mine operational model – Phasing

Item	Resultant sound power level, dBA	BS5228 Appendix reference	Operating time (hours/ day)	Height (m)	Quantity	Phasing
Semi Mobile Crusher	109.4	BS52282009C11 4	8	2	1	Operational during phases 2 – 6 in Knocknacran West Mine
Drilling Rig	114.8	BS52282009C94	8	2	2	Operational during phases 2 – 6in Knocknacran West Mine

Item	Resultant sound power level, dBA	BS5228 Appendix reference	Operating time (hours/ day)	Height (m)	Quantity	Phasing
Overland Conveyor	103.7	BS52282009C10 21	8	2	1	Operational during phases 2 – 6 in Knocknacran Restoration Area
Tunnel Conveyor	103.7	BS52282009C10 21	8	2	1	Operational during phases 2 – 6 in Knocknacran Restoration Area
Ramp Conveyor	103.7	BS52282009C10 21	8	2	1	Operational during phases 2 – 4 in Knocknacran Restoration Area
Tipping Conveyor	103.7	BS52282009C10 21	8	2	1	Operational during phases 2 – 6 in Knocknacran Restoration Area
Reclaim stockpile conveyor	103.7	BS52282009C10 21	8	2	1	Operational during phases 2 – 6 in Knocknacran Restoration Area
Excavator	106	BS52282009C81 1	8	2	1-3	Operational during phases 1 – 6 in Knocknacran Restoration Area
Excavator	97.0	BS52282009C81 0	8	2	1	Operational during phase 7 in Knocknacran West Restoration Area
Articulated Dump Truck	104.9	BS52282009C61 8	4 - 8	2	2	Operational during phases 2 – 6 in Knocknacran West Mine
CAT Dozer	107.4	BS52282009C21 3	4	2	1	In restoration areas
Roller	101.6	BS52282009C23 8	4	2	1	Operational in Phase 7 restoration area
Haul trucks	112	BS52282009C61 8	8	2	3 - 8	Operational during phases 1 – 7 in Knocknacran Restoration Area or Knocknacran West Mine during stripping and restoration activities

Predicted noise levels have been evaluated against the target levels for the daytime, and evening periods (see Section 11.3.6).

A robust approach has been applied to all modelling. The predicted noise levels assume a receptor height of 4 m above local ground level, (representative of a first-floor bedroom window). This is a robust approach, which minimises the attenuation due to ground absorption. Predicted levels at the height of a person standing at ground level, (e.g. effective receptor height of 1.5 - 1.8 m) will be lower.

Conservative equipment 'on-times' have been applied in all predictions for all fixed and mobile plant throughout the working day. All equipment and plant have been modelled in simultaneous operation. The resultant predictions may be considered conservative and actual noise levels are likely to be lower.

For Phase 1 and Phase 7, in which mining operations occur close or at original ground level, the modelled scenarios focus on operations when these are closest to NSR1 and NSR9, respectively. This represents a worst case scenario and compliance with criteria at NSR1 and NSR9 denotes compliance at the remaining, more distant NSRs.

Construction of Community Sports Complex

The construction of the Community Sports Complex will be undertaken over a two-year process. The sand carpet pitches will be constructed first, as they require 1 year settling and growing period before they can be played on.

The buildings will be constructed during the growing year, and approximately 2 - 3 months beyond..

The following assumptions have been made for the modelling:

- Construction works which are audible at the site boundary shall only be carried out between the hours of 07:00 and 20:00 hours Monday to Friday and between the hours of 08:00 hours and 16:00 hours on Saturday. No works shall be carried out on Sundays.

The pitch construction equipment usage will be as follows:

- A maximum of 1 medium and 1 small bulldozer operating at any time;
- A maximum of three 10-20 tonne excavators and two 3-7 tonne excavators at any one time;
- Up to 5 medium sized Agricultural type tractors shall be used for transporting materials within the site. (topsoil, stone, sand) at any one time;
- Occasional use of cut-off saw will be required during manhole construction;
- Deliveries of materials to site will be made with normal road haulage trucks; and
- Specialist equipment would be limited to possible use of chain trencher to dig collector drains.

The building construction equipment usage will be as follows:

- One 20 tonne excavator and two 3 - 7 tonne excavators;
- Two agricultural type tractors and trailers and dumper trucks to transport excavated or imported materials;

- One forklift / hi lift; and
- Ready mix concrete lorries / crushed stone lorries / delivery lorries (assumed 5 'haul trucks').

The items of plant to be used, along with their sound power level, on-time (operating time), assumed effective height and operation with reference to phasing are provided in Table 11.8. Appropriate source noise terms for the mobile plant have been obtained from BS5228. The model has utilised 100% on-time for all plant and maximum working hours of 11 hours/day for the duration of all works.

Table 11.8: Source noise terms – Construction Phase – Community Sports Complex

Name	Resultant sound power level (Day dB)	BS5228 reference	Operating Time (hours/day)	Quantity
10 to 20t excavator	96.0	BS_5228_2009_C2_24	11	3
Small Dozer	96.6	BS_5228_2009_C2_13	11	1
Medium Tractors	105.2	BS_5228_2009_C4_74	11	5
3 to 7t excavator	86.0	BS_5228_2009_C4_68	11	2
Medium Dozer	97.0	BS_5228_2009_C2_11	11	1
Haul Trucks	93.3	BS_5228_2009_C2_34	11	5

Construction Phase – Mine Development

Full details have been provided by the mine for construction plant and activities at the Proposed Development. The construction schedule comprises the following stages of work:

- House Demolition;
- Screening Berms;
- R179 Road Diversion; and
- Cut and Cover of Mine Tunnel.

An indicative list of plant for each stage has been assumed for each stage of works and is provided in Table 11.9.

All items of plant have been placed at the distance of likely closest approach to the closest NSR. The assumed plant is considered to represent a likely worst-case scenario of noisy plant items which may operate simultaneously. All modelled plant and activities have been modelled with an on-time of 100% (i.e. operating continuously throughout the working day); in reality most items of plant will operate at on-times substantially lower than 100%.

ITPEnergised assumes that construction activities will be confined to the 'weekday daytime' period, as defined in BS5228; Monday to Friday 07:00 – 19:00 and Saturday mornings 07:00 – 13:00.

Noise levels arising from construction have been predicted using noise modelling software CadnaA, using the BS5228 prediction method. Sound power levels for items of plant have been obtained from the plant library in Annex B and Annex C to BS5228. Items of plant have been placed within the noise model at locations representative of the assumed activities. The assumed list of plant for each stage of the construction phase, and the BS5228 references for the plant sound power data are provided in Table 11.9.

Table 11.9: Source noise terms – Construction Phase – Mine Development

Phase of works	Item	BS5228 reference	Operating Time (hours/day)	Quantity
House Demolition	Excavator	BS_5228_2009_C8_11	11	1
	Haul Trucks	BS_5228_2009_C6_18	11	1
	Road Truck	BS_5228_2009_C11_16	11	1
Screening Berms	Excavator	BS_5228_2009_C8_11	11	1
	Haul Trucks	BS_5228_2009_C6_18	11	2
	Road Truck	BS_5228_2009_C11_16	11	1
R179 Road Diversion	Excavator	BS_5228_2009_C8_11	11	2
	Haul Trucks	BS_5228_2009_C6_18	11	3
	Road Truck	BS_5228_2009_C11_16	11	2
	Dozer	BS_5228_2009_C2_13	11	1
	Roller	BS_5228_2009_C11_16	11	1
Cut and Cover of Mine Tunnel	Excavator	BS_5228_2009_C8_11	11	2
	Haul Trucks	BS_5228_2009_C6_18	11	2
	Road Truck	BS_5228_2009_C11_16	11	2
	Dozer	BS_5228_2009_C2_13	11	1

Model Settings

A typical air temperature of 10°C and relative humidity of 70% have been assumed within the model. Ground absorption within the mine and in the area surrounding the mine has been assumed G = 1 representative of soft ground conditions (as the overburden and interburden are soft enough to be removed by excavator and do not require blasting).

Local topography has been included within the model for all scenarios, using detailed contour line data provided.

11.4 Baseline

11.4.1 Existing Noise Data from the Operational Knocknacran Mine Site

As noted, the Knocknacran Mine is an existing operational mine site which operates under IE Licence P0519-04. Three monitoring locations (MS1-MS3) are used to record noise levels at the site; their locations are shown in Figure 11.3. Noise monitoring results are provided in Tables 11.10, Tables 11.11 and Table - 11.12 , which summarise the most recent noise monitoring undertaken at the Knocknacran Mine from 2017 to 2023. Noise monitoring results for the years 2017 - 2023 were taken from the monthly monitoring record which only recorded daytime noise and recorded $L_{A01,}$ dB L_{A10}, L_{A90} and L_{Aeq} (Tables 11.4 - 11.6). L_{A01} describes the level which was exceeded for only 1% of the time.

Noise monitoring at the Knocknacran site is based on procedures outlined in ISO 1996: Description, Measurement and Assessment of Environmental Noise, and, BS4142:2014 Method for Rating and Assessing Industrial and Commercial Sound. Full reference can be made to Guidance Note for Noise: Licence Applications, Surveys and Assessments in Relation to Scheduled Activities (NG4) January 2016.

The instrument used to monitor noise levels at the Site during the 2015 - 2019 events was a Cirrus CR:171B Optimus Green Class 1 Sound Level Meter, (Serial No. G071638) with Microphone Type MK:224, (Serial No. 204143A). The field calibrator used was a Cirrus CR:511 Calibrator, (Serial No. 75510). The microphone was fitted with a polypropylene windshield for all measurements.

Comments on Monitoring Results

There have been the no breaches in the 55 dB(A) daytime limit for the most recent years monitored (2017 to 2023). There is a shop and filling station located adjacent to MS2 and daytime noise levels are dominated by activity emanating from the shop area. The R179 is a busy thoroughfare and is located ca. 20 m from MS1. The L_{AF90} noise index is used to give a good indication of the noise levels arising from operation of the Knocknacran Mine site.

The existing Knocknacran Mine operates a processing plant; this forms part of the baseline noise environment. The use of this processing plant is not expected to change.

Table 11.10: Daytime Monthly Noise Monitoring at MS 1 between 2017 and 2023

Results MS1 2017 - 2021						
Day	**Date**	**Time**	**L_{A01}**	**L_{A10}**	**L_{A90}**	**L_{Aeq}**
Tuesday	24-Jan-17	10:16 - 10:31	51.5	46.5	35.5	43.4
Wednesday	15-Feb-17	12:26 - 12:41	51.5	49.0	40.5	46.2
Monday	13-Mar-17	10:24 - 10:39	57.0	51.5	38.0	47.6
Tuesday	25-Apr-17	08:30 - 08:45	51.1	47.0	33.3	42.7
Tuesday	02-May-17	09:00 - 09:15	52.0	47.5	35.5	45.9
Tuesday	13-Jun-17	09:59 - 10:14	51.5	48.0	38.7	45.0
Monday	17-Jul-17	14:20 - 14:35	53.9	51.7	43.4	50.6

Results MS1 2017 - 2021

Day	Date	Time	L_{A01}	L_{A10}	L_{A90}	L_{Aeq}
Thursday	24-Aug-17	14:40 - 14:55	54.4	50.9	43.6	48.3
Thursday	28-Sep-17	12:48 - 13:03	48.2	44.3	37.0	41.3
Thursday	19-Oct-17	11:26 - 11:41	49.0	45.7	38.1	42.7
Tuesday	28-Nov-17	11:32 - 11:47	56.6	52.3	43.5	48.8
Tuesday	12-Dec-17	10:32 - 10:47	56.2	53.3	48.0	51.1
Tuesday	16-Jan-18	11:30 - 11:45	57.5	51.5	41.2	48.0
Thursday	22-Feb-18	09:04 - 09:19	57.0	53.8	50.0	52.1
Wednesday	21-Mar-18	09:36 - 09:51	56.0	52.0	46.3	49.8
Wednesday	25-Apr-18	11:56 - 12:11	56.4	52.3	46.4	49.8
Tuesday	15-May-18	12:32 - 12:47	54.1	49.0	41.2	47.8
Tuesday	26-Jun-18	08:59 - 09:14	55.1	51.7	32.9	47.3
Thursday	19-Jul-18	10:03 - 10:18	48.2	39.6	30.0	36.3
Tuesday	28-Aug-18	08:50 - 09:05	50.6	47.5	38.0	44.2
Monday	10-Sep-18	12:05 - 12:20	51.3	48.1	38.6	44.8
Wednesday	24-Oct-18	10:27 -10:42	58.7	55.1	42.3	50.8
Monday	26-Nov-18	10:29-10:44	51.2	45.9	36.6	43.0
Monday	10-Dec-18	11:18-11:33	52.7	47.7	40.5	45.0
Tuesday	22-Jan-19	10:26 - 10:41	54.6	50.4	39.5	46.6
Tuesday	19-Feb-19	11:30-11:45	57.4	55.5	46.8	52.2
Friday	08-Mar-19	8:39-08:54	57.3	53.1	46.8	51.0
Tuesday	09-Apr-19	11:32 - 11:47	53.6	48.8	38.2	45.1
Wednesday	22-May-19	08:48 - 09:03	58.8	55.3	50.2	53.3
Tuesday	25-Jun-19	13:12 - 13:27	59.3	56.7	49.7	54.0
Wednesday	17-Jul-19	09:41 - 09:56	54.4	51.3	43.9	48.5
Monday	19-Aug-19	12:24 - 12:39	58.7	53.8	44.4	50.7
Monday	16-Sep-19	08:54 - 09:09	55.4	49.4	46.0	47.9
Monday	21-Oct-19	09:51 - 10:06	55.9	51.9	44.6	48.9
Wednesday	20-Nov-19	09:02 - 09:17	53.8	51.2	45.6	48.8
Thursday	10-Dec-20	08:29 - 08:44	53.6	50.3	37.4	46.6
Monday	20-Jan-20	13:53 - 14:08	55.8	53.0	46.1	50.3
Thursday	06-Feb-20	11:11 - 11:26	50.9	47.3	39.9	44.3
Tuesday	19-Jan-21	10:46 - 11:01	55.1	50.8	41.8	47.6
Tuesday	09-Feb-21	10:13 - 10:28	51.1	47.1	37.5	43.7
Thursday	04-Mar-21	10:56 - 11:11	49.2	45.8	33.9	41.9
Wednesday	21-Apr-21	09:53 - 10:08	54.1	49.2	38.3	45.9
Monday	17-May-21	13:26 - 13:41	55.7	49.8	37.8	46.7
Monday	14-Jun-21	11:30 - 11:45	55.1	51.5	40.6	48.2
Tuesday	20-Jul-21	08:34 - 08:49	51.9	46.8	31.5	42.6
Monday	23-Aug-21	11:28 – 11:43	50.0	45.8	31.5	41.4
Tuesday	14-Sep-21	09:31 – 09:47	51.1	47.3	30.4	43.1
Wednesday	13-Oct-21	13:42 – 13:57	52.8	49.4	41.5	46.7
Monday	29-Nov-21	15:37 – 15:52	55.6	52.0	41.7	48.8
Monday	20-Dec-21	09:14 – 09:29	49.9	46.6	34.3	42.5
Wednesday	12-Jan-22	11:44 – 11:59	55.7	50.9	40.8	47.5
Thursday	03-Feb-22	11:41 – 11:56	59.8	54.5	45.0	51.6

Results MS1 2017 - 2021						
Day	**Date**	**Time**	L_{A01}	L_{A10}	L_{A90}	L_{Aeq}
Monday	21-Mar-22	10:55 – 11:10	47.2	42.6	31.5	39.1
Monday	25-Apr-22	14:36 – 14:51	49.7	46.4	35.7	42.8
Wednesday	18-May-22	10:07 – 10:22	55.4	51.9	44.7	49.4
Wednesday	15-Jun-22	14:06 – 14:21	55.5	50.8	41.9	48.0
Wednesday	20-Jul-22	10:30 – 10:45	51.4	48.0	37.0	44.5
Monday	29-Aug-22	13:08 – 13:23	47.9	45.2	34.9	41.2
Monday	19-Sep-22	10:25 – 10:40	52.5	47.5	32.0	43.7
Thursday	13-Oct-22	12:05 – 12:20	52.4	49.1	39.5	45.8
Tuesday	15-Nov-22	10:23 – 10:38	56.2	51.1	41.1	48.1
Tuesday	06-Dec-22	11:37 – 11:52	52.9	48.6	33.7	44.3
Monday	23-Jan-23	10:36 – 10:51	53.7	49.4	35.7	45.9

Table 11.11: Daytime Monthly Noise Monitoring at MS 2 between 2017 and 2021

Results MS2 2017 - 2021						
Day	**Date**	**Time**	**LA01**	**LA10**	**LA90**	**LAeq**
Thursday	19-Jan-17	13:00 - 13:15	51.5	47.5	39.5	44.6
Thursday	09-Feb-17	09:35 - 09:50	55.0	51.5	42.5	48.6
Tuesday	14-Mar-17	12:16 - 12:31	53.0	48.5	42.5	47.0
Wednesday	12-Apr-17	12:42 - 12:57	61.5	54.5	43.0	51.3
Wednesday	03-May-17	10:30 - 10:45	56.5	52.5	44.0	49.8
Tuesday	20-Jun-17	10:57 - 11:12	56.0	54.4	50.6	53.0
Tuesday	18-Jul-17	16:00 - 16:15	61.8	50.6	40.6	50.6
Wednesday	23-Aug-17	13:46 - 14:01	57.3	53.4	45.9	50.5
Monday	18-Sep-17	08:54 - 09:09	57.4	51.9	41.9	48.5
Monday	09-Oct-17	10:02 - 10:17	55.3	50.9	45.5	49.0
Monday	27-Nov-17	10:47 - 11:02	56.6	52.5	45.6	49.8
Monday	04-Dec-17	11:19 - 11:34	58.0	49.3	39.7	47.5
Tuesday	09-Jan-18	11:26 - 11:41	57.4	54.3	47.2	51.5
Wednesday	07-Feb-18	11:32 - 11:47	56.8	50.4	43.8	48.1
Wednesday	07-Mar-18	14:26 - 14:41	55.4	51.0	46.4	48.9
Thursday	19-Apr-18	14:25 - 14:40	55.4	52.0	47.0	49.4
Tuesday	08-May-18	12:20 - 12:35	54.7	51.8	45.4	49.0
Tuesday	19-Jun-18	11:39 - 11:54	53.6	50.2	44.6	47.8
Tuesday	03-Jul-18	13:54 - 14:09	52.8	50.7	46.3	48.6
Tuesday	21-Aug-18	11:00-11:15	57.2	53.0	45.6	50.0
Monday	03-Sep-18	13:23 - 13:38	52.3	50.1	44.8	48.0
Wednesday	03-Oct-18	11:25 -11:40	53.8	48.9	43.6	46.7
Wednesday	14-Nov-18	12:30-12:45	53.7	50.3	44.3	47.9
Monday	03-Dec-18	12:09-12:24	54.4	49.9	45.1	47.8
Tuesday	15-Jan-19	08:56 - 09:11	55.8	51.8	45.1	49.2
Monday	11-Feb-19	10:47-11:03	54.3	48.9	42.2	46.6
Tuesday	19-Mar-19	8:46-09:01	56.1	52.1	43.3	48.9

Results MS2 2017 - 2021

Day	Date	Time	LA01	LA10	LA90	LAeq
Thursday	18-Apr-19	09:13 - 09:28	57.6	54.5	47.3	51.5
Tuesday	14-May-19	15:41 - 15:56	58.2	56.2	51.6	54.0
Wednesday	19-Jun-19	11:02 - 11:17	55.1	50.2	45.4	48.2
Wednesday	24-Jul-19	11:06 - 11:21	55.8	51.4	46.4	49.7
Monday	12-Aug-19	12:00 - 12:15	55.9	52.0	45.5	49.6
Monday	09-Sep-19	10:00 - 10:15	58.2	51.9	44.2	49.2
Tuesday	08-Oct-19	09:20 - 09:35	57.3	53.4	46.2	50.6
Wednesday	06-Nov-19	10:47 - 11:02	54.3	49.7	40.6	46.8
Tuesday	08-Dec-20	09:11 - 09:26	54.9	51.5	43.0	48.6
Wednesday	22-Jan-20	10:22 - 10:37	56.7	54.3	51.1	52.7
Wednesday	26-Feb-20	09:20 - 09:35	58.0	54.1	46.6	51.2
Tuesday	19-Jan-21	10:24 - 10:39	57.2	52.2	47.6	50.3
Thursday	04-Feb-21	10:52- 11:07	55.9	51.1	46.2	49.0
Tuesday	02-Mar-21	08:33 - 08:48	56.0	52.9	48.0	50.6
Monday	19-Apr-21	11:42 - 11:57	55.9	51.0	43.7	48.2
Wednesday	12-May-21	10:08 - 10:23	55.6	51.3	43.2	48.7
Thursday	14-Jun-21	09:15 - 09:30	60.9	53.4	43.4	50.5
Monday	12-Jul-21	12:29 - 12:44	53.2	49.2	43.0	46.8
Wednesday	18-Aug-21	11:07 – 11:22	55.6	49.2	40.3	46.5
Tuesday	07-Sep-21	11:37 – 11:52	55.3	50.5	42.6	47.5
Tuesday	05-Oct-21	10:22 – 10:37	58.0	52.5	44.5	49.7
Tuesday	09-Nov-21	14:54 – 15:09	56.7	51.2	41.8	47.7
Tuesday	14-Dec-21	08:41 – 08:56	57.2	53.7	46.6	51.0
Wednesday	19-Jan-22	11:12 – 11:27	60.3	55.5	47.7	53.1
Wednesday	09-Feb-22	09:43 – 09:58	69.8	67.9	61.4	65.4
Monday	14-Mar-22	13:14 – 13:29	60.3	53.9	49.2	52.7
Monday	11-Apr-22	09:20 – 09:35	67.8	63.2	57.0	61.2
Monday	23-May-22	10:59 – 11:14	58.4	55.0	50.8	53.1
Wednesday	01-Jun-22	12:34 – 12:49	61.3	58.9	53.8	57.0
Monday	18-Jul-22	10:13 – 10:28	56.4	52.4	46.7	50.1
Tuesday	30-Aug-22	15:31 – 15:46	51.3	47.7	38.4	44.7
Wednesday	07-Sep-22	11:05 – 11:20	53.5	48.5	40.1	46.0
Wednesday	12-Oct-22	08:48 – 09:03	54.0	47.2	39.2	45.8
Tuesday	08-Nov-22	15:23 – 15:38	56.4	52.4	44.3	50.3
Tuesday	20-Dec-22	09:41 – 09:56	55.0	51.0	43.4	48.3
Tuesday	17-Jan-23	11:32 – 11:47	51.6	48.1	37.4	45.0

Table 11.12: Daytime Monthly Noise Monitoring at MS 3 between 2017 and 2021

Results MS3 2017 - 2021

Day	Date	Time	LA01	LA10	LA90	LAeq
Monday	16-Jan-17	14:03 - 14:18	50.5	48.0	46.0	47.4
Tuesday	14-Feb-17	11:35 - 11:50	47.5	47.0	45.5	46.4

Results MS3 2017 - 2021

Day	Date	Time	LA01	LA10	LA90	LAeq
Wednesday	01-Mar-17	13:31 - 13:46	49.5	49.0	47.5	48.4
Thursday	06-Apr-17	09:45 - 10:00	50.0	48.0	46.5	47.4
Tuesday	16-May-17	09:04 - 09:19	52.5	48.5	44.5	46.3
Tuesday	06-Jun-17	09:18 - 09:33	53.7	53.2	49.6	51.9
Tuesday	11-Jul-17	09:02 - 09:17	42.0	41.0	39.1	40.0
Wednesday	30-Aug-17	12:22 - 12:37	48.0	46.2	43.5	45.1
Monday	25-Sep-17	11:10 - 11:25	52.0	52.4	44.3	49.8
Thursday	12-Oct-17	10:34 - 10:49	49.3	47.2	45.4	46.3
Wednesday	22-Nov-17	10:49 - 11:04	52.3	49.7	48.0	49.0
Wednesday	13-Dec-17	11:24 - 11:39	52.0	50.2	48.2	49.2
Wednesday	10-Jan-18	12:41 - 12:56	48.4	47.9	46.3	47.1
Thursday	15-Feb-18	11:22 - 11:37	54.1	51.7	49.1	50.8
Tuesday	06-Mar-18	13:26 - 13:41	49.9	48.2	46.7	47.4
Wednesday	18-Apr-18	10:25 - 10:40	55.8	47.8	44.8	47.2
Wednesday	09-May-18	13:01 - 13:16	52.1	48.6	45.3	47.3
Wednesday	06-Jun-18	14:32 - 14:37	47.0	43.4	40.4	42.1
Thursday	12-Jul-18	09:37 - 09:52	46.2	37.6	30.0	35.4
Monday	20-Aug-18	09:06 - 09:21	45.2	39.8	<30	36.6
Wednesday	05-Sep-18	13:15 - 13:30	45.9	43.7	41.6	42.6
Thursday	18-Oct-18	14:04 -14:19	54.9	49.5	47.9	49.0
Tuesday	06-Nov-18	14:57-15:12	54.4	51.3	47.6	49.6
Tuesday	04-Dec-18	13:01-13:16	50.7	48.8	46.7	48.4
Thursday	10-Jan-19	10:49 - 11:04	50.1	47.0	45.5	46.3
Wednesday	06-Feb-19	11:34-11:49	55.4	50.6	48.6	50.1
Wednesday	20-Mar-19	9:49-10:04	49.6	48.9	47.4	48.0
Monday	15-Apr-19	09:23 - 09:38	56.6	51.3	47.2	49.6
Thursday	16-May-19	09:47 - 10:02	52.2	47.5	45.2	46.5
Tuesday	18-Jun-19	09:45 - 10:00	47.2	42.8	36.0	40.3
Tuesday	16-Jul-19	08:52 - 09:07	45.6	43.4	42.0	42.7
Tuesday	13-Aug-19	12:51 - 13:06	51.8	49.0	47.6	48.6
Tuesday	24-Sep-19	12:40 - 12:55	53.2	48.5	45.5	47.2
Tuesday	22-Oct-19	11:14- 11:29	50.8	48.5	44.6	48.1
Tuesday	05-Nov-19	09:15 - 09:30	49.5	48.6	47.3	47.9
Wednesday	02-Dec-20	09:03 - 09:18	49.5	48.8	47.5	48.1
Thursday	09-Jan-20	10:35 - 10:50	51.0	46.7	44.8	45.8
Wednesday	05-Feb-20	09:22 - 09:37	52.7	49.5	47.6	48.6
Tuesday	12-Jan-21	13:42 - 13:57	48.1	47.3	46.2	46.7
Wednesday	03-Feb-21	10:01 - 10:16	51.1	50.0	48.6	49.3
Wednesday	03-Mar-21	09:58 - 10:13	51.1	49.8	48.5	49.0
Tuesday	13-Apr-21	08:19 - 08:34	52.2	48.8	46.5	47.7

Results MS3 2017 - 2021						
Day	**Date**	**Time**	**LA01**	**LA10**	**LA90**	**LAeq**
Monday	10-May-21	11:32 - 11:47	52.7	49.0	46.2	47.7
Wednesday	02-Jun-21	09:48 - 10:03	50.1	46.4	43.6	45.1
Wednesday	14-Jul-21	09:38 - 09:53	49.0	48.2	46.6	47.4
Tuesday	17-Aug-21	09:02 – 09:17	51.4	49.5	47.6	48.5
Thursday	02-Sep-21	11:55 – 12:10	55.4	52.2	49.9	51.3
Tuesday	12-Oct-21	09:28 – 09:43	52.1	47.0	45.6	46.5
Monday	08-Nov-21	13:59 – 14:14	53.6	48.8	47.3	48.9
Wednesday	15-Dec-21	10:57 – 11:12	51.1	50.0	47.3	48.6
Tuesday	11-Jan-22	08:56 – 09:11	51.0	50.0	48.3	49.0
Wednesday	02-Feb-22	09:39 – 09:54	51.1	49.1	50.1	51.1
Thursday	03-Mar-22	10:13 – 10:28	54.2	50.5	48.3	49.4
Tuesday	12-Apr-22	11:19 – 11:34	52.2	49.5	47.2	48.5
Thursday	12-May-22	09:25 – 09:40	51.3	49.6	47.5	48.6
Monday	20-Jun-22	14:08 – 14:23	47.0	41.9	33.3	39.0
Wednesday	13-Jul-22	11:10 -11:25	50.0	48.6	46.9	47.9
Wednesday	24-Aug-22	12:31 – 12:46	50.7	49.0	47.2	48.1
Wednesday	14-Sep-22	10:37 – 10:52	52.3	50.1	48.2	49.3
Wednesday	05-Oct-22	08:30 – 08:45	50.9	49.0	47.9	48.6
Thursday	10-Nov-22	08:37 – 08:52	54.9	50.7	49.1	50.1
Monday	05-Dec-22	09:28 – 09:43	51.9	49.3	48.1	49.1
Thursday	19-Jan-23	14:15 – 14:30	50.0	49.4	48.3	48.9

11.4.2 Knocknacran West Mine Site: Characterisation of Baseline Noise Environment

The measured noise levels at all NMPs for the September 2021 and March 2023 surveys are summarised in Table 11.13 and Table 11.14.

Table 11.13: Baseline Noise Monitoring Data 2021 – all NMPs

Location / Reading	Date	Time	Measured Noise Levels (dB re. 2x10^{-5} Pa)			
			L_{Aeq}	L_{Amax}	L_{A10}	L_{A90}
NMP1 Daytime	01/09/2021	13:26:45	59.3	71.9	64.1	39.8
NMP1 Daytime	01/09/2021	14:18:27	57.3	69.3	62.1	38.7
NMP1 Daytime	02/09/2021	14:36:26	58.7	70.5	63.8	39.0
NMP1 Daytime	01/09/2021	15:08:43	57.4	70.0	61.8	38.9
						39.1
NMP1 Evening	02/09/2021	19:10:35	54.9	68.2	60.2	32.8
NMP1 Evening	01/09/2021	21:19:56	53.1	67.5	58.4	29.3
NMP1 Evening	01/09/2021	22:13:23	49.2	66.1	47.6	24

						28.7
NMP1 Night	01/09/2021	23:04:36	45.2	62	42.2	25.3
NMP1 Night	01/09/2021	23:54:59	49.7	69.7	48.6	25.8
NMP1 Night	02/09/2021	00:45:52	45.3	67.5	40.0	22.5
NMP1 Night Arithmetic Average of L_{AF90}						24.5
NMP2 Daytime	01/09/2021	13:05:12	56.8	68.4	60.5	49.8
NMP2 Daytime	02/09/2021	14:09:13	57.4	75.4	61.3	47.5
NMP2 Daytime	01/09/2021	14:12:47	57.9	69.8	61.9	44.9
NMP2 Daytime	02/09/2021	16:07:51	57.5	69.1	61.6	44.8
NMP2 Daytime Arithmetic Average of L_{AF90}						46.8
NMP2 Evening	02/09/2021	20:10:37	55.2	67.9	60.0	34.4
NMP2 Evening	01/09/2021	21:18:28	57.9	71.3	63.1	32
NMP2 Evening	01/09/2021	22:13:48	56	72.3	58.7	30.7
NMP2 Evening Arithmetic Average of L_{AF90}						32.4
NMP2 Night	01/09/2021	23:18:57	55.2	72.2	56.8	28.7
NMP2 Night	02/09/2021	00:23:38	48.1	69.7	46.9	26.2
NMP2 Night	02/09/2021	01:35:39	32.3	52.3	33.5	28.0
NMP2 Night Arithmetic Average of L_{AF90}						**27.6**
NMP3 Daytime	01/09/2021	13:53:46	40.7	50.8	43.9	34.3
NMP3 Daytime	01/09/2021	14:42:23	44.2	53.7	47.4	38.8
NMP3 Daytime	02/09/2021	14:59:08	42.2	55.9	45.4	35.8
NMP3 Daytime	01/09/2021	15:38:54	42.9	56.7	46.1	36.3
						36.3
NMP3 Evening	02/09/2021	19:36:23	45.5	71.7	43.8	30.3
NMP3 Evening	01/09/2021	21:45:40	38.3	54.7	42.7	28.4
NMP3 Evening	01/09/2021	22:37:32	35.9	48.4	39.4	28.9
						29.2
NMP3 Night	01/09/2021	23:28:50	32.7	55.5	36.3	24.7
NMP3 Night	02/09/2021	00:20:07	32.0	45.8	33.8	25.4
NMP3 Night	02/09/2021	01:09:34	30.6	51.4	32.6	26.4
NMP3 Night Arithmetic Average of L_{AF90}						25.5
NMP4 Daytime	01/09/2021	13:48:57	51.0	81.4	52.8	41.6
NMP4 Daytime	01/09/2021	14:50:50	53.1	77.6	55.7	45.9
NMP4 Daytime	02/09/2021	15:27:45	55.1	83.7	52.0	35.7
NMP4 Daytime	02/09/2021	16:29:26	45.6	62.1	47.7	35.3
						39.6
NMP4 Evening	02/09/2021	19:11:49	47.5	66.7	50.8	33.7
NMP4 Evening	02/09/2021	19:48:25	45.8	61.9	48.7	33.3
NMP4 Evening	01/09/2021	21:54:36	41.0	63.9	40.2	30.3
						32.4
NMP4 Night	01/09/2021	23:00:09	42.0	63.2	38.3	33.8
NMP4 Night	02/09/2021	00:02:39	44.1	67.1	33.4	26.6
NMP4 Night	02/09/2021	01:02:30	34.2	50.2	34.7	33.5
NMP4 Night Arithmetic Average of L_{AF90}						31.3

NMP5 Daytime	01/09/2021	13:30:46	38.1	55.6	40.6	33.5
NMP5 Daytime	01/09/2021	14:32:17	39.1	63.9	39.1	32.0
NMP5 Daytime	02/09/2021	15:47:52	44.0	68.2	40.3	33.3
NMP5 Daytime	02/09/2021	16:44:39	39.2	61.1	41.0	33.8
						33.2
NMP5 Evening	02/09/2021	19:30:36	37	53	39.6	31.0
NMP5 Evening	01/09/2021	21:37:09	35.8	52.5	38.7	30.2
NMP5 Evening	01/09/2021	22:32:25	33.5	54.2	36.2	27.3
						29.5
NMP5 Night	01/09/2021	23:38:00	29.7	49.1	32.1	26.4
NMP5 Night	02/09/2021	00:43:28	31.3	49.5	33.4	26.4
NMP5 Night	02/09/2021	01:20:57	32.5	61.4	32.4	28.0
NMP5 Night Arithmetic Average of L_{AF90}						26.9

Table 11.14: Baseline Noise Monitoring Data 2023 – all NMPs

Location / Reading	Date	Time	Measured Noise Levels (dB re. $2x10^{-5}$ Pa)			
			L_{Aeq}	L_{Amax}	L_{A10}	L_{A90}
NMP1 Daytime	07/03/2023	14:33:58	60.4	72.6	65.5	38.8
NMP1 Daytime	07/03/2023	16:14:09	61.6	71.1	66.1	43.1
NMP1 Daytime	07/03/2023	13:28:01	57.1	70.9	62.1	37.7
NMP1 Daytime	07/03/2023	15:18:59	58.9	72.7	64.2	38.9
NMP1 Daytime Arithmetic Average of L_{AF90}						40.0
NMP1 Evening	07/03/2023	20:35:10	53.6	67.4	58.8	34.8
NMP1 Evening	07/03/2023	19:10:19	58.8	70.4	64.2	42.6
NMP1 Evening Arithmetic Average of L_{AF90}						38.7
NMP1 Night	08/03/2023	00:16:39	46.1	67.4	42.3	19.6
NMP1 Night	07/03/2023	23:00:36	51.1	69.4	48.2	25.3
NMP1 Night Arithmetic Average of L_{AF90}						22.5
NMP2 Daytime	07/03/2023	13:12:20	42.0	58.8	45.7	37.5
NMP2 Daytime	07/03/2023	14:54:00	49.4	63.9	52.8	40.6
NMP2 Daytime	07/03/2023	13:49:22	47.2	63.2	50.5	38.9
NMP2 Daytime	07/03/2023	15:38:38	51.7	65.2	55.4	41.7
NMP2 Daytime Arithmetic Average of L_{AF90}						39.7
NMP2 Evening	07/03/2023	19:09:23	53.7	62.8	57.7	44.6
NMP2 Evening	07/03/2023	19:33:23	55.7	66.3	59.2	46.6
NMP2 Evening Arithmetic Average of L_{AF90}						45.6
NMP2 Night	07/03/2023	23:00:05	50.8	71.7	54.8	24.4
NMP2 Night	07/03/2023	23:20:54	43.6	58.8	45.0	22.1
NMP2 Night-time Arithmetic Average of L_{AF90}						**23.3**
NMP3 Day	07/03/2023	13:34:22	41.8	58.1	46.2	30.9
NMP3 Day	07/03/2023	15:15:18	39.4	55.8	43.2	30.0
NMP3 Day	07/03/2023	14:14:58	42.8	60.9	46.9	31.6
NMP3 Day	07/03/2023	16:03:03	46.0	70.7	43.0	33.7
NMP3 Daytime Arithmetic Average of L_{AF90}						31.6

NMP3 Evening	07/03/2023	19:31:06	39.4	55.6	42.1	33.8
NMP3 Evening	07/03/2023	19:57:33	39.0	58.6	40.1	32.7
NMP3 Evening Arithmetic Average of L_{AF90}						33.3
NMP3 Night	07/03/2023	23:43:08	31.5	55.9	33.0	28.3
NMP3 Night	07/03/2023	23:19:29	42.0	78.5	33.6	28.5
NMP3 Night-time Arithmetic Average of L_{AF90}						28.4
NMP4 Daytime	07/03/2023	13:53:57	50.9	74.8	53.9	39.2
NMP4 Daytime	07/03/2023	15:34:18	44.1	67.1	45.8	36.1
NMP4 Daytime	07/03/2023	14:35:27	45.7	62.1	49.9	32.1
NMP4 Daytime	07/03/2023	16:22:14	47.4	63.9	50.3	34.9
NMP4 Daytime Arithmetic Average of L_{AF90}						35.6
NMP4 Evening	07/03/2023	20:16:52	45.9	64.5	45.8	30.3
NMP4 Evening	07/03/2023	19:51:52	47.0	65.3	49.8	32.9
NMP4 Evening Arithmetic Average of L_{AF90}						31.6
NMP4 Night	08/03/2023	00:03:41	32.5	44.5	34.6	25.9
NMP4 Night	07/03/2023	23:37:24	33.1	54.5	36.1	25.7
NMP4 Night Arithmetic Average of L_{AF90}						25.8
NMP5 Day	07/03/2023	14:13:21	53.9	75.2	54.0	28.7
NMP5 Day	07/03/2023	15:53:29	46.6	69.9	49.0	34.2
NMP5 Day	07/03/2023	16:41:31	49.2	71.9	52.8	38.7
NMP5 Day	07/03/2023	14:57:27	48.2	66.1	51.6	31.9
NMP5 Daytime Arithmetic Average of L_{AF90}						33.4
NMP5 Evening	07/03/2023	20:13:34	40.5	54.4	44.3	32.3
NMP5 Evening	07/03/2023	20:37:11	40.1	55.3	42.9	30.8
NMP5 Evening Arithmetic Average of L_{AF90}						31.6
NMP5 Night	08/03/2023	00:28:10	26.1	42.5	29.4	19.8
NMP5 Night	07/03/2023	23:57:31	32.5	61.6	34.8	20.8
NMP5 Night Arithmetic Average of L_{AF90}						**20.3**

At NMP1 during the daytime and evening periods, the dominant noise source was cars passing on the R179. The other significant contributor to the noise environment was birdsong during the daytime period. Less significant contributors included dogs barking and foxes calling.

During the night-time period at NMP1 the dominant noise source was distant road traffic from the surrounding road network. Lesser contributors to the noise environment included sporadic traffic passing on the R179 and occasional noise from cows.

At NMP2 during the daytime and evening periods the dominant noise source was road traffic on the adjacent main road. Birdsong and activity from a nearby shop were also significant contributors to overall noise levels. Lesser contributors to noise levels included noise from cows and dogs barking.

During the night-time period at NMP2 the dominant noise source was cars passing on the adjacent main road. Noise from the nearby shop was still audible. Wind induced vegetation noise and cows from the field opposite the shop were still audible.

At NMP3 during the daytime and evening periods the noise environment was dominated by distant road traffic from the surrounding road network and birdsong. Lesser contributors to noise levels included sporadic cars passing on the farm road and dogs barking intermittently.

During the night-time period at NMP3 the dominant noise sources was distant road traffic from the surrounding road network. Other noise sources included dogs barking and distant beeps from machinery.

At NMP4 during the daytime and evening periods the dominant noise source was road traffic on the adjacent road and from the R179 during quieter times. Activity from the school was heard during monitoring, this included children and parents shouting and talking in the car park. Other noise sources included occasional deliveries from the mushroom factory and dogs barking intermittently.

At NMP4 during the night-time period the dominant noise sources were road traffic on the adjacent road and from the R179. Other noise sources included dogs barking intermittently.

At NMP5 during the daytime and evening periods the dominant noise source was cars passing on the adjacent farm road. Traffic from the R179 was constant but at a low level. Birdsong was also a significant contributor to overall noise levels.

During the night-time period at NMP5 the dominant noise source was constant traffic on the R179. Birdsong was still audible but a lesser contributor to overall noise levels. Lesser contributors to the noise environment included cows in the adjacent field and sporadic traffic on the farm road.

11.5 Key Characteristics of the Proposed Development

11.5.1 Construction Phase: Community Sports Complex

During this phase, the existing Community Sports Complex will be further developed. The initial phase of this development has been constructed (Reg. Ref.: 20/365), and the next phase will involve extending the Community Sports Complex with the construction of two further playing pitches, one with a perimeter running track, an all-weather pitch, a new club building, including a sports hall, a handball alley, changing rooms & toilets, a viewing gallery, a part-covered grandstand, additional parking and associated siteworks.

11.5.2 Construction Phase: Mine Development

During this phase:

- Screening berms will be constructed;
- Planting (including bolstering and retention of the existing perimeter hedgerow which sits in front of/is separate to the proposed planted screening berms) will be carried out;
- Perimeter fencing, will be installed;
- One residential house and three unoccupied houses and sheds on the Knocknacran West site will be demolished;
- A temporary diversion of the R179 will be constructed to maintain traffic flow while a Cut-and-Cover Tunnel is constructed; and

- A new vehicular entrance will be constructed to the existing mine site from the L4816.

11.5.3 Operational Phase: Mine Development

During this phase:

- Open Cast mining will be undertaken to allow extraction of the Gypsum from the Drumgoosat Underground mine area closed in 1989. The gypsum extracted will maintain a continuous supply of mineral as the current Knocknacran mine will be exhausted as the new mine is brought into operation;

- The proposed Mine Development amounts to the replacement of the loss of mining of gypsum at the Knocknacran Open-Cast Mine with the mining of gypsum at Knocknacran West Open-Cast Mine. Both mine sites are comparable in size and nature of operations;

- Overburden and Interburden will be stripped (by mechanical means, i.e. excavator and up to 8 haul trucks) to expose the Gypsum Mineral at the new Knocknacran West Open cast mine;

- The stripping of the site will be undertaken in a series of campaigns at specific times and will last for defined periods of time (typically < 6 months) over the life of the proposed Mine Development. The stripping earthworks will be undertaken by a specialist contractor following a tender process;

- The gypsum remaining in the former Drumgoosat Underground Mine will be extracted by open-cast mining methods;

- The existing Knocknacran Mine will be restored to near original ground level;

- The existing processing plant on the existing Knocknacran Open-Cast Mine site will be refurbished; and

- The existing plant site will process and despatch the extracted gypsum in line with current permitted levels.

11.5.4 Restoration/Closure Phase: Community Sports Complex

There is no proposal to close the Community Sports Complex development, and this phase is therefore not applicable in this case.

11.5.5 Restoration/Closure Phase: Mine Development

During this phase:

- The new Knocknacran West site will be returned to grassland and a waterbody;

- The existing Knocknacran Plant site will be partially dismantled whereby mine plant is removed; and

- In line with the current CRAMP it is presented that here that a suitable developer would be sought to utilise the general buildings existing on the existing site for a light industrial usage into the future. This would be subject to a future developer seeking the necessary permits for continuation of use and change of use from mining to a non-mining use.

11.6 Potential Effects

11.6.1 Potential Effects: Construction Phase: Community Sports Complex

Evaluation of the predicted noise levels against the limiting value for all NSRs during the construction period for the Community Sports Complex are within target levels by at least 5.5 dB for the daytime period, Table 11.15. Some construction activities will take place on Saturday afternoons and occasional evenings. For these periods, the model has assumed reduced number of plant and lower operating times (see Appendix 11.3). The limiting value for evenings and weekends is met by at least 0.5 dB.

The sensitivity of the receptors are High, the magnitude of impact is considered to be Low (adverse) to No change and the significance of the effect is considered to be Slight to Neutral.

Table 11.15: Predicted noise levels at NSRs during the construction of the Community Sports Complex

Results – Community Sports Complex construction			
Daytime (07:00 – 19:00) and Saturdays (07:00-1300)			
NSR	**Limiting Value - Category A (65dB)**	**Predicted level**	**Comparison with target level dB**
	Day dB	**Day dB**	**Day dB**
NSR17	65	44.5	-20.5
NSR18	65	59.5	-5.5
NSR19	65	50.7	-14.3
Evenings and Weekends			
NSR	**Limiting Value - Category A (55dB)**	**Predicted level**	**Comparison with target level dB**
	Day dB	**Day dB**	**Day dB**
NSR17	55	40.2	-14.8
NSR18	55	54.5	-0.5
NSR19	55	45.1	-9.9

11.6.2 Potential Effects: Construction Phase: Mine Development

Evaluation of the predicted noise levels against the limiting value for all NSRs during the construction period for the Mine Development are within target levels by at least 1.1 dB for the daytime period, Table 11.16.

The sensitivity of the receptors are High, the magnitude of impact is considered to be Low (adverse) to No change and the significance of the effect is considered to be Slight to Neutral.

Table 11.16: Predicted noise levels at NSRs during the construction of the mine

Results – Construction Phase – Mine Development				
Stage of works	Daytime (07:00 – 19:00) and Saturdays (07:00-1300)			
	NSR	Limiting Value - Category A (65dB)	Predicted level	Comparison with target level dB
		Day dB	Day dB	Day dB
House Demolition	NSR22	65	55.8	-9.2
	NSR23	65	59.9	-5.1
Screening Berms	NSR1	65	60.9	-4.1
	NSR16	65	60.0	-5.0
Road Diversion	NSR22	65	63.9	-1.1
	NSR23	65	61.5	-3.5
Mine Tunnel	NSR17	65	54.2	-10.8
	NSR18	65	58.2	-6.8

11.6.3 Potential Effects: Operational Phase: Mine Development

Noise modelling has predicted noise from proposed mining activities to determine the likely worst-case contribution of the Mine Development to the noise environment. The predicted noise levels are presented in Table 11.17 Table 11.20. Phase 1 and Phase 4 represent the extraction activities within the northern extraction area in Knocknacran West and phased restoration in Knocknacran, from shallowest works to deepest works in the Knocknacran West open-cast respectively. Phase 5 and 6 represent the southern extraction activities in Knocknacran West from shallowest works to deepest works in the open-cast respectively.

The model considers both stripping activities (stripping campaigns), which remove overburden and interburden by mechanical means, and gypsum extraction occur simultaneously. However, this is a worst case scenario. Stripping campaigns on the existing site typically last < 6 months and occur every few years to enable the gypsum to be exposed and extracted. Gypsum extraction will not occur in Phase 1 as the gypsum has not been exposed yet and gypsum extraction will not occur in Phase 7 as no gypsum remains to be extracted.

Eight haul trucks modelled in these phases represent the movement of soils and over/interburden materials. As discussed in Section 11.3.1 operational road traffic has been scoped out, based on the traffic data provided in Appendix 14.1 of the EIAR.

The magnitude of impact and significance of effect have been determined with reference to criteria provided in Table 11.4 and Table 11.5, respectively.

Table 11.17: Evaluation of predicted levels against target levels – Phase 1

Noise Sensitive Receptor	Predicted Noise Level dB(A)	Predicted level minus target level, LAeq,15mins	Magnitude of Impact	Significance of effect
Daytime – 08:00 to 19:00 – Low Noise NSRs - Target Level 45 dB(A) – Haul Trucks with engines off while being loaded				
NSR1	42.3	-2.8	Low Adverse	Slight
NSR2	29.1	-15.9	No change	Neutral
NSR3	27.9	-17.1	No change	Neutral
NSR4	25.9	-19.1	No change	Neutral
NSR7	30.8	-14.2	No change	Neutral
NSR9	35.3	-9.7	No change	Neutral
NSR10	33.5	-11.5	No change	Neutral
Daytime – 08:00 to 19:00 - Target Level 55 dB(A				
NSR15	28.7	-26.3	No change	Neutral
NSR17	29.0	-26.0	No change	Neutral
NSR18	29.5	-25.5	No change	Neutral
NSR19	27.3	-27.7	No change	Neutral
NSR22	28.6	-26.4	No change	Neutral
NSR23	42.3	-12.7	No change	Neutral
Evening – 19:00 to 20:00, Low Noise NSRs - Target Level 40 dB(A) - 5 Haul truck movements per hour, assumed 20km/h speed, 1 Excavator in operation, Haul Trucks with engines off while being loaded				
NSR1	39.5	-0.5	Low Adverse	Slight
NSR2	26.8	-13.2	No change	Neutral
NSR3	25.7	-14.3	No change	Neutral
NSR4	23.8	-16.2	No change	Neutral
NSR7	28.6	-11.4	No change	Neutral
NSR9	33.1	-6.9	No change	Neutral
NSR10	31.5	-8.5	No change	Neutral
Evening – 19:00 to 20:00 Level 50 dB(A)				
NSR15	26.5	-23.5	No change	Neutral
NSR17	26.9	-23.1	No change	Neutral
NSR18	27.5	-22.5	No change	Neutral
NSR19	25.2	-24.8	No change	Neutral
NSR22	27.2	-22.8	No change	Neutral
NSR23	41.3	-8.7	No change	Neutral

Table 11.18: Evaluation of predicted levels against target levels – Phase 4

Noise Sensitive Receptor	Predicted Noise Level dB(A)	Predicted level minus target level, LAeq,15mins	Magnitude of Impact	Significance of effect
Daytime – 08:00 to 19:00 – Low Noise NSRs - Target Level 45 dB(A)				
NSR1	40.1	-4.9	Low Adverse	Slight
NSR2	30.7	-14.3	No change	Neutral
NSR3	31.1	-13.9	No change	Neutral
NSR4	29	-16.0	No change	Neutral
NSR7	31.8	-13.2	No change	Neutral
NSR9	39.4	-5.6	No change	Neutral
NSR10	32.7	-12.3	No change	Neutral
Daytime – 08:00 to 19:00 - Target Level 55 dB(A				
NSR15	39.6	-15.4	No change	Neutral
NSR17	42.9	-12.1	No change	Neutral
NSR18	50.1	-4.9	Low Adverse	Slight
NSR19	47.8	-7.2	No change	Neutral
NSR22	49.3	-5.7	No change	Neutral
NSR23	42.7	-12.3	No change	Neutral
Evening – 19:00 to 20:00, Low Noise NSRs - Target Level 40 dB(A) - 5 Haul truck movements per hour, assumed 20km/h speed, Haul Trucks with engines off while being loaded				
NSR1	39.7	-0.3	Low Adverse	Slight
NSR2	30.4	-9.6	No change	Neutral
NSR3	30.9	-9.1	No change	Neutral
NSR4	28.6	-11.4	No change	Neutral
NSR7	31.6	-8.4	No change	Neutral
NSR9	38.2	-1.8	Low Adverse	Slight
NSR10	32.3	-7.7	No change	Neutral
Evening – 19:00 to 20:00, Target Level 50 dB(A)				
NSR15	38.0	-17.0	No change	Neutral
NSR17	41.7	-13.3	No change	Neutral
NSR18	45.7	-9.3	No change	Neutral
NSR19	44.7	-10.3	Low Adverse	Slight
NSR22	47.2	-7.8	No change	Neutral
NSR23	41.4	-13.6	No change	Neutral

Table 11.19: Evaluation of predicted levels against target levels – Phase 5

Noise Sensitive Receptor	Predicted Noise Level dB(A)	Predicted level minus target level, LAeq,15mins	Magnitude of Impact	Significance of effect
Daytime – 08:00 to 19:00 – Low Noise NSRs - Target Level 45 dB(A)				
NSR1	41.2	-3.8	Low Adverse	Slight
NSR2	38.4	-6.6	No change	Neutral
NSR3	37.6	-7.4	No change	Neutral

NSR4	35.4	-9.6	No change	Neutral
NSR7	40.5	-4.5	Low Adverse	Slight
NSR9	43.8	-1.2	Low Adverse	Slight
NSR10	43.8	-1.2	Low Adverse	Slight
Daytime – 08:00 to 19:00 – Target Level 55 dB(A)				
NSR15	34.5	-20.5	No change	Neutral
NSR17	40.1	-14.9	No change	Neutral
NSR18	41.9	-13.1	No change	Neutral
NSR19	40.4	-14.6	No change	Neutral
NSR22	41.3	-13.7	No change	Neutral
NSR23	46.4	-8.6	No change	Neutral
Evening – 19:00 to 20:00, Low Noise NSRs - Target Level 40 dB(A) - 5 Haul truck movements per hour, assumed 20km/h speed, 1 Excavator in operation, Haul Trucks with engines off while being loaded				
NSR1	38.9	-1.1	Low Adverse	Slight
NSR2	27.3	-12.7	No change	Neutral
NSR3	28.3	-11.7	No change	Neutral
NSR4	28.5	-11.5	No change	Neutral
NSR7	29.2	-10.8	No change	Neutral
NSR9	36.8	-3.2	Low Adverse	Slight
NSR10	40.0	0.0	Low Adverse	Slight
Evening – 19:00 to 20:00, Target Level 50 dB(A)				
NSR15	34.5	-15.5	No change	Neutral
NSR17	40.1	-9.9	No change	Neutral
NSR18	41.9	-8.1	No change	Neutral
NSR19	40.4	-9.6	No change	Neutral
NSR22	41.3	-8.7	No change	Neutral
NSR23	46.4	-3.6	Low Adverse	Slight

Table 11.20: Evaluation of predicted levels against target levels – Phase 6

Noise Sensitive Receptor	Predicted Noise Level dB(A)	Predicted level minus target level, LAeq,15mins	Magnitude of Impact	Significance of effect
Daytime – 08:00 to 19:00 – Low Noise NSRs - Target Level 45 dB(A) - Haul Trucks with engines off while being loaded				
NSR1	41.2	-3.8	Low Adverse	Slight
NSR2	34.4	-10.6	No change	Neutral
NSR3	31.8	-13.2	No change	Neutral
NSR4	31.0	-14.0	No change	Neutral
NSR7	30.5	-14.5	No change	Neutral
NSR9	37.9	-7.1	No change	Neutral
NSR10	42.9	-2.1	Low Adverse	Slight
Daytime – 08:00 to 19:00, Target Level 55 dB(A)				
NSR15	37.0	-18.0	No change	Neutral

NSR17	42.9	-12.1	No change	Neutral
NSR18	43.7	-11.3	No change	Neutral
NSR19	42.4	-12.6	No change	Neutral
NSR22	48.1	-6.9	No change	Neutral
NSR23	50.0	-5.0	Low Adverse	Slight
Evening – 19:00 to 20:00, Low Noise NSRs - Target Level 40 dB(A) - 5 Haul truck movements per hour, assumed 20km/h speed, Haul Trucks with engines off while being loaded				
NSR1	39.6	-0.4	Low Adverse	Slight
NSR2	32.6	-7.4	No change	Neutral
NSR3	29.7	-10.3	No change	Neutral
NSR4	28.9	-11.1	No change	Neutral
NSR7	28.5	-11.5	No change	Neutral
NSR9	36.8	-3.2	Low Adverse	Slight
NSR10	39.8	-0.2	Low Adverse	Slight
Evening – 19:00 to 20:00, Target Level 50 dB(A)				
NSR15	35.8	-14.2	No change	Neutral
NSR17	40.3	-9.7	No change	Neutral
NSR18	42.3	-7.7	No change	Neutral
NSR19	40.4	-9.6	No change	Neutral
NSR22	44.3	-5.7	No change	Neutral
NSR23	45.5	-4.5	Low Adverse	Slight

Predicted noise levels at all NSRs for phases 1 - 6 are below the daytime and evening target levels for proposed operations at the mine.

Noise effects associated with proposed mining operations during the daytime period, and evening period have been evaluated as being of 'neutral' or 'slight' significance and are therefore **Not Significant**.

Night Time Road Haulage

The proposed Mine Development is not seeking to change the existing road haulage hours. Transport of gypsum from the Knocknacran Processing Plant will continue to take place between 06:00 hours and 21:00 hours Monday to Saturday.

EPA night-time hours are 23:00 to 07:00 hours. A one-hour period from 06:00 to 07:00 falls within EPA night-time hours.

Supplementary modelling of road haulage truck movements has been undertaken during the 1 hour period, as this was sought during the former planning application consultation from Monaghan County Council (MCC).

A maximum of 5 road haulage trucks will be in operation and each load will be ca. 25 tonnes. The road trucks were modelled as points sources moving along a line at a speed of 48 km/h. Each truck has been assigned an operating time of 10 minutes per hour. The road trucks will travel along the R179 from the west and turn right onto the L4816 towards the entrance to Knocknacran East.

Predicted noise levels at the closest receptor (NSR20) are 40.2 dB, which is 4.8 dB below the night-time noise limit (45 dB). Noise effects associated during the night-time period have therefore been evaluated as being of 'slight' significance and are therefore **Not Significant**. The detailed results of the night-time noise modelling, including the source noise terms used for the road haulage trucks, are presented in Appendix 11.3.

Drumgoosat National School (NSR3)

Additional consideration has been given to the predicted internal noise levels at Drumgoosat National School A technical assessment is provided in Appendix 11.4. In summary, the technical assessment states that the noise levels will meet the target indoor ambient noise levels recommended in Table 1 of the Department of Education and Skills SDG 02-0503 "Acoustic performance in New Primary and Post Primary School Buildings" document. This assessment also considered the potential cumulative effect with the recently granted Community Centre development application in the village.

11.6.4 Potential Effects: Restoration/Closure Phase: Community Sports Complex

There is no proposal to close the Community Sports Complex development, and this phase is therefore not applicable in this case.

11.6.5 Potential Effects: Restoration/Closure Phase: Mine Development

Noise modelling has predicted noise from proposed restoration activities to determine the likely worst-case contribution of the Mine Development to the noise environment. Phase 6, assessed above in the operational assessment is applicable in the restoration phase as the haul truck movements in this phase move overburden and interburden material from the south to the north of Knocknacran West during operations. During restoration, these haul trucks will move the material from north to south and follow the same route. The Phase 7 model represents the final restored profile when works are winding down and the material from Phase 6 has been moved.

Works will be undertaken by mechanical plant. Modelling undertaken in Eight haul trucks modelled in these phases represent the movement of soils over/interburden materials.

The predicted noise levels are presented in Table 11.22 and Table 11.22.

The magnitude of impact and significance of effect have been determined with reference to criteria provided in Table 11.4 and Table 11.5, respectively.

As the restoration phase progresses and the site is restored and left to passive aftercare, noise generating activities will gradually cease on site.

Table 11.21: Evaluation of predicted levels against target levels – Phase 6

Noise Sensitive Receptor	Predicted Noise Level dB(A)	Predicted level minus target level, LAeq,15mins	Magnitude of Impact	Significance of effect
Daytime – 08:00 to 19:00 – Low Noise NSRs - Target Level 45 dB(A) - Haul Trucks with engines off while being loaded				
NSR1	41.2	-3.8	Low Adverse	Slight
NSR2	34.4	-10.6	No change	Neutral
NSR3	31.8	-13.2	No change	Neutral

NSR4	31.0	-14.0	No change	Neutral
NSR7	30.5	-14.5	No change	Neutral
NSR9	37.9	-7.1	No change	Neutral
NSR10	42.9	-2.1	Low Adverse	Slight
Daytime – 08:00 to 19:00, Target Level 55 dB(A)				
NSR15	37.0	-18.0	No change	Neutral
NSR17	42.9	-12.1	No change	Neutral
NSR18	43.7	-11.3	No change	Neutral
NSR19	42.4	-12.6	No change	Neutral
NSR22	48.1	-6.9	No change	Neutral
NSR23	50.0	-5.0	Low Adverse	Slight
Evening – 19:00 to 20:00, Low Noise NSRs - Target Level 40 dB(A) - 5 Haul truck movements per hour, assumed 20km/h speed, Haul Trucks with engines off while being loaded				
NSR1	39.6	-0.4	Low Adverse	Slight
NSR2	32.6	-7.4	No change	Neutral
NSR3	29.7	-10.3	No change	Neutral
NSR4	28.9	-11.1	No change	Neutral
NSR7	28.5	-11.5	No change	Neutral
NSR9	36.8	-3.2	Low Adverse	Slight
NSR10	39.8	-0.2	Low Adverse	Slight
Evening – 19:00 to 20:00, Target Level 50 dB(A)				
NSR15	35.8	-14.2	No change	Neutral
NSR17	40.3	-9.7	No change	Neutral
NSR18	42.3	-7.7	No change	Neutral
NSR19	40.4	-9.6	No change	Neutral
NSR22	44.3	-5.7	No change	Neutral
NSR23	45.5	-4.5	Low Adverse	Slight

Table 11.22: Evaluation of predicted levels against target levels – Phase 7

Noise Sensitive Receptor	Predicted Noise Level dB(A)	Predicted level minus target level, L_{Aeq},15mins	Magnitude of Impact	Significance of effect
Daytime – 08:00 to 19:00 – Low Noise NSRs - Target Level 45 dB(A) – Haul Trucks with engines off while being loaded, 3 Haul Truck movements per hour, 1 small excavator in operation				
NSR1	33.9	-11.1	No change	Neutral
NSR2	32	-13	No change	Neutral
NSR3	33.1	-11.9	No change	Neutral
NSR4	33.1	-11.9	No change	Neutral
NSR7	34.9	-10.1	No change	Neutral
NSR9	44.0	-1.0	Low Adverse	Slight
NSR10	39.9	-5.1	No change	Neutral
Daytime – 08:00 to 19:00, Target Level 55 dB(A)				
NSR15	25.5	-29.5	No change	Neutral
NSR17	31.6	-23.4	No change	Neutral
NSR18	32.8	-22.2	No change	Neutral

NSR19	30.5	-24.5	No change	Neutral
NSR22	36.7	-18.3	No change	Neutral
NSR23	41.1	-13.9	No change	Neutral

Predicted noise levels at all NSRs are below the daytime target levels for the proposed restoration at the mine.

Noise effects associated with proposed restoration during the daytime period have been evaluated as being of 'neutral' or 'slight' significance and are therefore **Not Significant**.

The plant site at Knocknacran is likely to be demolished during this phase. Demolition phase activities will be of short duration; furthermore, this assessment considers that potential noise at existing noise-sensitive receptors during demolition can be addressed through implementation of appropriate controls. Recommended good practice and standard mitigation measures are detailed in Section 11.7.6.

11.7 Mitigation and Management

11.7.1 Mitigation and Management: Construction Phase: Community Sports Complex

Embedded Design Mitigation: Construction Phase: Community Sports Complex

- Works will be undertaken in line with any conditions set by MCC;
- Perimeter screening berms and/or bolstering of hedges will be take place along the site boundary; and
- Screening berms will be planted with native tree and shrub species.

Additional Mitigation: Construction Phase: Community Sports Complex

In addition to the embedded design mitigation presented in Section11.7.1 the following mitigation will also be undertaken:

- Construction phase activities at the Community Sports Complex will take place in accordance with the Construction Environmental Management Plan.
- Scheduling of particularly noisy works to more acceptable times of day (avoiding evenings and early mornings);
- Use of environmentally acceptable plant and equipment which is properly maintained and silenced;
- Proper instruction and supervision of staff – Tool Box talks;
- Rest periods during which all operations are temporarily ceased;
- Shutting down plant when not in active use;
- Limiting dump height of materials into transport vehicles during loading;

- Locating material storage compounds and haul roads away from sensitive areas (i.e. those close to NSRs or with little topographic screening);
- Heavy goods vehicles entering and leaving the existing Site will have tailgates securely fastened; all mobile plant used at the Proposed Development will have noise emission levels that comply with relevant guidance;
- Plant will be operated in a proper manner with respect to minimising noise emissions, e.g. no unnecessary revving of engines, plant used intermittently not left idling; and
- Plant will be subject to regular maintenance, i.e. all moving parts kept well lubricated, the integrity of silencers and acoustic hoods maintained.

11.7.2 Mitigation and Management: Construction Phase: Mine Development

Embedded Design Mitigation: Construction Phase: Mine Development

- During the construction phase, a 2 m to 4 m-high screening berm will be constructed and completed on all sides of the Knocknacran West Open-Cast Mine site.

Additional Mitigation: Construction Phase: Mine Development

In addition to the embedded design mitigation presented in Section11.7.2, above, the following mitigation will also be undertaken:

- Works will be undertaken in line with any conditions set by the MCC;
- Construction phase activities will take place in accordance with the Construction Environmental Management Plan;
- Plant will be operated in a proper manner with respect to minimising noise emissions, e.g. minimisation of drop heights, no unnecessary revving of engines, plant used intermittently not left idling;
- Plant will be subject to regular maintenance, i.e. all moving parts kept well lubricated, the integrity of silencers and acoustic hoods maintained; and
- A noise monitoring programme will be maintained at the existing mine monitoring locations (MS1 and MS2) which are proximal to the construction works areas;
- Perimeter screening berms will be constructed along the site boundary;
- Screening berms will be planted with native tree and shrub species;
- Woodland to the north, nearest Drumgoosat village will be largely retained to provide an additional buffer between the mine site and receptors in the village (such as the national school);
- All haul roads will be kept clean and maintained in a good state of repair;

- Heavy goods vehicles entering and leaving the construction areas will have tailgates securely fastened; all mobile plant used at the proposed Mine Development will have noise emission levels that comply with relevant guidance;

- Plant will be fitted with effective exhaust silencers and maintained in good working order to meet manufacturers' noise rating levels. Defective silencers will be replaced;

- The mine manager will maintain a written complaints log in which all complaints made by local residents are detailed. This will require that the concerns of local residents who may be affected by site activities are considered during the management of activities at the mine site; and

- A point of contact will be established between the mine and local residents, to maintain good community engagement.

11.7.3 Mitigation and Management: Operational Phase: Community Sports Complex

- Works will be undertaken in line with any conditions set by MCC; and

- Any plant will be regularly maintained and kept in good order on the proposed Community Sports Complex site.

11.7.4 Mitigation and Management: Operational Phase: Mine Development

Embedded Mitigation: Operational Phase: Mine Development

- The extraction of gypsum will take place using the mining industry standard method of cyclical drilling, blasting, loading, hauling and supporting;

- Perimeter screening berms will be maintained along the site boundary, as will perimeter hedging and planting on the berms; and

- The removal of soils will be conducted in a phased basis to reduce the overall potential impact on noise.

Additional Mitigation: Operational Phase: Mine Development

In addition to the embedded design mitigation presented in Section11.8.4 the following mitigation will also be undertaken:

- Works will be undertaken in line with any conditions set by the IE licence;

- A noise monitoring programme will be maintained at the existing mine monitoring locations;

- Plant will be operated in a proper manner with respect to minimising noise emissions, e.g. minimisation of drop heights, no unnecessary revving of engines, plant used intermittently not left idling; and

- Plant will be subject to regular maintenance, i.e. all moving parts kept well lubricated, the integrity of silencers and acoustic hoods maintained.

- When the Knocknacran West Mine is in operation, work practices and site activities will be managed, coordinated and timed in such a manner to ensure mining activities do not exceed target noise levels. The company will seek to invest in the best available technologies for plant and equipment so that numbers of plant and equipment are managed, , to ensure operations remain within permitted noise levels at sensitive receptors;

- Woodland to the north, nearest Drumgoosat village will be largely retained to provide an additional buffer between the mine site and receptors in the village (such as the national school);

- All haul roads will be kept clean and maintained in a good state of repair;

- Heavy goods vehicles entering and leaving the existing Site will have tailgates securely fastened; all mobile plant used at the Proposed Development will have noise emission levels that comply with relevant guidance;

- Plant will be fitted with effective exhaust silencers and maintained in good working order to meet manufacturers' noise rating levels. Defective silencers will be replaced;

- The mine manager will maintain a written complaints log in which all complaints made by local residents are detailed. This will require that the concerns of local residents who may be affected by site activities are considered during the management of activities at the mine site; and

- A point of contact will be established between the mine and local residents, to maintain good community engagement.

11.7.5 Mitigation and Management: Restoration/Closure Phase: Community Sports Complex

There is no proposed decommissioning of the Community Sports Complex and so this is not considered further.

11.7.6 Mitigation and Management: Restoration/Closure Phase: Mine Development

Mitigation: Restoration/Closure Phase: Mine Development

- Works will be undertaken in line with any conditions set by the IE licence;

- A noise monitoring programme will be maintained at the existing mine monitoring locations until it is agreed with the Regulatory Authority to no longer be required as restoration progresses;

- All haul roads will be kept clean and maintained in a good state of repair;

- Heavy goods vehicles entering and leaving the existing site will have tailgates securely fastened; all mobile plant used at the proposed Mine Development will have noise emission levels that comply with relevant guidance;

- Plant will be operated in a proper manner with respect to minimising noise emissions, e.g. minimisation of drop heights, no unnecessary revving of engines, plant used intermittently not left idling;
- Plant will be subject to regular maintenance, i.e. all moving parts kept well lubricated, the integrity of silencers and acoustic hoods maintained;
- Plant will be fitted with effective exhaust silencers and maintained in good working order to meet manufacturers' noise rating levels. Defective silencers will be replaced;
- The mine manager will maintain a written complaints log in which all complaints made by local residents are detailed. This will require that the concerns of local residents who may be affected by site activities are considered during the management of activities at the mine site; and
- A point of contact will be established between the mine and local residents, to maintain good community engagement.

11.8 Monitoring

11.8.1 Monitoring: Construction Phase: Community Sports Complex

There is no proposed environmental monitoring of the Community Sports Complex and so this is not considered further.

11.8.2 Monitoring: Construction Phase: Mine Development

Two noise monitoring locations (MS1 and MS2) are located on the Knocknacran Mine site and are both proximal to the construction areas for the Cut-and-Cover tunnel and temporary road diversion; noise levels associated with the works will therefore be captured at these stations during routine mine monitoring.

11.8.3 Monitoring: Operational Phase: Community Sports Complex

There is no proposed environmental monitoring of the Community Sports Complex and so this is not considered further.

11.8.4 Monitoring: Operational Phase: Mine Development

The Mine Development (specifically Knocknacran West) will be integrated into the existing IE Licence during a licence review process. Monitoring will be controlled by licence condition., It is expected that the monitoring program will be in line with existing requirements for the site but at additional monitoring locations around Knocknacran West Mine.

11.8.5 Monitoring: Restoration/Closure Phase: Community Sports Complex

There is no proposed decommissioning of the Community Sports Complex and so this is not considered further here.

11.8.6 Monitoring: Restoration/Closure Phase: Mine Development

Monitoring will be undertaken in line with any conditions set by the IE Licence and CRAMP (a provisional CRAMP is provided in Appendix 3.3). The physical closure works will be followed by a period of monitoring, during which time the mining company must carry out monitoring and measurements to demonstrate that the closure works have been successful, and that all environmental metrics for the site are stable. This will be controlled by the EPA through the IE Licencing procedure. Following this, it is envisaged that the former mining areas will transition to an aftercare period, which will be of reduced scope and intensity to the monitoring carried out during the closure works; and

Appendix 3.3 sets out details of the closure and aftercare vision for the Application Site, which will be developed in line with Saint-Gobain's Stakeholder Management Plan and the CRAMP will evolve through the life of the mine, taking community and statutory interests into account.

11.9 Residual Effects

11.9.1 Community Sports Complex

Once the identified mitigation measures, appropriate design standards and operational infrastructure management plans are adhered to, it is considered that any effects surrounding the Community Sports Complex will be **Not Significant.**

11.9.2 Mine Development

Once the identified mitigation measures, appropriate design standards and operational infrastructure management plans are adhered to, it is considered that any effects from the Mine Development will be **Not Significant.**

11.10 Cumulative Effects

11.10.1 The Project – Community Sports Complex and Mine Development

The construction phases of the Community Sports Complex and the Mine Development will occur simultaneously, however, no significant effects are identified for either and this assessment considers that there is no likelihood of cumulative effects between the two developments.

The proposed Community Sports Complex has been considered as a receptor in the operational and restoration phase modelling for the Mine Development nearby. In all phases the significance of the effect on this facility is not significant and this assessment considers that there will be no cumulative impacts in relation to the Community Sports Complex from the mine sites.

11.10.2 The Project and Other Offsite Projects

The underground Drummond Mine, located to the south, uses the processing plant at Knocknacran to process material and is part of the existing baseline noise environment. Cumulative effects between the Project and the underground mine are therefore not expected.

Other extractive industries near to the Project include four operational quarries within a radius of 5 km of the Project. These are; (i) Cormey Clay Pit, Breedon Brick Ltd. open-cast clay quarry, located ca. 1.5 km south of the Site. (ii) an associated site located ca. 4 km south of the Site, (iii) Limestone Industries Ltd limestone quarry, located ca. 2 km west of the Site, and (iv) Roadstone Barley Hill open-cast quarry located ca. 4 km southeast of the Site. These facilities are sufficiently remote from the Site (ca. 1 km), that cumulative noise effects will not occur.

Other reasonably foreseeable developments in the area include an extension to the existing TEREX MDS site ca. 800 m to the south which is still under planning consideration (Reg. Ref. 22/279). A review of the planning file (to date 10th February 2023) indicates that there will not be an overlap with this development. There will therefore be no cumulative effect due to this development.

The Community Centre in the village of Drumgoosat, which is yet to be constructed, has already been considered as a receptor to the Mine Development in this chapter and it is considered that the cumulative effect of simultaneous construction activities will not be significant.

Losset ADN Materials Ltd. also has a planning application under consideration (Reg. Ref. 22/254) and is located ca. 1 km to the north of the Project site. Based on a review of the current planning file data (10th February 2023), there will be no cumulative effect due to this development.

Other existing developments in the area include a mushroom farm, chicken farm, school and industrial/commercial facilities (e.g. car dealership). There will be no cumulative effect between the Project and these developments.

Potential cumulative effects have been determined to be **Not Significant** between the Project and other off site Projects.

11.11 ‘Do-Nothing’ Scenario

In the ‘Do-Nothing’ scenario no mining would occur to the north of the R179 and noise levels will remain at current baseline levels on the Knocknacran West site. The Community Sports Complex will not be further developed on the site, and the initial operational phase will remain undeveloped.

11.12 Difficulties Encountered

No difficulties were encountered during the assessment which could have any bearing on the outcome.

11.13 References

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assessment/noise/NG4-Guidance-Note-(January-2016-Update).pdf (Accessed: 24 March 2023).

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- European Union (2011) 'Directive 2011/92/EU of the European Parliament and of the Council on the assessment of the effects of certain public and private projects on the environment'. Official Journal of the European Union. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32011L0092&from=EN (Accessed: 24 March 2023).

- European Union (2014) 'Directive 2014/52/EU of the European Parliament and of the Council, amending Directive 2011/92/EU on the assessment of the effects of certain public and private projects on the environment'. Official Journal of the European Union. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32014L0052&from=EN (Accessed: 24 March 2023).

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APPENDIX 11.1
SLM Calibration Certificates

MEASUREMENT SYSTEMS

CERTIFICATE OF CALIBRATION

ilac-MRA

UKAS CALIBRATION 0653

RECEIVED: 11/04/2023

Date of Issue: 28 April 2022

Certificate Number: UCRT22/1587

Calibrated at & Certificate issued by:
ANV Measurement Systems
Beaufort Court
17 Roebuck Way
Milton Keynes MK5 8HL
Telephone 01908 642846 Fax 01908 642814
E-Mail: info@noise-and-vibration.co.uk
Web: www.noise-and-vibration.co.uk
Acoustics Noise and Vibration Ltd trading as ANV Measurement Systems

Approved Signatory

K. Mistry

Customer	ANV Measurement Systems Beaufort Court 17 Roebuck Way Milton Keynes MK5 8HL
Order No.	ANV MS HIRE
Description	Sound Level Meter / Pre-amp / Microphone / Associated Calibrator

Identification

Manufacturer	*Instrument*	*Type*	*Serial No. / Version*
Rion	Sound Level Meter	NL-52	00620807
Rion	Firmware		2.0
Rion	Pre Amplifier	NH-25	20867
Rion	Microphone	UC-59	03633
Rion	Calibrator	NC-74	34536109
	Calibrator adaptor type if applicable		NC-74-002

Performance Class 1

Test Procedure TP 2.SLM 61672-3 TPS-49

Procedures from IEC 61672-3:2006 were used to perform the periodic tests.

Type Approved to IEC 61672-1:2002 YES Approval Number 21.21 / 13.02

If YES above there is public evidence that the SLM has successfully completed the applicable pattern evaluation tests of IEC 61672-2:2003

Date Received 26 April 2022 ANV Job No. UKAS22/04288

Date Calibrated 28 April 2022

The sound level meter submitted for testing has successfully completed the class 1 periodic tests of IEC 61672-3:2006, for the environmental conditions under which the tests were performed. As public evidence was available, from an independent testing organisation responsible for approving the results of pattern evaluation tests performed in accordance with IEC 61672-2:2003, to demonstrate that the model of sound level meter fully conformed to the requirements in IEC 61672-1:2002, the sound level meter submitted for testing conforms to the class 1 requirements of IEC 61672-1:2002.

Previous Certificate	*Dated*	*Certificate No.*	*Laboratory*
	19 February 2020	TCRT20/1097	ANV Measurement Systems

CERTIFICATE OF CALIBRATION	Certificate Number UCRT22/1587
UKAS Accredited Calibration Laboratory No. 0653	Page 2 of 2 Pages

RECEIVED: 11/04/2023

Sound Level Meter Instruction manual and data used to adjust the sound levels indicated.

SLM instruction manual title	Sound Level Meter NL-42 / NL-52		
SLM instruction manual ref / issue	11-03		
SLM instruction manual source	Manufacturer		
Internet download date if applicable	N/A		
Case corrections available	Yes		
Uncertainties of case corrections	Yes		
Source of case data	Manufacturer		
Wind screen corrections available	Yes		
Uncertainties of wind screen corrections	Yes		
Source of wind screen data	Manufacturer		
Mic pressure to free field corrections	Yes		
Uncertainties of Mic to F.F. corrections	Yes		
Source of Mic to F.F. corrections	Manufacturer		
Total expanded uncertainties within the requirements of IEC 61672-1:2002	Yes		
Specified or equivalent Calibrator	Specified		
Customer or Lab Calibrator	Lab Calibrator		
Calibrator adaptor type if applicable	NC-74-002		
Calibrator cal. date	28 April 2022		
Calibrator cert. number	UCRT22/1574		
Calibrator cal cert issued by	0653		
Calibrator SPL @ STP	94.04	dB	Calibration reference sound pressure level
Calibrator frequency	1002.05	Hz	Calibration check frequency
Reference level range	25 - 130	dB	

Accessories used or corrected for during calibration - Extension Cable & Wind Shield WS-15
Note - if a pre-amp extension cable is listed then it was used between the SLM and the pre-amp.

Environmental conditions during tests	Start	End			
Temperature	24.51	24.58	±	0.30	°C
Humidity	37.9	38.5	±	3.00	%RH
Ambient Pressure	102.06	102.06	±	0.03	kPa

Response to associated Calibrator at the environmental conditions above.

Initial indicated level	93.9	dB	Adjusted indicated level	94.0	dB
The uncertainty of the associated calibrator supplied with the sound level meter ±				0.10	dB

Self Generated Noise	This test is currently not performed by this Lab.		
Microphone installed (if requested by customer) = Less Than	N/A	dB	A Weighting
Uncertainty of the microphone installed self generated noise ±	N/A	dB	

Microphone replaced with electrical input device - UR = Under Range indicated

Weighting	A			C			Z		
	12.7	dB	UR	17.1	dB	UR	23.5	dB	UR

Uncertainty of the electrical self generated noise ± 0.12 dB

The reported expanded uncertainty is based on a standard uncertainty multiplied by a coverage factor *k* =2, providing a coverage probability of approximately 95%. The uncertainty evaluation has been carried out in accordance with UKAS requirements.

For the test of the frequency weightings as per paragraph 12. of IEC 61672-3:2006 the actual microphone free field response was used.

The acoustical frequency tests of a frequency weighting as per paragraph 11 of IEC 61672-3:2006 were carried out using an electrostatic actuator.

………………………………………………… END …………………………………………………

Calibrated by: B. Bogdan R 2

Additional Comments The results on this certificate only relate to the items calibrated as identified above.

None

CERTIFICATE OF CALIBRATION

MEASUREMENT SYSTEMS

0653

RECEIVED: 11/04/2023

Date of Issue: 06 January 2023

Certificate Number: UCRT23/1022

Calibrated at & Certificate issued by:
ANV Measurement Systems
Beaufort Court
17 Roebuck Way
Milton Keynes MK5 8HL
Telephone 01908 642846 Fax 01908 642814
E-Mail: info@noise-and-vibration.co.uk
Web: www.noise-and-vibration.co.uk
Acoustics Noise and Vibration Ltd trading as ANV Measurement Systems

Approved Signatory

K. Mistry

Customer	ANV Measurement Systems Beaufort Court 17 Roebuck Way Milton Keynes MK5 8HL
Order No.	ANV MS HIRE
Test Procedure	Procedure TP 1 Calibration of Sound Calibrators
Description	Acoustic Calibrator

Identification	*Manufacturer*	*Instrument*	*Model*	*Serial No.*
	Rion	Calibrator	NC-74	34235944

The calibrator has been tested as specified in Annex B of IEC 60942:2003. As public evidence was available from a testing organisation (PTB) responsible for approving the results of pattern evaluation tests, to demonstrate that the model of sound calibrator fully conformed to the requirements for pattern evaluation described in Annex A of IEC 60942:2003, the sound calibrator tested is considered to conform to all the class 1 requirements of IEC 60942:2003.

ANV Job No.	UKAS23/01004	
Date Received	05 January 2023	
Date Calibrated	06 January 2023	
Previous Certificate	*Dated*	09 February 2022
	Certificate No.	UCRT22/1204
	Laboratory	0653

Measurements

The sound pressure level generated by the calibrator in its WS2 configuration was measured five times by the Insert Voltage Method using a microphone as detailed below. The mean of the results obtained is shown below. It is corrected to the standard atmospheric pressure of 101.3 kPa (1013 mBar) using original manufacturers information.

Test Microphone	*Manufacturer*	*Type*
	Brüel & Kjær	4134

Results

The level of the calibrator output under the conditions outlined above was

93.97 ± 0.10 dB rel 20 µPa

Functional Tests and Observations

The frequency of the sound produced was	1001.70	±	0.12	Hz
The total distortion was	1.31	±	0.09	% Distortion

During the measurements environmental conditions were

Temperature	23	to	24	°C
Relative Humidity	45	to	52	%
Barometric Pressure	100.4	to	100.5	kPa

The reported expanded uncertainty is based on a standard uncertainty multiplied by a coverage factor k=2, providing a coverage probability of approximately 95%. The uncertainty evaluation has been carried out in accordance with UKAS requirements.

The uncertainties refer to the measured values only with no account being taken of the ability of the instrument to maintain its calibration.

A small correction factor may need to be applied to the sound pressure level quoted above if the device is used to calibrate a sound level meter which is fitted with a free-field response microphone. See manufacturers handbook for details.

……………………………………………… END ………………………………………………

Note:

Calibrator adjusted prior to calibration?	NO	
Initial Level	N/A	dB
Initial Frequency	N/A	Hz

Additional Comments

The results on this certificate only relate to the items calibrated as identified above.

None

Calibrated by: PB

R 1

CERTIFICATE OF CALIBRATION

MEASUREMENT SYSTEMS

0653

RECEIVED: 11/04/2023

Date of Issue: 08 June 2022 **Certificate Number: UCRT22/1744**

Calibrated at & Certificate issued by:
ANV Measurement Systems
Beaufort Court
17 Roebuck Way
Milton Keynes MK5 8HL
Telephone 01908 642846 Fax 01908 642814
E-Mail: info@noise-and-vibration.co.uk
Web: www.noise-and-vibration.co.uk
Acoustics Noise and Vibration Ltd trading as ANV Measurement Systems

Approved Signatory

K. Mistry

Customer: ANV Measurement Systems
Beaufort Court
17 Roebuck Way
Milton Keynes
MK5 8HL

Order No.: ANV MS HIRE

Description: Sound Level Meter / Pre-amp / Microphone / Associated Calibrator

Identification

Manufacturer	*Instrument*	*Type*	*Serial No. / Version*
Rion	Sound Level Meter	NL-52	00586906
Rion	Firmware		2.0
Rion	Pre Amplifier	NH-25	87025
Rion	Microphone	UC-59	13364
Rion	Calibrator	NC-74	34536109
	Calibrator adaptor type if applicable		NC-74-002

Performance Class: 1

Test Procedure: TP 2.SLM 61672-3 TPS-49

Procedures from IEC 61672-3:2006 were used to perform the periodic tests.

Type Approved to IEC 61672-1:2002 YES Approval Number 21.21 / 13.02

If YES above there is public evidence that the SLM has successfully completed the applicable pattern evaluation tests of IEC 61672-2:2003

Date Received: 23 May 2022 ANV Job No. UKAS22/05351

Date Calibrated: 08 June 2022

The sound level meter submitted for testing has successfully completed the class 1 periodic tests of IEC 61672-3:2006, for the environmental conditions under which the tests were performed. As public evidence was available, from an independent testing organisation responsible for approving the results of pattern evaluation tests performed in accordance with IEC 61672-2:2003, to demonstrate that the model of sound level meter fully conformed to the requirements in IEC 61672-1:2002, the sound level meter submitted for testing conforms to the class 1 requirements of IEC 61672-1:2002.

Previous Certificate	*Dated*	*Certificate No.*	*Laboratory*
	05 August 2021	UCRT21/1962	0653

CERTIFICATE OF CALIBRATION

UKAS Accredited Calibration Laboratory No. 0653

Certificate Number
UCRT22/1744

Sound Level Meter Instruction manual and data used to adjust the sound levels indicated.

SLM instruction manual title	Sound Level Meter NL-42 / NL-52		
SLM instruction manual ref / issue	11-03		
SLM instruction manual source	Manufacturer		
Internet download date if applicable	N/A		
Case corrections available	Yes		
Uncertainties of case corrections	Yes		
Source of case data	Manufacturer		
Wind screen corrections available	Yes		
Uncertainties of wind screen corrections	Yes		
Source of wind screen data	Manufacturer		
Mic pressure to free field corrections	Yes		
Uncertainties of Mic to F.F. corrections	Yes		
Source of Mic to F.F. corrections	Manufacturer		
Total expanded uncertainties within the requirements of IEC 61672-1:2002	Yes		
Specified or equivalent Calibrator	Specified		
Customer or Lab Calibrator	Lab Calibrator		
Calibrator adaptor type if applicable	NC-74-002		
Calibrator cal. date	31 May 2022		
Calibrator cert. number	UCRT22/1719		
Calibrator cal cert issued by	0653		
Calibrator SPL @ STP	94.02	dB	Calibration reference sound pressure level
Calibrator frequency	1002.03	Hz	Calibration check frequency
Reference level range	25 - 130	dB	

Accessories used or corrected for during calibration - Extension Cable & Wind Shield WS-15
Note - if a pre-amp extension cable is listed then it was used between the SLM and the pre-amp.

Environmental conditions during tests	Start	End			
Temperature	24.57	24.80	±	0.30	°C
Humidity	55.3	53.2	±	3.00	%RH
Ambient Pressure	99.35	99.37	±	0.03	kPa

Response to associated Calibrator at the environmental conditions above.

Initial indicated level	94.1	dB		Adjusted indicated level	94.0	dB
The uncertainty of the associated calibrator supplied with the sound level meter ±					0.10	dB

Self Generated Noise — This test is currently not performed by this Lab.

Microphone installed (if requested by customer) = Less Than	N/A	dB	A Weighting
Uncertainty of the microphone installed self generated noise ±	N/A	dB	

Microphone replaced with electrical input device - UR = Under Range indicated

Weighting	A			C			Z		
	11.8	dB	UR	15.7	dB	UR	21.7	dB	UR

Uncertainty of the electrical self generated noise ± 0.12 dB

The reported expanded uncertainty is based on a standard uncertainty multiplied by a coverage factor *k* =2, providing a coverage probability of approximately 95%. The uncertainty evaluation has been carried out in accordance with UKAS requirements.

For the test of the frequency weightings as per paragraph 12. of IEC 61672-3:2006 the actual microphone free field response was used.

The acoustical frequency tests of a frequency weighting as per paragraph 11 of IEC 61672-3:2006 were carried out using an electrostatic actuator.

…………………………………………………… END ……………………………………………………

Calibrated by: C. Hirlav R 3

Additional Comments — The results on this certificate only relate to the items calibrated as identified above.

None

APPENDIX 11.2
Monitoring Data, Photographs and Notes

Noise monitoring 07/03/23 and 08/03/23 – Monitoring Point Locations

Figure 1. NMP locations

RECEIVED: 11/04/2023

Noise monitoring 07/03/23 – Daytime field notes

Weather: Cold but dry (6-7˚C). Calm.

NMP 1

Dominant noise sources:

- Road Traffic from adjacent R179
- Birdsong

Other noise sources:

- Industrial Machinery
- Airplanes

NMP 2

Dominant noise sources:

- Road Traffic from adjacent R179
- Birdsong

Other noise sources:

- Faint hum from other roads
- Chatting in neighbouring fields
- Activity from shop
- Dogs Barking Intermittently
- Industrial Machinery to north (like pallets being moved)

NMP 3

Dominant noise sources:

- Hum from Road Traffic
- Birdsong
- Background Industrial

Other noise sources:

- Dogs Barking Intermittently
- Airplanes
- Cows in fields
- Chatting and radio from neighbouring surrounds
- Beeping machinery

NMP 4

Dominant noise sources:

- Road Traffic on adjacent road and from surrounding road network during quieter times
- School activity and kids and parents shouting/talking in car park and school yard.
- Machinery and workers working in mushroom factory across road and hum from plant.

Other noise sources:

- Dogs Barking Intermittently
- Aircraft flying overhead intermittently
- Activity in nearby shop
- Crows and birdsong

NMP 5

Dominant noise sources:

- Light road Traffic
- Tractor in adjacent field
- R179, constant but low level (and wider road network hum)
- Birdsong

Other noise sources:

- Dogs Barking Intermittently
- Birdsong
- Cows in adjacent fields

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Noise monitoring 07/03/23 – Evening field notes

Weather: Cold but dry (2-3˚C). Calm.

NMP 1

Dominant noise sources:

- Road Traffic

Other noise sources:

- Airplanes
- Birdsong

NMP 2

Dominant noise sources:

- Road Traffic from adjacent main road
- Activity from shop

Other noise sources:

- Dogs Barking Intermittently

NMP 3

Dominant noise sources:

- Road Traffic
- Background Industrial

Other noise sources:

- Birdsong
- Dogs Barking Intermittently
- Cows in adjacent field

NMP 4

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Dominant noise sources:

- Road Traffic on adjacent road and from main road during quieter times
- Mushroom factory across road and hum from plant

Other noise sources:

- Dogs Barking Intermittently

NMP 5

Dominant noise sources:

- Very light road traffic and hum from R179
- Cows rustling in adjacent field

Other noise sources:

- Birdsong

Noise monitoring 08/03/2023 and 08/03/2023 – Nighttime field notes

Weather: Cold but dry (0˚C - 1˚C). Calm.

NMP 1

Dominant noise sources:

- Road Traffic from R179

Other noise sources:

- Distant traffic on other roads

NMP 2

Dominant noise sources:

- Road Traffic from R179

Other noise sources:

- Fox Noise
- Distant hum from surrounding road network

NMP 3

Dominant noise sources:

- Road Traffic
- Background Industrial

Other noise sources:

- Cows mooing
- Distant industrial hum – mushroom farm?
- Techno music from neighbours, car idling and distant chatting

NMP 4

Dominant noise sources:

- Hum from mushroom farm in village

Other noise sources:

- Road Traffic on adjacent road and from main road quieter times

NMP 5

Dominant noise sources:

- Hum from surrounding road network and mushroom farm

Other noise sources:

- Occasional mooing

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1.25 Hz	1.6 Hz	2.0 Hz	2.5 Hz	3.15 Hz	4.0 Hz	5.0 Hz	6.3 Hz	8.0 Hz	10 Hz	12.5 Hz	16 Hz	20 Hz	25 Hz	31.5 Hz	40 Hz	50 Hz	63 Hz	80 Hz	100 Hz	125 Hz	160 Hz	200 Hz	250 Hz	315 Hz	400 Hz	500 Hz	630 Hz	800 Hz	1.0 kHz	1.25 kHz	1.6 kHz	2.0 kHz	2.5 kHz	3.15 kHz	4.0 kHz	5.0 kHz	6.3 kHz	8.0 kHz	10.0 kHz	12.5 kHz	16.0 kHz	20.0 kHz
36.6	31.2	33.8	29.2	32.7	27.6	31.2	30.6	29.6	31.6	34.3	35.7	36.4	42.4	39.6	40.2	39.7	39.7	41.4	40.7	31.6	24.2	22.5	25.6	24.5	24.6	23.3	25.6	26.6	25.9	24.6	23.8	20.5	16	13	11	10	10	9.9	9.9	9.9	9.8	10.9
33.1	32	33.2	29	27	29.6	28.3	30.1	30.2	28.9	29	31.3	28.4	33.1	31.8	28	30.8	31.4	31.2	27.3	27.8	22.6	18.9	19.6	21.7	55.3	63.2	74.4	93.4	114.2	93.6	74.2	63.6	49.4	47.2	34.4	30.5	25.4	22.4	19.8	19.9	20.8	21.6
31.4	29.1	31.1	29.5	26.7	25.8	26.2	27.2	28.2	28.4	28.7	30.6	27.6	31.4	31.2	28.9	30.1	31.2	29.8	27.5	25.3	23.6	19.7	19.1	17.6	17.7	18.2	16.2	13.7	13.8	12.4	9.9	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8
31.3	36.7	33.1	27.1	26.5	21.7	28.3	24.9	26.9	30.3	29.3	29.8	27.3	28.9	29.7	31.7	31.1	33.1	30	27.8	25.2	25.2	22.1	21	17.4	16.9	18.6	18.6	18	16.2	16.1	16.1	11.1	10	10.7	9.9	9.9	9.9	9.9	9.9	9.8	9.8	9.8
27.5	28.9	26.5	29.2	24.6	20.5	25.7	25.3	25.7	27.2	30.1	32.5	30.6	33.6	35.4	28.7	27.7	23.8	22.9	19.6	17.4	17.1	18.1	19.1	21.5	55.4	63.2	74.4	93.5	114.2	93.6	74.2	63.6	49.4	47.2	34.5	30.4	25.4	22.5	19.9	19.9	20.8	21.8
29.2	28.2	29.9	27.3	24.3	23.2	23.7	24.6	25.3	27.1	28.4	32.2	30.4	33.6	34.9	29.4	28.8	26.4	23.1	17.8	15.7	17.2	18.1	17.2	17.1	15.9	14.6	12.1	11.9	10.3	10.6	9.9	9.9	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8
39.2	36.6	26.4	34.8	32.5	23.4	27.4	28.8	24.6	25.8	30.6	33.8	31.6	35.8	29.4	33.4	29.3	31.2	25.8	15.8	16.2	21	22.8	20.4	21	19.8	18.6	16.4	20	18.6	17.6	13.8	10.2	10.8	9.9	9.9	9.8	9.8	9.8	9.8	9.8	9.8	9.8
25.1	32.3	30.2	28.6	28.4	28	25.9	27.7	27.1	26.6	30	30.3	27.4	31.2	29.9	26	28.5	27.3	26.3	25	25.3	18.5	16.5	17.9	21.4	55.4	63.2	74.4	93.6	114.2	93.6	74.2	63.6	49.4	47.2	34.6	30.6	25.5	22.3	20.2	19.9	20.8	21.7
29.1	29	29.3	27.1	24.9	24.7	25.2	26.1	26.7	27	27.6	29.2	27.3	30	27.6	25.9	30	29.6	29.5	27.3	28.6	21.1	17.8	18.3	18.7	19.9	19.5	23.3	14.4	13	10.3	9.9	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8
31.5	24	27	23.8	18.5	22.8	23.9	26.4	31.4	28.4	31.2	29.4	27.9	31.7	27.6	25.6	30.3	34.1	32.1	28.2	27.4	26.6	19.4	18.8	19.4	26	22.4	27.4	17.3	18	15.6	11.9	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.8	9.8	9.8	9.8
30.1	31	27.9	29.9	26.5	24.7	23.9	25.3	26.2	29.4	29.7	31	33.2	33.4	34.7	29.7	36.7	28.9	32.7	32.6	29.1	24.2	17.6	18.7	22.6	55.4	63.2	74.4	93.5	114.2	93.6	74.2	63.6	49.4	47.2	34.6	30.6	25.4	22.4	20	19.9	20.8	21.6
27.8	26.9	25.7	25.8	22.1	23	23.4	23.9	25.9	28.2	28.9	30.7	33.1	31.6	31.3	30	31.1	29.8	28.7	29.8	25.5	21.8	17.3	16	21.1	22	22	20.1	17.9	16.3	13.7	11.2	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8
27.8	26.9	25.7	25.8	22.1	23	23.4	23.9	25.9	28.2	28.9	30.7	33.1	31.6	31.3	30	31.1	29.8	28.7	29.8	25.5	21.8	17.3	16	21.1	22	22	20.1	17.9	16.3	13.7	11.2	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8
65.3	59.4	57.2	58.4	53.4	55.6	57.4	54.4	49.4	46.7	49.6	54.9	49.4	49.7	47.5	45.9	51.2	47	42.9	43.8	46.2	47	43	40.1	33.8	55.1	63	74.1	93.2	114	93.4	74	63.4	49.2	46.8	34.2	29.6	24.5	22.2	19.8	19.6	20.5	21.4
57.6	55.6	54.8	54	51.4	49.7	47.7	46	43.9	42.6	42.3	54.6	45.4	43.7	44.8	42	41.7	40.3	45.2	45.2	42.8	37.8	33.1	30.7	28.3	31.2	34.2	36.1	38.4	38.7	38.3	38.4	36.4	33.9	32	29	24.6	21	16.1	10.6	9.8	9.8	9.8
61.3	58.3	58.8	56.2	57	52.3	51.3	48.9	47.9	46.4	43.4	54.5	45.5	43.4	42.8	43.4	48.5	45.6	46	45.3	42.8	38.6	33.5	31.4	27.5	30.3	32.8	34.2	36	36.3	36.2	36.1	35.5	33.6	31.2	27.7	22.5	20.3	16.7	10.7	9.9	10.3	9.8
48.9	46.3	46.7	44.2	42.8	41.3	39.3	38	37.3	37.7	38.5	46.8	40.6	39.9	39.2	38.8	39.5	36.8	32.1	28.4	23.4	21.9	23.2	24.7	26.6	28.3	29.7	30.3	32.1	32.1	30	26.1	20.9	17.1	14.3	12.6	11.1	10	9.9	9.8	9.8	9.8	9.8
54.1	55.1	53.7	51.1	49.1	47.3	44.9	43.6	40.1	37.7	39	46.4	38.5	38.3	37.3	36.4	37	33.3	30.8	27.9	22.8	19.6	21.7	22.4	25.4	28.1	29.7	31	33.1	33.3	30.4	26.9	20.5	15.7	12.4	10.8	9.9	9.9	9.9	9.8	9.8	9.8	9.8
38	36.9	35.9	33.4	32.1	30.8	30	29.5	29.4	31.7	35	39.6	35.6	37.6	38.5	40.5	36.8	33.8	31.6	27.9	23.6	20.2	20.2	21.5	22.8	24.7	26.3	28	29.2	28.6	26.1	22.4	17.6	14.5	11.5	9.9	9.8	9.8	9.8	9.8	9.8	9.8	9.8
39.6	38.7	36.1	34.7	34	31.2	30.7	29.9	30	31.7	33.9	38.9	35.7	38.2	38.8	36.7	36.1	34	30.7	27.8	24.2	21.2	20.7	21.8	23.5	26	28.3	30.9	32.7	31.9	29	24.6	19.6	15.4	12	9.9	9.8	9.8	9.8	9.8	9.8	9.8	9.8
41.9	39.5	38.2	36.5	34.8	33.8	32.4	32	32.1	33.8	36.1	44.2	38.4	41.2	38.9	41.3	56	41.3	38	38.2	34.6	34.4	29.8	26.9	28.2	26.3	26.3	26.5	26.3	25.3	23.2	20	17.5	15.8	14.6	12.5	10	9.9	9.8	9.8	9.8	9.8	9.8
47.4	47.4	41.2	44.7	41	39.7	36.6	36	33.4	34.1	36.3	45.1	37.6	38.6	36.6	38.6	55.5	39.8	36.2	37.1	33.7	34.8	29.8	26.4	26.5	25.6	25.8	25.3	24.7	23	21.1	18.5	16.5	14.9	12.4	10	9.8	9.8	9.8	9.8	9.8	9.8	9.8
49.4	46.8	44.6	43.1	40.8	39.3	38	36.2	35.1	35.9	36.9	46.2	38.7	38.1	35.7	35.1	47	34.9	33	32.1	26.4	23.7	20.9	19.8	21.5	23.6	24.9	25.6	25.6	24.4	22.5	19.4	16.6	14.6	12.4	11.2	10.2	9.9	9.9	9.8	9.8	9.9	9.8
54.2	58.3	55.2	56	50.4	48.1	43	45.4	43.2	40.6	38.6	44.6	36.8	39.6	48.7	38.6	52.2	36.4	37	35.3	28.1	24.9	22.5	21.8	21.8	23.8	23.4	24.9	25.3	23.8	22.2	19.2	17.8	17.5	17.4	16.8	16	14.5	12.7	10.3	9.8	9.8	9.8
56.2	55.6	55.5	53.6	52.2	50.5	48.2	45.7	44.1	42.8	43	53.2	44.7	43	42.3	41.6	43.4	41.5	40.2	37.4	33.8	31.1	28.9	25.9	26	29.9	32.8	35	38.2	38.4	35.4	33.2	30.1	26.9	24.7	22.7	19.3	15.9	12.1	9.9	9.8	9.8	9.8
54.5	53.9	51	48.1	46.3	42.6	40.3	39	37.9	37.6	37.7	52.2	41.3	40	39.2	38	41.4	39.2	41.2	40	33	30.5	28.6	26.1	24.5	28.7	30.4	33.1	37.1	32.5	31.4	29.8	27.3	25.1	24.7	23.2	20.2	17.3	13.6	9.9	9.8	9.8	9.8
44.6	42.6	40.2	38.5	36.5	34.7	33.5	32.7	31.2	33	35	45.3	38	38.5	37.2	38.5	52.8	39.4	36.9	37.9	34.6	34.8	30.5	27.6	25.8	26.1	26	26.2	25.8	24.8	22.5	20.1	18.5	17.1	13.8	11.4	9.9	9.9	9.9	9.8	9.8	9.8	9.8
55.3	50.9	48	45.1	45.9	41.6	41.3	39.2	37	36	35.9	45.9	36.3	36	36	37.9	52.6	38.8	37.4	37.7	37.6	34.5	29.9	29.4	28.2	32.1	32.4	35.2	34.9	32.3	30.1	25	24.4	28.7	23.4	21.4	20.9	15.9	12.3	9.8	9.8	9.8	9.8
52.8	53.5	55.6	53.6	55.6	52.1	50.8	44.2	49.2	48.6	48.1	52.4	48.8	47.9	46.4	46.6	55.2	50.9	43.2	45.3	45.5	41.4	38	34.4	30.4	54.6	62.6	73.6	92.8	113.4	93	73.6	62.8	48.6	45.6	33.6	29.1	24.6	22.4	19.5	19.7	20.5	21.5
48.9	48.4	49.1	45.9	46.8	46.6	47	46.1	44.2	46.9	41.6	44.9	40.8	43.2	41.6	42.2	54.4	42.1	39.3	41.6	40.9	37.5	36.4	34	28.5	55	63	74.1	93.2	114	93.4	74	63.3	49	46.2	34	29.5	24.8	22.7	20	20.2	21	21.8
47.9	31.9	27.2	27.7	27.2	22.4	22.8	20.5	20.5	19.5	19	23.5	22.6	26.9	25	28.7	42.3	31	28.5	34.4	31.9	30.7	30.2	28	25	49	56.9	68	87.2	107.8	87.4	73.8	84.2	67.2	77	70	63.2	57	49	41.8	32.2	25.2	24
51.2	48.8	51.6	48	45.4	40.4	39.6	39.2	39.8	41.4	37.6	39.4	38.5	40.3	37.6	38.3	53.6	41.4	36.6	40.2	38	35.7	33.6	30.9	26	55	63	74	93.2	113.8	93.4	74	63.2	49	46.5	34.1	29.5	24.8	22.6	20	20.1	21	21.8
30.2	30.2	29	27.5	27.8	26.7	27.1	26.8	27.7	29.7	33.7	37.7	34.7	37.6	38	39.4	53.2	40	37.1	38.1	34.8	30.6	28.5	26.7	26.6	25.8	24.7	23.3	22.8	22.3	21.5	18.9	16.1	14.3	11.6	9.9	9.9	9.8	9.8	9.8	9.8	9.8	9.8
36.3	43	39.9	34.3	36.3	32.2	32.8	31	30.8	32	34.3	37.9	36.4	39.3	43.4	41.1	53	41.3	39.2	38.5	35.4	32.3	30.6	28.5	29.1	28.5	28.3	26.7	25.6	26	25.4	23.8	22.1	19.3	17.7	14.6	10.6	9.8	9.8	9.8	9.8	9.8	9.8
26.9	27.3	26.6	25.4	25.5	26.2	25.1	25.3	26.3	28.2	30.3	32.4	32.2	33.4	33.9	34.1	42.2	34.3	33.2	31.9	26.6	21.5	16.7	14.9	16.5	20.8	23	23.5	23.1	21.7	20	16.9	13.9	11.9	9.9	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8
23.5	18.6	32.9	24.3	27.7	29.3	20.1	26.1	27.1	27.9	27.1	33.8	33.1	36.1	34.8	34.1	43.3	32.3	33.7	31.5	28.2	22.4	18.7	16.9	19.8	26.9	30.1	27.6	29.6	26.3	22.6	18.3	14.3	10.3	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8
26.6	27.1	25.9	25.7	26.1	26.3	25.4	25.1	26.5	29.4	32	37.7	35.7	38.1	39.4	40.2	53.7	40.8	38	38.8	35.7	35.2	30.3	25.8	26.2	25.4	23.7	22.8	22.1	21.2	20.3	18	15.6	13.7	10.9	9.9	9.8	9.8	9.8	9.8	9.8	9.8	9.8
27.3	26.9	28.6	26.8	26.5	27.4	26.1	25.6	27.3	29.1	32.1	37.5	34.9	39.2	37.9	39.6	53.6	40.6	38	38.2	35.6	34.8	30.2	25.8	26.2	25.4	24	23.3	22.2	21.1	20.5	18.5	16.7	14.2	11.5	9.9	9.8	9.8	9.8	9.8	9.8	9.8	9.8
35	33.9	33.5	31.8	30.5	30.8	29.2	27.7	27.9	29.1	31.1	34.6	35.4	35.3	35.4	35.9	37.6	35.8	33.7	31.9	27.7	24.8	20.5	17.2	15.9	19.6	22.4	24.6	27.9	28.2	25.1	21.7	19.4	16.7	13.7	11.2	9.9	9.9	9.8	9.8	9.8	9.8	9.8
34.3	33.9	30.7	27.9	30.7	29.8	27.9	26.8	26.6	28	29.2	32.5	33.3	33.9	34.4	33.7	35.1	32.6	30.9	30.3	24.8	23.1	18.5	12.9	13.3	15.4	17.8	18	19.3	20.3	17.8	15.2	13	11.4	10	9.9	9.9	9.8	9.8	9.8	9.8	9.8	9.8
41	38.2	38.8	39	40.4	38	32.6	34.4	35.7	37.8	35.7	36.4	36.1	34.9	34.8	36	41.5	38.5	34.4	36.6	36.2	34.1	33.4	30.3	24.7	55	62.9	74	93.2	113.8	93.4	74	63.2	49	46.3	34	29.6	25	22.8	20.1	20.1	21	21.7

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Directory: C:\Users\JohMoran\AppData\Local\Temp\Norsonic\Downloaded Mea File version v1.0/6.1.1.50

File	Date		Duration	Status	LAeq	LAFmax	LAFmin	LCeq	LCFmax	LCFmin	LAF,Perc4	LAF,Perc6	LCF,Perc4	LCF,Perc6	Lfeq			
															0.4 Hz	0.5 Hz	0.63 Hz	0.8 Hz
NOR140_1658766_210901_0001.NBF	(2021/09/01 12:15:25.00)	CAL	(0:0:10.0)	N/A	114.1	114.1	114	-	-	-	114.2	114	-	-	76.9	75.2	72.8	65.3
NOR140_1658766_210901_0002.NBF	(2021/09/01 12:16:34.00)	VOID	(0:1:19.0)	N/A	67.6	80.8	41	-	-	-	71.8	52.9	-	-	66	66.6	66.5	67.3
NOR140_1658766_210901_0003.NBF	(2021/09/01 13:12:45.00)	VOID	(0:0:20.0)	N/A	48.3	67.2	34.1	-	-	-	48.2	35.[illegible]	-	-	89.4	87.2	84.2	79.1
NOR140_1658766_210901_0004.NBF	(2021/09/01 13:13:29.00)	VOID	(0:0:18.0)	N/A	48.3	61.2	27.3	-	-	-	52.5	29.1	-	-	77.6	74.1	75.1	72.3
NOR140_1658766_210901_0005.NBF	(2021/09/01 13:15:43.00)	VOID	(0:0:16.0)	N/A	55.1	63.8	38	-	-	-	60.1	39	-	-	80.1	77.2	67.9	61.4
NOR140_1658766_210901_0006.NBF	(2021/09/01 13:25:49.00)	CAL	(0:0:10.0)	N/A	114	114.1	114	-	-	-	114.2	114	-	-	63.8	63.1	71.7	73.8
NOR140_1658766_210901_0007.NBF	(2021/09/01 13:26:45.00)	NMP1 Day	(0:15:0.0)	N/A	59.3	71.9	31.6	-	-	-	64.1	39.8	-	-	61.3	62.3	63.1	62.3
NOR140_1658766_210901_0008.NBF	(2021/09/01 13:41:47.00)	VOID	(0:0:3.0)	N/A	61.1	63.9	55.5	-	-	-	63	57.4	-	-	49.5	66.1	63.7	50.4
NOR140_1658766_210901_0009.NBF	(2021/09/01 13:52:34.00)	VOID	(0:0:9.0)	N/A	57.6	75.8	31.2	-	-	-	55.3	32.1	-	-	79.4	73.7	73.7	72.6
NOR140_1658766_210901_0010.NBF	(2021/09/01 13:52:49.00)	CAL	(0:0:12.0)	N/A	114	114	114	-	-	-	114.1	113.8	-	-	74.8	68.9	69.8	71.6
NOR140_1658766_210901_0011.NBF	(2021/09/01 13:53:46.00)	NMP3 Day	(0:15:0.0)	N/A	40.7	50.8	29.7	-	-	-	43.9	34.3	-	-	59.1	58.9	58.2	59.3
NOR140_1658766_210901_0012.NBF	(2021/09/01 14:08:49.00)	VOID	(0:0:1.0)	N/A	36.8	38.5	35.7	-	-	-	37.8	35.9	-	-	43.2	43.5	43.9	46.2
NOR140_1658766_210901_0013.NBF	(2021/09/01 14:17:36.00)	CAL	(0:0:20.0)	N/A	113.9	114	112.9	-	-	-	114	113.8	-	-	76.8	71	72.5	65.9
NOR140_1658766_210901_0014.NBF	(2021/09/01 14:18:27.00)	NMP1 Day	(0:15:0.0)	N/A	57.3	69.3	31.6	-	-	-	62.1	38.7	-	-	61.4	63.6	63.5	64.3
NOR140_1658766_210901_0015.NBF	(2021/09/01 14:33:29.00)	VOID	(0:0:3.0)	N/A	41.9	44.4	40.5	-	-	-	43.4	40.8	-	-	53.2	44.9	42	42.5
NOR140_1658766_210901_0016.NBF	(2021/09/01 14:41:28.00)	CAL	(0:0:25.0)	N/A	113.8	114	112.6	-	-	-	114	113.7	-	-	76.4	72.2	66.9	60.7
NOR140_1658766_210901_0017.NBF	(2021/09/01 14:42:23.00)	NMP3 Day	(0:15:0.0)	N/A	44.2	53.7	34.7	-	-	-	47.4	38.8	-	-	63.3	64.8	64	63.3
NOR140_1658766_210901_0018.NBF	(2021/09/01 14:57:25.00)	VOID	(0:0:4.0)	N/A	41.5	43.9	39.2	-	-	-	42.7	39.4	-	-	53.5	56.3	56.9	56.8
NOR140_1658766_210901_0019.NBF	(2021/09/01 15:07:49.00)	CAL	(0:0:20.0)	N/A	113.9	114	113.8	-	-	-	114	113.8	-	-	66.1	68.2	71	71
NOR140_1658766_210901_0020.NBF	(2021/09/01 15:08:43.00)	NMP1 Day	(0:15:0.0)	N/A	57.4	70	33.2	-	-	-	61.8	38.9	-	-	66.5	66	68.3	68.3
NOR140_1658766_210901_0021.NBF	(2021/09/01 15:23:46.00)	VOID	(0:0:0.0)	N/A	61.8	62.2	61.8	-	-	-	- -		-	-	60.2	68.1	59.2	72.9
NOR140_1658766_210901_0022.NBF	(2021/09/01 15:38:17.00)	CAL	(0:0:21.0)	N/A	113.9	113.9	113.8	-	-	-	114	113.8	-	-	64.4	63.4	58.5	59
NOR140_1658766_210901_0023.NBF	(2021/09/01 15:38:54.00)	NMP3 Day	(0:15:0.0)	N/A	42.9	56.7	32.5	-	-	-	46.1	36.3	-	-	66.4	66.6	66.2	67
NOR140_1658766_210901_0024.NBF	(2021/09/01 15:53:56.00)	VOID	(0:0:25.0)	N/A	45	48	40.9	-	-	-	46.5	42.5	-	-	60.1	61.2	60.5	60.3
NOR140_1658766_210901_0025.NBF	(2021/09/01 21:18:57.00)	CAL	(0:0:21.0)	N/A	113.9	114	113.8	-	-	-	114	113.8	-	-	66.8	61.1	56.4	55.3
NOR140_1658766_210901_0026.NBF	(2021/09/01 21:19:56.00)	NMP1 Eve	(0:15:0.0)	N/A	53.1	67.5	24.4	-	-	-	58.4	29.3	-	-	48.9	48.3	46.5	45.6
NOR140_1658766_210901_0027.NBF	(2021/09/01 21:34:59.00)	VOID	(0:0:4.0)	N/A	57.7	61.4	48	-	-	-	60.8	51.5	-	-	38.3	42.2	41.1	38.7
NOR140_1658766_210901_0028.NBF	(2021/09/01 21:44:51.00)	CAL	(0:0:17.0)	N/A	114	114.1	114	-	-	-	114.2	114	-	-	60.7	56.2	51.6	49.2
NOR140_1658766_210901_0029.NBF	(2021/09/01 21:45:40.00)	NMP3 Eve	(0:15:0.0)	N/A	38.3	54.7	24.6	-	-	-	42.7	28.4	-	-	44.9	46.2	44.4	44.2
NOR140_1658766_210901_0030.NBF	(2021/09/01 22:00:42.00)	VOID	(0:0:7.0)	N/A	44.2	47.9	41.6	-	-	-	45.8	42.7	-	-	37.7	47.5	44.9	45.9
NOR140_1658766_210901_0031.NBF	(2021/09/01 22:12:06.00)	CAL	(0:0:22.0)	N/A	114.2	114.2	114.2	-	-	-	114.3	114	-	-	50.3	46.7	40	41
NOR140_1658766_210901_0032.NBF	(2021/09/01 22:13:23.00)	NMP1 Eve	(0:15:0.0)	N/A	49.2	66.1	20.4	-	-	-	47.6	24	-	-	45.9	42.5	42.5	40.8
NOR140_1658766_210901_0033.NBF	(2021/09/01 22:28:26.00)	VOID	(0:0:1.0)	N/A	26.7	30.9	22.7	-	-	-	29.7	22.8	-	-	36.5	43.7	33.4	44.7
NOR140_1658766_210901_0034.NBF	(2021/09/01 22:36:34.00)	CAL	(0:0:20.0)	N/A	114.2	114.3	114.2	-	-	-	114.4	114.2	-	-	52.8	38.8	42.6	38.6
NOR140_1658766_210901_0035.NBF	(2021/09/01 22:37:32.00)	NMP3 Eve	(0:15:0.0)	N/A	35.9	48.4	24.2	-	-	-	39.4	28.9	-	-	60.7	55.2	47	46.6
NOR140_1658766_210901_0036.NBF	(2021/09/01 22:52:35.00)	VOID	(0:0:0.0)	N/A	27.2	28.1	26.7	-	-	-	-	27	-	-	44	35.3	44.1	39.5
NOR140_1658766_210901_0037.NBF	(2021/09/01 23:03:22.00)	CAL	(0:0:23.0)	N/A	114.3	114.3	114.2	-	-	-	114.4	114.2	-	-	67.6	66.2	57.5	54.9
NOR140_1658766_210901_0038.NBF	(2021/09/01 23:04:36.00)	NMP1 Night	(0:15:0.0)	N/A	45.2	62	22	-	-	-	42.2	25.3	-	-	46.5	43	42.2	40.5
NOR140_1658766_210901_0039.NBF	(2021/09/01 23:19:38.00)	VOID	(0:0:0.0)	N/A	25.3	27.7	26.7	-	-	-	- -		-	-	23.9	40.2	47.3	29.1
NOR140_1658766_210901_0040.NBF	(2021/09/01 23:27:37.00)	CAL	(0:0:20.0)	N/A	114.3	114.3	114.2	-	-	-	114.4	114.2	-	-	68.3	65.1	62.5	52.9
NOR140_1658766_210901_0041.NBF	(2021/09/01 23:28:50.00)	NMP3 Night	(0:15:0.0)	N/A	32.7	55.5	21.9	-	-	-	36.3	24.7	-	-	55.9	49.9	48.2	44.8
NOR140_1658766_210901_0042.NBF	(2021/09/01 23:43:53.00)	VOID	(0:0:3.0)	N/A	38.4	42.8	33.4	-	-	-	40	36	-	-	41.5	33.7	41.8	44.8
NOR140_1658766_210901_0043.NBF	(2021/09/01 23:53:46.00)	CAL	(0:0:21.0)	N/A	114.3	114.3	114.3	-	-	-	114.4	114.2	-	-	69.6	61.9	58.7	49.9
NOR140_1658766_210901_0044.NBF	(2021/09/01 23:54:59.00)	NMP1 Night	(0:15:0.0)	N/A	49.7	69.7	22.9	-	-	-	48.6	25.8	-	-	53.4	51.2	41.5	42.6

1.0 Hz	1.25 Hz	1.6 Hz	2.0 Hz	2.5 Hz	3.15 Hz	4.0 Hz	5.0 Hz	6.3 Hz	8.0 Hz	10 Hz	12.5 Hz	16 Hz	20 Hz	25 Hz	31.5 Hz	40 Hz	50 Hz	63 Hz	80 Hz	100 Hz	125 Hz	160 Hz	200 Hz	250 Hz	315 Hz	400 Hz	500 Hz	630 Hz	800 Hz	1.0 kHz	1.25 kHz	1.6 kHz	2.0 kHz	2.5 kHz
60.8	57.9	57.9	58.5	57.2	58	57.3	53.5	50.7	52.3	52	52.1	69.6	56.4	50.2	52.5	54.6	51.7	47.7	49	55.5	49.7	47.5	55.7	50	53.7	58	63.9	74.2	93.3	114.1	93.6	74.2	63.4	49.2
66.6	65.9	65.6	65.2	64.3	62.4	61.6	61.3	58.7	57.2	54.4	54.2	55.2	49.7	52.6	52.7	56.8	55.8	50.3	56.9	57.2	57	52.5	59	59.1	58.3	63.9	63.2	61.4	58	52.1	52.3	55.7	57	55
72.2	67.1	64.3	63.9	60.3	61.1	61.8	60.2	57.1	59.4	57	53.9	52.1	50.7	49	46.7	46.9	48.6	46.1	43.4	41.2	35.8	35.3	36.4	33.4	33.4	39	41.1	41.2	45.8	39.8	30.4	32.1	31	26.5
67.5	61.9	64.2	60.6	55.2	52.1	50	48.6	49.1	48.8	46.9	44	43	43.7	44.5	43.2	41.3	43.6	43.6	41.7	38.7	36.1	33	34.2	31.1	31.5	32	36	41.3	47.1	40.4	28.2	21.2	16.7	13.2
57.9	57.7	60	61.1	62.4	59.6	59.8	62	60.7	61.7	62.6	59	60	57.5	57.8	57.8	55.7	62.2	70.2	53	52	53.4	44.7	44.1	44.2	46.6	44.3	48.1	50.7	52	44.5	32.4	26.1	21.7	17.7
70.5	70.9	69.1	70.8	69.9	66.7	65.7	68.7	67	68.6	64.8	62.3	60.2	58.5	58.2	56.7	55.2	53.6	51.5	49.9	50.7	47.1	44.9	45.3	40.4	40.1	55.4	63.1	74.2	93.3	114	93.5	74.1	63.4	49.2
62	61.3	60.2	59.6	58.4	56.5	54.8	53.1	51.2	49.9	48.9	49.6	51.5	51.6	49.9	50.7	50.1	57.3	59.8	54.5	48.3	47	42	40.4	41.6	46.1	47.5	51.2	52.6	53.3	52.9	50.3	47.5	43.8	40.7
55.6	52.9	57.3	51.5	49.6	47.2	47.5	46.3	43.7	42.9	54.5	51.8	50.9	52.2	50.9	50.7	50.3	53	64.3	55.1	49.8	45.5	40.9	38	39.7	40.8	45.7	49.2	54.3	56.9	54.6	51.4	48.8	45.9	43.3
66.7	70.1	64.6	63.8	61.8	62.2	55.2	60.1	56.6	56.9	55.3	57.6	53.3	50.3	52.3	54.9	51.3	46.7	47.3	43.5	42.4	41	41.8	42.4	43.9	45	38.6	39.8	45.1	55.9	52.8	39.6	37.7	37.2	22.9
65.3	64.7	63.8	60.6	60.2	56.3	54	55.3	54.8	53.3	51.2	51.8	51.9	49.8	48.8	48.3	46.8	42.8	42.9	38	34.8	30.4	28.1	32.6	28.3	32.2	55.1	63	74.1	93.3	114	93.5	74.1	63.3	49.1
57	56.7	55.7	55	53	49.5	46.5	44.4	42.5	42	42.4	44.7	44.9	40.7	44	46.6	44.4	43.8	47.3	46.1	38.4	34.8	31.8	28.8	27	29.3	29.9	33.1	34.2	34.8	34.1	31.3	27.7	23.3	19.4
42.3	46.5	42	37.3	45.9	41.4	39.3	34.3	40.7	34	38.3	41.9	43	42.7	42.1	45.9	42	47.6	38.1	34.5	29.2	27.3	24.3	23.4	25.5	26.4	31.5	29	31	30.8	29.6	26.6	22.8	17.6	12.9
67.3	64.8	67.3	64	65.3	67.8	66.4	66.2	65.5	65.6	67	65.3	62.7	60.1	60.1	56.4	55.3	53.4	51.1	48.8	44.5	41.3	38.5	34.8	30.6	28.9	55	62.9	74.1	93.2	113.9	93.4	74	70.6	54
63.8	63	63.2	61.5	60.1	59.1	57.1	55.5	54.1	51.9	50.3	49.2	50	48.8	50.4	49.7	50.1	58.4	55.9	53.5	47	42	38	36.6	38.9	41.3	42.9	47	49.9	51.3	51.6	48.9	46.2	41.7	37.8
43.6	37	41.4	49.1	38	37.6	38.1	37.5	35.7	39.7	40	45.2	46.4	45.6	44.3	43.4	47.8	48.1	47.8	39.2	32.4	29.4	24.8	27.2	30.4	34.3	34.1	30.7	32	34	34.7	32.5	30.1	25.6	22.3
62.1	55	55.6	57.3	53.8	57.6	57	56.3	57.6	54	53.4	54.2	53.1	51.1	50.6	50.8	50.3	49.2	46.4	44.4	40.9	37.3	33.9	31.6	25.4	26.6	55	62.9	74	93.1	113.8	93.3	74	74.4	57.7
63.3	61.6	60.9	60.2	58.4	56.3	54.3	53.8	50.8	48.4	46.4	46	46.3	43.2	47.1	47.7	46.3	46.8	47.7	43.8	42.1	38.1	34.7	32.3	32.6	32.1	33.3	34.7	36.7	38.2	38.5	35.4	32	27.3	23.1
54.6	54.5	53.3	55.5	51	51.5	50.9	49.4	48.5	41.7	42.2	39.1	45.4	38.6	46	45.6	41.8	41.2	43.1	43.2	40.4	38.6	35.6	35.5	29.1	28.3	32.3	33.3	34.1	35.7	35.1	31.2	29.1	24.8	21.6
71.3	72.7	73.2	72.5	73.2	75.1	69.2	71.3	69.8	70.1	71.2	67.2	67.4	64.4	61.8	59.7	57.4	56.7	55.2	53.9	52.2	49.6	46.1	43.1	39.4	38	55.1	63	74.1	93.2	113.9	93.4	74	63.2	49
68.3	68	66.8	66.3	65.1	63.8	61.6	60.1	58.6	56.2	54.4	52.6	54.5	50.5	50.9	50.7	55.1	52.3	53.8	52.1	46.8	41.4	36.4	35.9	38.2	41.5	43	46.2	50.6	52.1	51.5	48.7	45.6	41.4	37.6
73.8	63.6	63.9	75.8	77.2	73	68.4	70.8	73	70.1	72.2	60.2	63.1	58	62.5	51.8	60.3	54.8	58.3	57.2	61.8	45.9	42.2	43.4	46.4	47.4	52.3	51	52.2	55.1	54.9	54.3	50.8	47.3	46.2
53.1	56.6	53.8	54.2	51.4	54.2	53.5	53.2	51.9	52.2	50.9	48.8	47.8	48.8	47.7	46.3	42.2	40.1	39.6	34.7	33.5	30.9	28.4	28.8	27.1	29.8	55	62.9	74	93.1	113.9	93.4	74	63.2	49
66.9	65.1	63.4	62.7	61.1	59.6	57.6	54.5	52.9	50.3	48.5	46.4	45.2	42.2	44.6	46.2	42.6	44.7	45.8	39.9	37.4	34.2	30.6	28.6	28.2	30.8	32.9	35.3	36	37.1	36.6	33.4	29.8	26.2	23.6
59.8	57.7	55.6	59.3	56.4	52.4	53.9	52.3	49.3	47.1	46.9	47.9	50.2	45.5	51.5	51.9	46.5	47.7	51.1	45.8	41.3	38.2	36.4	32.5	31.5	33	36.2	39.7	38.7	38.9	38.3	34.8	31	26.7	23
48.2	45.3	45	45.1	43.9	41.9	38.3	36.5	36.9	37.1	36.7	36.2	39.2	37.2	38.9	34.8	34.4	34.1	32.2	28.2	24.3	21.7	20.5	22.9	23.2	23.4	55	62.9	74.1	93.2	113.9	93.4	74	63.2	49
46.1	45.5	43.8	44.5	42.6	40.5	38.4	36.9	36.8	37.7	39.3	41	43.7	43.2	43.7	44.4	44.6	47.6	48.1	45.9	45.6	36.7	31.1	32.6	35.2	37	39.9	42.2	45.2	47.7	47.2	44.9	41.7	38.1	34.2
46.5	41.5	42.9	40.6	41.2	40.6	39.7	31.9	38	39.2	40.7	41	42.2	41.6	44.5	45.8	45.5	46.9	53.8	50	43.3	37.9	32.9	35	39.1	39.4	41.9	45.8	48.9	51.4	52.3	50.6	46.7	42	39.1
52.1	55.7	50.2	52.9	50.5	49.7	47.7	46.1	43.8	46.5	44.8	41.7	44.1	41.1	40.9	44	43.2	49.3	44.2	35.4	35.8	28.9	26.6	25.4	24.2	26.6	55.2	63.1	74.2	93.3	114	93.5	74.1	63.3	49.2
46.1	44.8	45.1	45.6	43.2	39.9	37.8	36	36.3	37.1	37.5	38.5	40.1	37.6	42	42.6	40.1	45.1	46.1	38.6	35.5	30.7	28.9	28.5	25.1	29.3	27	28.7	30.8	32.6	32	29.5	26	21.2	17.6
43.5	41.5	44.1	49.2	44.3	41.8	38.7	35.6	37	36.8	36.4	38.1	37.4	35.6	41.5	40.5	43.4	47	39.1	38.6	39.3	33.5	27.8	25.1	23.9	26.9	29.1	31.2	33.3	37.1	38.8	37.5	34.7	29.3	23.5
45	41.7	43.9	45.6	42.8	40	44.5	45.5	47.3	48.6	41.8	45.3	43.2	44	44.8	43.7	42.3	43	43.4	43.6	45	34	28.4	29.6	27.4	29.4	55.3	63.2	74.4	93.5	114.2	93.7	74.3	63.6	49.4
43.8	43.5	41.9	44.4	40.2	37.6	35.2	34.9	35.5	37.6	38.3	38.2	39.3	39.1	41.2	38.9	38.8	42.5	42.9	40	36.1	30.6	25.1	25.3	28.4	29.8	32.2	36	41.2	44.2	43.7	40.9	37.6	33.7	29.6
29.2	45.3	46.7	39.1	35.6	35.7	29.7	37.2	40.3	43.2	40	33.9	39.7	39.7	39.2	34.3	31.4	31.2	30.3	24.8	21.9	23.6	16.8	19.7	19.2	18.8	17	16.8	17.4	17.3	16.5	15.3	15	15	15
39.8	43.6	44.4	42.4	45.6	42	39	37.1	36.8	37.8	36	36	36.5	34.5	38.2	36.8	33.3	34.5	34.3	33.1	30.2	30.3	26.3	32.8	25.8	27.2	55.4	63.3	74.4	93.5	114.2	93.7	74.3	63.6	49.4
47	45.4	45.5	44.5	42.5	39.8	37.9	37.8	38.4	39	37.6	38.6	39.8	37	43.2	40.6	36.1	38.3	39	35.4	31.9	29.6	26.7	25.3	22.9	23.8	28.9	27.3	31	29.5	29	25.9	22.3	17.9	13.4
39.5	38.1	40.1	35.4	42.9	40.1	33.8	26.9	36.5	40.3	31.3	28.2	36.3	35.9	38.2	34.7	32.4	34.6	34	32.5	27.3	24.9	22.5	18.8	19.1	17.8	21.8	21.2	25	16.4	14.2	11.8	9.7	8.5	7.7
43.8	42	41.9	40.4	38.1	38.4	37.1	36.1	35.8	38.1	36.2	34.8	39.2	35.9	38.3	35.5	36.3	34.8	31.4	30.9	31.5	24.8	24.1	26.7	27	26.1	55.4	63.3	74.4	93.6	114.3	93.7	74.3	63.7	49.4
42.4	41.8	41.5	42.1	39.8	37	35.5	34	34.4	35.1	35.4	35.2	39.8	37.1	39.5	37.6	37.9	42.6	41.4	36.7	32.9	27.5	22.5	23.9	26.9	28	30.2	32.7	35.8	39.6	39.9	37.2	34.1	30.6	25.8
31.9	29.5	21.2	38.1	35.6	38.1	39.7	30.9	40.3	39.5	30.6	36.8	42.7	42.7	43.2	33.4	30.6	26.7	29.8	21.5	23.5	21.1	20.8	22.8	26.7	23.8	19.4	19.8	18.4	15.2	12.3	8	7.2	6.1	5.7
47.8	39.9	44.2	44.6	42	40.6	39.8	38.7	38.6	37.9	37	36.7	38.2	36	37.6	34	32.6	34.3	34.8	36.1	33.3	28.4	25.7	29.5	26.1	25.7	55.4	63.3	74.4	93.5	114.2	93.7	74.3	63.6	49.4
45	43.3	42.6	42.7	40	37.3	35.7	35.5	36.5	35.9	35.9	36.1	37.7	35.4	38.8	35.8	34.2	36.6	33.6	32.7	28.7	26.1	24.5	23.3	23.1	22.5	24.6	23.6	25	26	26	23.8	20.8	17.3	14.2
39.7	43	41.8	50.8	46.7	40.4	37.5	42	39.1	37	35.1	37.1	34.8	34.9	41.4	38	32.8	33.8	34.1	31.1	29.9	24.8	24.4	23	23.3	24.3	25.2	28.8	31.1	32.3	31.4	29.8	27.2	24.2	22.5
43.3	45.1	40.1	41.8	39.4	35.5	36.3	36	37.6	38	39.3	52.1	53.7	49.2	49.2	46.4	45.9	48	45.9	43.9	37	33.5	28.3	28	31.9	32.6	55.4	63.4	74.5	93.6	114.3	93.8	74.4	63.7	49.5
42.3	41.7	39.2	39.6	37.6	36.2	35	34.7	35.9	37.3	38.3	40.5	45.2	47.7	54.4	47.5	43.7	45.5	45.8	43.6	38.6	34.6	30.3	32.4	35.8	40.1	39.4	41.3	42.6	43.6	43.1	40.9	38.1	35.3	31.1

3.15 kHz	4.0 kHz	5.0 kHz	6.3 kHz	8.0 kHz	10.0 kHz	12.5 kHz	16.0 kHz	20.0 kHz	LfFmax 0.4 Hz	0.5 Hz	0.63 Hz	0.8 Hz	1.0 Hz	1.25 Hz	1.6 Hz	2.0 Hz	2.5 Hz	3.15 Hz	4.0 Hz	5.0 Hz	6.3 Hz	8.0 Hz	10 Hz	12.5 Hz	16 Hz	20 Hz	25 Hz	31.5 Hz	40 Hz	50 Hz	63 Hz	80 Hz	100 Hz
45.9	34.2	29.9	25.3	23	20.4	20.5	21.4	22.3	86.2	81.6	79.6	78.1	67.8	68	62.8	64	62.3	64.6	64	61.6	57.3	60.3	57.7	58.9	71.2	60.6	54.3	58.5	58.9	58.4	55.9	54.3	61.4
48.6	49.6	42.5	41.9	39.2	36.3	30.1	22.6	24.3	72.7	73.8	77.1	76.6	74.8	75.2	73.6	75.8	74.5	74	74	72.6	72	70	67.8	69.4	64.6	58.5	62.3	64.5	67.9	63.3	66.2	72.7	67.6
26.1	25.5	24.9	24.6	23.9	23.3	23	23	23.3	97.2	97	96.2	93.8	86.7	77.9	77.6	73.9	71	70.8	71.8	68.6	67.5	73.4	71.8	63.5	61.6	60.9	59.7	56.6	58.8	60	57.7	55.4	53.7
13.9	15	15.1	16.3	17	17.5	18.4	19.4	21.3	84.8	81.2	83.6	82.2	78.5	75.7	78.5	76.1	71.5	67.8	62.1	60.1	60.8	62.5	59.7	55.2	51.7	52.7	53.8	52	52.5	50.6	54.5	53.4	49
15.8	16.9	16.8	17.8	18.8	19.1	20.1	21.2	22.1	86.3	86	79.5	70.9	66.8	64.1	69.2	73.5	73.9	71	68.3	70.5	70.6	72	75.7	67.9	74	66.7	66.3	66	66.3	69.4	77.3	59.3	58.2
45.9	34.1	29.9	25.2	23	20.2	20.6	21.2	22.1	67.6	69.4	78	79.9	77	77.5	74.5	78.7	78.3	73.5	73.4	76.1	76.3	78.5	74.4	69.8	68.7	68	69.4	67.7	66.3	62.8	64.5	61	63.7
37.7	34	30.3	28.5	25.5	19.9	16.4	10.5	10.9	75.8	82.1	84.5	80	83.3	79.2	76.2	80	78.1	73.3	75.4	70.2	70.3	70.2	69.6	68.2	70.1	72.9	68.2	68.7	68.2	79.8	80.2	75.1	63
40.3	36	31.9	28.5	24.6	20.2	13.9	9	7.2	54.4	69.7	66.1	57.5	60.5	57.2	60.7	55.4	53.9	51.5	52	49.7	51.7	48.9	59.6	57.3	56.5	54.8	54	55.5	56.1	57.8	69.5	58.3	57.6
19.5	18.4	17.2	22.6	19.5	20	20.8	21.1	22.6	84.4	80.5	82	82.2	78.3	78.1	74.8	73.3	73.6	72.4	62.6	70.6	64	66	65.7	67.6	61.1	58.2	60	62.4	59.8	58.5	53.2	51.2	51
46.2	34.1	29.7	25	23	20.4	20.4	21.2	22.4	80.4	73.1	79.5	82	76.9	77.8	73.4	74.8	74.3	68.1	64.8	64.2	63.4	63.1	58.2	62	60.6	60.8	58.1	55.7	53.1	52.7	56.8	56.5	50.7
17.1	15.1	14	12.4	10.2	8.9	7.7	5.9	7.1	73.1	73.6	73.3	73.2	73.2	76.7	77.3	77.9	75.9	70.3	63	62.7	61.9	59.2	63.7	61.8	60.3	60	56.7	63	59.9	57.7	61	67.7	54.5
9.5	8.1	7.4	7	7.5	6.3	6.4	4.6	5.3	46.6	46.3	48.4	48.7	45	50.6	46.2	42.2	51.1	46.3	42	42.4	43.2	37.9	41.6	45	47.9	46	46.6	49.8	47.2	50.5	41	36.3	31.6
62.3	55	48.1	42	34.6	27.7	22.2	21.4	22.3	87.4	79.5	84.1	73.8	72.9	74.8	73.5	71.2	72.2	77.8	75.3	75.5	75.8	74.6	74.9	73.9	72.3	69.5	70.6	66	64	62.8	61.8	57.4	54
33.8	29.8	26.6	25.2	23.6	17.1	13.9	10.9	8.3	79.6	80.2	79.2	79.4	80.6	80.3	82.6	77.7	78.6	78.3	74.6	75.4	75.2	72.9	74.1	69.4	68.5	71.5	68.5	67.8	70.9	80.9	75.8	72.6	67.6
20.1	28.9	30.2	24.4	26.5	10.9	8	5.5	4.8	56.4	51.5	45.6	46.1	46.1	41.4	45.8	53.5	42	40.3	44.9	43	41.5	43.9	45.7	50.1	51.8	49.7	47.6	47.6	54.4	51.4	51.1	43.1	35.7
67.2	60.2	53.5	48.5	42.4	36.3	28.9	23.4	22.3	87.6	82	79.8	71.4	70.9	62.5	65.6	66.7	60.6	67.7	66.5	65.9	67.3	63.1	64.2	68.4	67.4	64	61.8	61.5	63.6	58	57.8	56.1	53.6
20.8	18.6	16.3	14.5	12.4	10.8	10.2	8.8	7.1	77.7	80.2	81.3	80.6	80.5	79.3	77.2	78.3	78.5	74.8	76.4	78.5	74.1	71.5	69.4	69.3	67.7	64	62.7	62.8	61.4	60.8	61.4	63	63.7
20	17.3	14.1	11.2	10.3	10.8	9.9	8.1	6.6	59.2	63	61.1	60.5	58.9	58.2	57.5	64.4	58.6	59	60.3	56.5	55.9	49.1	47.8	43.7	52.7	44.2	49.6	50.8	46.8	44.3	47.2	47.3	44.6
45.7	34	29.5	25.1	23	19.8	20.3	21.2	22.3	71.1	74.5	76.5	78.8	80	82	83.1	82.4	84	85.8	80.8	82.4	80.1	83.3	81.3	78.3	79.2	76.7	73.6	70.7	67.8	67.8	66.8	64.8	65.4
34.4	30.8	26.7	22.8	20.2	16.6	14.9	12.3	9.5	79.9	77.8	81.6	83.4	85.6	86.3	84.2	83.5	84.6	80.1	78.6	79.2	75.6	73.8	76	69.7	71.3	70.2	67.8	69.8	69.6	70.1	73	68.6	66
44.3	41.9	37.6	34	27.7	21.7	18.1	13.7	9.8	63	66.9	70	77.9	80.4	68.2	68.8	83.7	82.2	73.1	71.6	70.2	73	69.8	72.6	65	66.5	58.9	61.1	56.3	59.6	55.9	57.1	58.3	62.9
45.6	33.9	29.4	25	23	19.6	20.3	21.1	22	75.3	69.3	68.1	67.3	59.3	64	61	62.7	62.1	63	63.4	64.6	63.7	64	64.5	61.7	60.8	64.7	62.8	57.1	54.7	51.1	51.5	47.8	50.6
20.9	19.4	17.4	15.5	13.4	11.1	9.7	8.4	6.8	81.9	80.9	79.7	85.3	82.6	83.2	81	79.6	77.9	79	76.5	76.2	75.3	74.6	71.7	66.8	60.2	56.1	59	61.4	53.3	60.1	62.5	54	51.7
20.3	17.9	15.9	13.5	10.7	8.4	7.3	5.5	4.8	68.1	68.7	70.5	69.2	71.5	62.9	64	68.4	65.9	60.5	66.6	64.8	61.1	57.7	55.9	58.5	57.3	54.2	61.2	64.1	55.1	60.3	61.1	54	50.5
46	34	29.7	24.9	22.8	20	20.3	21.1	22	79.7	74.4	66	68.1	57.2	56.1	52.7	53.8	53.1	52.2	44.4	47.8	45.8	48.5	44.6	43.1	46.8	42.3	44.5	39.8	40.3	39.4	38.2	40.4	38.6
30.8	26.8	22.5	18.5	16.9	11.7	9	6.4	9	71.7	72.1	68.7	65.6	61.3	65.8	58.6	58.5	57.1	56.8	57.1	52.3	54	55.6	56.9	62.4	63.9	63.6	62.7	66	65.3	67	65.2	62.6	69.7
35.1	30.5	26.1	23	21.8	17.1	13.1	9.4	8.5	42.4	46.1	44.6	42.9	48.9	46.1	46.2	45.8	47.2	44.5	43.7	35.8	44.9	45.8	47.7	47.7	48	46	50.5	53.2	52.2	51.8	59.3	54	48.7
46.5	34.2	30	25.1	22.6	20.4	20.3	21.1	22	69.6	67.2	61.2	57.6	57.5	63.4	59.2	58.8	57.9	57.2	56.8	55.7	52.1	56.6	56	50.6	50.2	49.7	46.5	52.1	50.8	55.4	53.4	42.3	43.3
13.6	11.2	9.5	8.3	7.5	7.6	5.7	5.4	9.8	64.2	69.6	59.9	65.5	69	64.2	64.1	60.7	57.3	51.8	47.4	51.6	47	49.1	50.4	56.4	53.8	54.2	58.2	55.9	65.5	64.6	67.8	57.2	54.3
19	15.8	14.8	13.2	11.4	9.3	7.3	5.7	7.3	41	52.5	50.1	49.2	48.4	46.6	50.1	54.9	48.2	47.8	45.6	39.6	41.3	41.5	41.7	43.9	43.1	42	46.3	44.8	48.2	55.7	43.9	43.1	45.9
46.4	34.3	30.3	25.2	22.9	20.3	20.1	21	22.4	59.6	56.2	47.6	47.1	51.3	48	49.2	53.5	50.5	45.5	51.3	54.2	54.4	57.2	49.9	52.5	53.6	57.3	54.2	56.2	53	54.5	55	53.6	56.6
25.8	21.4	16.6	13.3	10.4	10.4	6.8	6	12.7	71.7	64	63.9	63.4	65.1	61.9	57.6	53.1	53.8	50.9	49.1	45.9	45.6	47	51	51.2	53.4	56.9	56.4	57.6	58.7	61.6	64.1	61.4	57.7
13.1	11.6	11.6	10.8	9.3	9.9	7.8	6.5	11.8	39.5	46.3	37.3	46.3	35.1	47.5	49.3	41.1	39.4	37.1	32.3	39.1	43.2	46	42.4	41.2	42.7	42.6	41.7	37.8	33.1	34	33.7	27.2	25.6
46.7	34.4	30.5	25.4	22.6	20.6	20.2	21	21.9	59.7	46.8	49	45.1	48.3	49.7	50	48.5	51.5	47.8	47.7	42.9	43.6	46	43.9	44	41.5	40.4	43.9	42.2	39.3	41.1	40.2	46.7	47.5
11.5	9.6	8.5	7.4	7	9.4	5.7	6	16.2	85	83.6	67.3	71.3	67.1	69.8	66.6	55.3	52.7	51	48.2	48.4	47.7	52.3	50.9	56.3	56.8	52.2	61.2	62.7	53.2	55.1	57.9	49	49.7
7.6	8.6	7.3	7.3	8	7.5	6.4	4.8	6.6	45.8	39	46.6	41.9	42.2	41.1	42.2	38.6	44.5	43.7	37.8	29.9	39	42	34.3	31.6	39.3	38.4	39.7	38.3	35.8	37.8	35.7	34.6	28.6
46.8	34.5	30.5	25.4	22.8	20.2	20.1	21	21.8	75.8	77.5	72	66.8	54.2	50.8	47.6	47.5	43.1	45.2	51.4	46.3	46.6	54.5	47.1	41.4	46.1	41.2	45.3	40.2	40.7	40.8	38.5	36.3	37.9
22	17.8	13.9	11.4	9.2	9	6.7	5.7	11.2	71.7	66.2	64	58.6	63.1	60.8	52.1	53.5	51	45.9	45.8	44	43.7	44.5	44.7	46	48.1	51.1	56.1	62.2	61.7	62.8	62.3	57.7	50.5
6.2	6.5	6.2	5.8	6	6.6	5.4	4.8	9.2	28.1	38.8	46.4	40.5	30.4	27.7	28.9	40.7	34.6	40.5	39.3	29.7	39.4	38.1	37.1	36.8	41	40.8	42.1	34.2	34.7	30.5	29.9	23.6	23.3
47.1	34.5	30.6	25.6	22.6	20.6	20.2	21	21.9	77.5	73.8	74.6	62.1	60.8	51	52	51.4	47.7	48.8	49.4	48.5	45.5	45.1	45	44.3	44.8	43.5	45.1	40.1	38.4	40.8	42.8	49.1	49.9
12.6	11.2	10.3	9	8.1	7.1	5.8	5.2	7.9	81.3	76.1	71.1	64	66.4	60.6	59	53.3	53.2	49.1	49.1	45.6	46.4	45.7	49.5	50.4	50.6	49.7	48.1	46.8	46.6	52.1	45.9	44.7	38.9
19.6	18	16.8	15.6	14.7	13	11.1	8.5	8.5	45.7	39.8	47.8	49.4	44.6	47.6	47.6	55.4	52	43.3	43.2	46.8	42.2	42.4	40.1	42.4	39.5	41.6	46.3	43.2	37.2	37.3	37	34.2	33.7
47.2	34.6	30.6	25.5	22.6	20.3	20.2	21.1	21.8	78.6	76.3	68.1	61.9	51.8	54.2	49.4	48.4	45.6	42.8	46.3	44.6	46.5	46.7	49.1	62.1	65.8	61.1	60.4	58	57.6	60.2	57.6	56	49
27.8	24	19.4	15.9	12.5	9.7	7.3	5.9	9.8	80.7	77.4	65.4	68.4	65.8	65	59.6	53.8	53.5	54.4	51	55.5	56.8	58.3	59.5	64.4	70.8	72	76.3	70.5	66	69.4	69.2	63.1	62.1

4.0 Hz	5.0 Hz	6.3 Hz	8.0 Hz	10 Hz	12.5 Hz	16 Hz	20 Hz	25 Hz	31.5 Hz	40 Hz	50 Hz	63 Hz	80 Hz	100 Hz	125 Hz	160 Hz	200 Hz	250 Hz	315 Hz	400 Hz	500 Hz	630 Hz	800 Hz	1.0 kHz	1.25 kHz	1.6 kHz	2.0 kHz	2.5 kHz	3.15 kHz	4.0 kHz	5.0 kHz	6.3 kHz	8.0 kHz	10.0 kHz
46.8	34.6	35.3	40.4	38	42.9	67.8	53.1	38.5	44	47.2	42.6	40.1	41.9	39.7	34.2	32.5	31.3	33.9	33.2	55.2	63.1	74.2	93.3	114	93.5	74.1	63.4	49.2	45.8	34.1	29.7	24.9	22.6	19.7
34.9	40	37.7	37.4	32.5	39	42	39.5	40.7	40.1	36.9	40.2	38.4	39.8	34.1	29.8	33.1	32.3	29.5	29.6	31.4	30	28.8	25.7	26.8	28.2	29.1	28.5	28	25.2	22	19	16.4	13.8	10.8
18.9	15.9	20.4	16.2	13.6	17.6	21.3	17.1	20.4	16.4	20.3	20.8	24.3	17.1	20.2	19.5	17.3	20.5	20.4	20.6	18.7	19.1	20.3	28.7	25.9	14.9	13.2	14	7.8	8.1	8.6	8.9	9.8	10.5	11.5
31.7	26.6	26.9	24	28.4	29.9	31.7	30.7	33.4	32.8	33.1	31.8	29.8	22.3	23.6	16.5	14.9	19.3	19.1	18.1	16.7	17.2	17.6	23.8	18	7	3.5	2.4	3.2	3.7	4.2	4.8	6.1	4.8	5.5
36.9	43.8	44.1	40	40.7	41	41	37.8	43.3	39.8	42.3	40.8	38	36.8	37.1	33.9	29	25.8	26.5	24.8	23.4	25.5	29.1	34.2	29.1	19	13.7	14.2	13.2	14.5	15.9	16.2	17.2	18.3	18.5
48.6	41.1	39.3	46	45.7	42.6	40.5	32.7	35.6	32.2	35.4	40.3	30.8	31.1	28.3	22.1	18.1	21.8	23.8	23.6	55.1	63	74.1	93.2	114	93.5	74.1	63.3	49.1	45.8	34.1	29.7	24.7	22.7	19.8
20.8	19.7	17.2	20.3	23.2	24.9	27.9	28.7	29.8	28.9	27.9	27.9	26.7	24.1	17.2	13.7	13.7	15.9	18.8	19.9	20.5	21.1	21.3	23.1	24.7	20.2	17.4	14.4	11.4	9.2	7.9	7.1	6.1	5.5	5.6
34.7	34.1	33.5	34	43.9	40.7	39.8	44.7	43.8	44.7	44.7	45	49.2	46	45.6	39.8	34.4	35.6	34	37.7	40.8	43.6	46.8	50	47.7	47.5	44.5	41.7	37.9	34.7	30.1	25.2	21.1	16	11.2
37.7	41.2	34.9	31.6	33.4	41.5	42.2	39	40.4	40.3	41.9	37	36.4	35.7	32.2	27.4	27	23.6	19.7	19.3	17.3	18.3	19.7	23.7	18.1	12.2	12.2	14.1	13.3	14.2	15.9	16	17	17.4	18.6
41.7	36.1	41.5	34.7	35.5	38.8	38.4	30	36.8	39.8	39.4	35	32.3	30	27.3	24.1	20	20.1	20.5	22.2	55.1	63	74.1	93.2	113.9	93.4	74	63.3	49.1	46.1	34.1	29.5	24.8	22.7	20
10.3	16.9	18.7	21.7	22.4	26.1	26.7	24	28.2	30.2	31.2	27.7	28.6	25.4	20.5	19	17	14.1	14.3	15.6	17.7	18.9	21	21.9	20.7	18.2	15.7	11.4	8.6	6.5	6	5.2	5.1	4.9	5.4
35.2	27.6	36	23.9	31.1	34.3	37.2	38	36.7	40.6	35.4	44	34.1	31.2	26.4	24.1	21.6	20.5	21.7	23.7	29.6	27.1	27.7	28.2	28.2	25.2	21.4	15.2	11.2	8.3	6.8	6.2	5.9	6.2	5.1
34.4	37	39.4	31.3	28.7	36.8	39.6	40.5	38.3	35.8	36.7	38.7	34.8	27.6	23.8	20	20.4	20.9	21.1	21.4	54.1	62	73.1	92.2	112.9	92.4	73.6	63	49	45.7	34	27.7	24.7	22.6	19.5
13.7	13.2	19.4	20.4	21.7	25.4	27.2	29.9	28.9	30.3	27.5	29.2	26.8	23.1	18	14.8	15.2	16.6	18.2	19.9	21.3	19.6	18.7	20.2	20.8	19.1	16.8	14	12.3	11.2	8.6	6.6	6	5.8	5.6
32	24	29.7	33.8	31.2	33.7	36.7	39.3	40.8	37.1	43.4	43.2	43.6	33.7	27.1	24.8	21.6	23.7	27.7	31.3	31.6	28.2	29.7	32.3	32.2	30.3	28.4	23	17.8	15.2	17	13.5	10.8	12.4	7.1
22.5	20.3	24.5	31.5	21.7	28.6	30.5	30.1	32.5	30.4	29.6	32.2	30.6	28	27.3	23	21.9	16.4	17.3	20	53.6	61.6	72.7	91.8	112.5	92	73.6	62.9	48.9	45.6	33.9	27.4	24.7	22.7	19.2
16.4	17.4	17.6	22.4	23.1	25.5	27.7	26.5	31.1	31.3	28.1	31.2	29.9	27.7	24.4	22.5	20.1	20.2	19.4	20.9	22	23	25.7	26.2	25.8	23.6	21	18.1	13.2	10.4	8.5	7.3	6.9	6.3	5.5
29.1	30.5	34	25.1	26.5	29.9	33.9	28.2	37.9	40.4	34.1	37.1	35.6	37.5	35.6	32.1	31.9	28.5	26.7	24.4	26.5	28.6	29.2	32.3	32.7	28.9	26.7	22.4	20.2	18.8	16	13	10.2	9.3	9.6
40.2	49.9	47.7	41.5	44.6	44.1	47.5	45	40.3	43.7	41.7	37.9	38.6	33.8	35	25.9	22.5	25.2	23.8	24.8	54.9	62.9	74	93.1	113.8	93.3	73.9	63.1	49	45.5	33.9	29.3	24.7	22.7	19.3
22.5	22.5	18.8	23.7	23	25.9	37.9	33.6	33.6	32.5	32.1	34.3	29.4	25.3	22.2	17.3	16.4	18.5	20.2	22.3	23.1	22.5	23.3	25.3	26.4	23.9	20.2	15.1	11.5	9.7	8.3	7.5	7.2	6.8	6.3
69.8	66.9	71.3	68.3	71.8	63.2	64.7	58.3	56.8	54.2	58.1	54.6	52.2	57.2	62.3	45.2	41.8	43.4	45.3	48.2	52.4	51.1	51.9	54.3	54.9	53.8	51	47.8	46	45	41.5	37.4	32.7	26.7	21.2
34	29.7	29	32.5	34.2	32.7	32.1	31	36	35.4	32.3	30.6	30.2	27.4	25.4	23.1	19.8	18.4	19.1	21.1	54.9	62.8	74	93.1	113.8	93.3	73.9	63.1	48.9	45.6	33.9	29.2	24.7	22.6	19.1
18.4	21	19.6	22.2	21.8	25.6	28	24.3	28.1	29.9	24.6	28.9	27.3	25.7	23.3	21.6	19.4	18.5	18.3	20	22	22.3	23.1	24.1	23.6	21.1	18.9	16.5	14	13.1	11.6	9.8	7.8	6.7	5.7
18.6	27.4	26	28.6	33.2	37.2	38.1	36.4	39.4	39.3	37.8	35.3	40.2	32.2	29.6	28.5	23.8	23	25.5	26.9	31.2	32.8	33.4	34.2	33	30.6	26.4	23.1	19.7	17.3	14.9	11.9	9.4	7.3	6.2
16.9	16.8	17.7	21.4	23.4	24.6	29.3	27.3	29.7	26.5	25.7	27.2	25.5	21.4	18.1	16.6	15.9	18	18.7	19.9	54.9	62.9	74	93.1	113.8	93.3	73.9	63.1	49	45.9	33.9	29.5	24.6	22.5	19.6
17	11.5	14.2	17.7	18.6	21.1	25.6	26.2	24.8	25.5	24.2	23.7	24.6	20.8	16.6	16.7	15.2	17.9	20.1	18.7	17	14.7	15.7	13.3	13.4	10.6	6.2	3.9	3.5	3.9	3.9	4.4	4.6	4.7	4.8
33	24.3	26.7	27.8	32.3	34.5	30.8	32.7	35.2	35	35.9	39	45.9	42.2	34.2	27.5	26.6	30.5	33.3	33.3	35.2	37.3	37.6	40.9	43.4	39.3	36.9	30.4	26.6	22	17.9	13.5	11.5	8.4	7.7
20.2	26.3	26.1	26.6	25.2	30.7	33.3	29	28.6	32.3	32.8	34.3	32.5	28.6	26.5	22.5	18.5	17.6	18.5	20.8	55.1	63	74.1	93.2	114	93.5	74.1	63.3	49.1	46.4	34.2	29.8	24.7	22.3	19.9
15.2	12.9	17.2	18.3	16.9	19.4	21.9	22.2	24.3	25.6	24	24.1	26.8	24.4	21.1	18.3	16.9	15	14.6	14.1	14.2	15.4	14.7	13.6	13.6	10.7	7.8	4.9	3.4	3.6	3.8	4.3	4.3	4.6	5.7
26.6	26.8	27.3	27.2	25.4	26.6	27.1	27.7	32.7	32.5	37.1	33.9	33.3	31.9	31	25.2	20	19.3	19.3	22.6	25.2	26.1	30.7	34.2	35.8	34.5	30.4	22.7	16.7	11.8	8.3	5.8	5.1	5.2	6.2
31.4	33	33.7	36.6	30.1	31.2	28.5	27.7	32.4	29.5	27.9	29.5	30.1	25.3	18	14.8	14.1	16	17.7	21	55.3	63.2	74.3	93.4	114.1	93.6	74.2	63.5	49.3	46.3	34.3	30.1	24.9	22.6	19.9
13	14.3	16.4	13.2	20.6	18.7	23.7	23.8	24.5	24.4	23.3	24.2	22	17	13.2	10.2	10.2	12.5	13.7	13.3	11.1	9.7	9.7	9	7.6	5.1	4.1	3	3.1	3.4	3.7	4.4	4.4	4.5	6.6
26	31.6	36.3	28.1	36.7	28.4	36.6	32.8	35	30.3	28.3	29.6	26.3	21.5	19.4	22.6	14.8	18.4	16.5	16.8	15.5	13.6	13.3	13	11.7	11.6	8.8	6.6	6.1	6.5	5.7	6	5.9	5.8	7.8
21	23.9	24.5	25.5	20.6	20.3	25.1	27	29.5	26.1	24.8	27.8	26.7	25.6	23	23.3	20.9	17.3	18.3	21.5	55.3	63.2	74.4	93.5	114.2	93.7	74.3	63.6	49.3	46.6	34.4	30.3	25.1	22.3	20.2
12.8	17.6	18	18.7	17.4	20.9	22.7	22	26.7	23.5	24.1	24.9	26.5	24.4	20.2	17.8	16	15	13.3	14.9	14.6	15.6	14.8	11.7	11.7	7.6	6.1	3.9	3.2	3.5	3.8	4.2	4.5	4.5	6.2
24.8	19.1	31.2	37.8	29.3	24.3	28.7	31.8	35.7	30	30.4	31	31.8	29.8	25	23.5	20.2	15.4	18	16.7	19.8	20.2	23.6	14.8	13.5	10.2	7.7	6	5.1	5.4	6.4	5.7	5.8	6	6.5
23.3	18.3	21.3	21.7	22.5	22.8	27	28.8	24.8	27.3	29.6	27.3	25.8	24.8	26.6	18.7	16	15.5	18.3	20.5	55.3	63.3	74.4	93.5	114.2	93.7	74.3	63.6	49.4	46.8	34.4	30.3	25	22.4	19.6
14	11.1	14.2	17.2	19.5	19.8	23.2	23.7	25.8	24.1	24.7	22.8	22.8	19.8	16	12.7	12.3	14.2	16.7	16.3	13.3	10.6	10.6	10.7	7.7	4.6	3.5	2.6	3.3	3.6	4	4.2	4.4	4.5	5.4
36.8	26.8	36.7	35.5	34.9	35.8	38.3	35.5	40.3	33.8	32.9	28.8	28.9	22.4	21.1	21	22.6	22.4	23.4	23.3	20.1	21.7	20.2	16.5	15.8	9.6	14.2	10	7.5	7.2	6.5	6.5	6	6.4	6.9
22.6	23.7	27.2	25.4	22.4	25.7	29	24.5	30.4	27.5	26	26.4	27.4	28.2	24.9	22.5	20.4	18.2	18.8	21.7	55.3	63.3	74.4	93.5	114.2	93.7	74.3	63.6	49.4	47	34.5	30.3	25.2	22.3	20.1
11.1	11.4	16.6	16.6	18.6	20.7	20.1	21.3	24.3	23.2	22.8	23.9	23.7	22.9	20.1	18.9	17.2	15.2	15.9	13.4	14	13.1	12.3	9.4	8.5	4.8	3	2.7	3	3.3	3.7	4.3	4.3	4.5	4.6
29.9	31.1	30.8	26.9	24.7	30.6	22.9	28.2	30.8	31	28.4	26.1	30.2	26.8	25.9	20.8	19.5	18.2	18	20.1	21.1	21.2	22.1	26.6	28.3	25.7	21.7	17.7	10.8	8.9	8.7	9.5	7.8	6.2	6.3
17.3	16.5	21.2	25.1	25.1	31.8	29.3	29.5	29.6	28.4	26.1	28.5	23.6	21.4	18.5	15.1	16.5	19.8	23.9	24	55.4	63.3	74.4	93.6	114.3	93.7	74.3	63.6	49.4	47.1	34.5	30.3	25.2	22.2	19.8
8	11.7	13.2	15.1	19.1	19.9	23.3	23	27	23	23.6	24.5	22.3	19.2	18	13.9	14.3	14.5	16.4	17.7	14.3	12.9	13.3	11.7	10.5	7.9	4.4	2.9	2.9	3.5	3.9	4.3	4.5	4.7	4.9

12.5 kHz	16.0 kHz	20.0 kHz	LfF,Perc4 0.4 Hz	0.5 Hz	0.63 Hz	0.8 Hz	1.0 Hz	1.25 Hz	1.6 Hz	2.0 Hz	2.5 Hz	3.15 Hz	4.0 Hz	5.0 Hz	6.3 Hz	8.0 Hz	10 Hz	12.5 Hz	16 Hz	20 Hz	25 Hz	31.5 Hz	40 Hz	50 Hz	63 Hz	80 Hz	100 Hz	125 Hz	160 Hz	200 Hz	250 Hz	315 Hz	400 Hz	500 Hz
20	21.1	21.7	82.2	79.4	78	71.6	65.8	63	60.8	61.6	60.7	62.4	61.8	57.8	54.6	56	55.8	55.8	70.6	57.5	53	55.1	57.1	53.9	50.4	51.5	59.6	53.4	51	59.2	53.6	56.4	61	65.1
9	5.9	5.2	69.9	70.5	70.7	71.5	70.6	69.4	69.6	69.2	69.2	66.6	65.6	66.1	63	61.7	58.6	57.3	58.2	52.8	55.5	56	62.4	58.9	52	56	61.5	61.1	56.3	63.3	62.3	62.8	68.1	67.3
12.5	12.6	15	95.1	93.1	89.7	82.1	75.8	73.3	66.7	69.3	65.1	66	67.7	65.4	61.9	60.8	60.1	59.1	56.9	55.5	53.5	50.7	52	53.5	51.3	48.5	46	41.3	36.5	35.5	33.9	31.4	34.1	37.5
5.5	4.3	11	82.7	79.1	80.7	78.4	73.8	64.5	65.9	60.9	56.3	53.9	52.7	51.7	53.1	49.3	48.4	46.2	45.9	47.3	48.1	46.9	44.9	46.9	48.9	46.5	44.9	42.4	37.1	34.5	34.1	34.1	35.4	40.1
19.6	20.7	21.8	84.6	82.7	70.4	65.8	61.3	61.4	64	59.4	65.2	60.4	64.7	68.2	64.9	67.2	66.2	64.1	61.2	61.8	61.6	61.4	59.1	67.3	75.7	56.5	55.5	58.3	49.1	48	49.1	52.1	49.5	53.4
20.1	20.8	21.7	66.2	67.8	74.9	78.1	75.2	75	72.1	76.2	75.4	71.3	71.7	74.3	71.8	73.5	69.5	66.5	65.3	63.9	62.5	60.1	60.2	58.8	56.3	54.3	54.2	51.3	48.7	49.7	44.6	44.1	55.7	63.2
6.2	4.1	5.9	65.1	66	66.7	66	65.1	65	64.2	63.2	61.7	59.8	57.6	56	54.4	52.9	52.4	53.1	54.3	54.4	53.7	54.3	53.5	58.6	62	57.3	52.9	50.9	45.5	45	45.7	48.4	50.3	53.5
7.6	4.7	5.1	53.6	68.9	65.8	55.5	58.8	55.6	60	54.4	52.4	50	50.8	48.5	48.2	46	58.6	55	54.8	54.2	53.3	52.8	51.6	55.6	67.4	57	52.4	48	43.8	39.4	41.2	42.2	47.5	51.9
19.7	19.8	21.7	83.5	78.2	79.1	76.8	69.4	75.5	69.7	68.7	63.6	66.3	58.6	65.7	61.7	61.8	59.4	63.5	57.7	54.1	56.6	59.1	55.3	48.1	50.7	46.3	45.7	41.7	45.5	46.5	46.9	45.5	41.5	41.5
20	20.8	21.9	79.2	72.4	75.4	77.1	70.9	69.5	70.3	63.3	63.8	60.7	57.3	60.1	59.5	56.9	55.3	56.1	55.9	53.1	52.2	51.1	49.4	46.6	47.3	42.4	38.4	32.9	30.3	27.7	26.3	27.6	55.2	63.2
4.7	4	4	63	63	62.3	63.5	61.4	59.9	58	57.8	55.5	52.2	50.4	48	45.1	45.1	45.2	47.8	48.3	43.8	47.5	49.5	47.7	47.4	51.6	46.3	42.9	39.1	35.5	32.8	30.4	31.5	33.3	36.5
5.5	4.2	4.1	46.4	46	48.2	48.2	44.5	49.2	45.2	41	49.4	44.8	41.6	38.4	42.4	36.8	40.6	44.2	47.2	45.6	45.2	49.2	44.8	49.4	40	35.7	30.2	28.6	26.2	24.4	27.2	27.6	33.4	30.4
19.9	20.8	21.9	80.3	76.6	76.6	70	70.1	69.3	71.2	68.3	69.9	71.6	71.2	70.8	69.8	69.8	71.9	69.6	66.7	64.3	63.6	60.6	58.8	57.9	55.3	53.4	48.7	45.4	42.9	39.1	34.4	31.7	55.2	63
4.9	4	4	65	67.1	68.2	68.2	67.6	66.6	66	65.3	64.2	62.6	60.2	58.2	55.9	54.4	52.5	51.4	51.3	50.4	51.6	51.6	51.9	57.1	58.2	55.7	49.3	44.9	41.1	39.9	42.2	43	45.3	49.2
6.5	4.4	3.9	55.6	50.5	45.2	45.4	45.3	40	44.4	52.8	41	39.2	39	42	40	43.1	43.4	47.8	49.8	48.2	46	45.6	49.6	50.2	50	41.4	34.2	31.4	26.5	28.2	31.6	35.6	35.2	32.4
19.9	20.7	21.6	81.6	78	68.3	65.6	66.3	59	59.8	62	58.3	62.8	62.1	61.2	63.1	58.7	57.7	58	56	55	54.6	55.6	54.2	53	49.8	47.3	44.2	40.1	35.9	30	25.9	25.1	55.2	63
4.9	4.1	3.5	67.4	68.8	67.8	67	66.6	65.3	64.7	63.2	61.7	59.6	57.1	54	51.4	48.9	47.1	48.4	49.2	46.1	50.2	50.8	49.7	49.9	51.6	46.1	44.7	42.1	38.4	35.6	34.9	34.9	36.2	37.8
8	6.5	5.1	57.1	60.5	60.5	59.8	58.1	57.2	56.2	60.3	55.3	56.3	54.5	52.8	54.7	45.5	45.9	42.3	49.5	41.5	48.8	48	44.9	42.8	45.9	45.3	42.5	41.3	37.6	37.8	30	29.3	33	35.6
19.7	20.8	21.7	70.1	72.6	75.1	75.8	75.6	77.8	78.4	78.2	77.8	79.6	72.8	75.6	75	74	77.6	72.8	72.4	69.4	66.4	64.4	62.1	61.3	59	58.1	57.1	54.6	51.4	48.2	43.9	41	55.2	63
6.1	4.3	3.9	70.6	70.3	72.6	72.5	72	71.7	70.6	70	69	67.9	65.6	64	62.1	59.9	57.8	56	57.2	53.7	53.8	53.7	56.6	56	57	55.9	49.2	44.2	39.5	38	41.2	43.4	45.5	49.2
17.4	13.1	9.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19.8	20.7	21.6	67.7	66.9	62.4	62.7	56.5	60.1	57.2	58.6	54.1	57.9	57.8	57.2	56.2	56.2	55.5	50.7	50.6	49.4	48.6	48.3	44	43.2	42.2	36.6	33.7	30.3	27	24.2	24.2	26	55.1	63
5.1	4.1	3.7	70.3	70.6	70.3	70.6	71.1	68.9	67.3	66.6	64.8	63	61.2	57.6	55.5	52.6	50.1	49.1	48.5	45.5	48	49.2	46.1	47.5	48.8	43.5	41.3	37.7	34.3	32	31.2	34	36.5	38.5
5.9	4.3	4	63.9	65.7	63.8	65.3	62.8	61	59.6	64.1	61.2	56.8	57.1	56.9	53.2	51	50.5	50.4	53.1	48.3	54.9	54.6	49.2	50.6	54.3	50.6	45.7	42.7	40.8	35.5	34.2	35.6	38.2	42.4
19.8	20.7	21.5	69.8	64.2	62.3	58.6	52.8	48.7	48.5	48.2	47.1	45.3	42.5	40.2	40.1	39.5	39.5	39.2	43.1	39.7	41.7	37.1	37.2	36.1	34.1	29.3	24.6	22.8	21.9	23.8	24.5	24.5	55.2	63
4.4	3.8	5.8	49.8	48.3	48.4	46.9	49.6	47.5	47.1	48.1	46	43.6	41.6	40.1	39.5	40.4	42	42.7	45.6	45.6	46.6	46.9	47.4	50.7	51.9	49.7	45.3	39.6	34.4	34.5	37.7	39.4	41.5	44.9
6	4.4	6.8	41.5	45.5	44.1	41.9	48.5	44.3	45	44.5	45.5	43.1	42.3	34.7	42.9	42.9	45.3	43.7	45.3	45	48.3	48.4	48.7	48.7	57.3	52.6	46.3	41.5	35.7	37.7	41.3	41.8	45.3	49.9
19.9	20.5	21.7	65.2	60.2	55.2	54.2	56.2	60.7	55	55.9	55.5	54.8	52.2	51	47.8	52.8	47.8	45.7	47.4	43.9	43.8	47.5	46.8	52.2	47.4	37.6	39.3	31.9	29.6	25.2	24.6	26	55.2	63.2
4.2	3.6	3.7	47	46.5	47.7	46.9	48.9	48.3	48.9	49.2	46.8	43.3	41.3	39.4	39.8	40.3	40.7	41.5	43.1	40	43.5	46.6	41.5	42.3	43.2	39	37.2	32.7	31.8	30.7	27.9	29.7	30	32.2
4.8	3.9	6.6	40.4	51.6	48.8	48.4	46.9	44.9	48	53.2	46.5	46.1	42.7	38.1	39.8	40	39.1	41.6	40.5	38.1	44.5	43.1	45.9	52.1	41.4	41.7	43	37.6	31.6	27.6	26	28.3	30.8	33
19.7	20.6	21.7	53.8	52	43.3	44.3	49	44.7	47	50.1	46.5	43.5	47.9	48.3	50.4	52.2	45.3	49.2	46.8	48.1	49.1	47.2	46.7	47.6	48.4	49.2	49	38.8	32.7	34.7	31.7	33.9	55.4	63.4
4.3	4.1	8	45.2	45	45.2	43.6	47	47	45.6	48	43.7	41.1	38.7	38.4	38.8	41	41.6	41.4	42.2	41.7	43.8	41	40.9	45	43.6	41.4	37.4	30.4	26.3	27.3	31.1	32.5	33	34.6
5	5	11	39.4	46.2	34.6	46.2	31	47	48	40.8	37.4	36.9	31.2	38.8	42.9	45.4	40.2	37	42.4	41.6	41.4	36.4	32.4	32.8	32.8	26.4	23.8	24.9	18	20.3	20.6	20	18.4	18.9
19.8	20.7	21.6	57.4	42.1	47.1	41.7	43.1	47.9	47.9	46.3	48.3	45.1	42.2	40.3	39.9	41.6	39.9	38.9	39.6	37.5	40.9	39	35.6	36.5	37.8	34.4	29	31.5	27	24.6	22.5	25.3	55.4	63.4
4.3	3.7	4.3	50.1	50.5	49.5	48.4	49.5	48.5	49.1	48.2	46.3	43.4	41.4	41.3	41.9	42.4	40.7	41.4	42	39.9	43.9	42.3	38.6	40.9	41	37.9	33.8	31.7	29	28.3	25.7	26.4	31.2	30.1
5.5	4.5	5.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19.6	20.6	21.4	72.9	71.9	62.6	60.5	48.1	44.8	45.2	45	41.5	41.7	39.4	39.5	39.3	38.8	38.9	37.7	42.7	38.5	41.1	37.8	38.6	37.2	33.3	33	33.2	25.5	22	21.8	23	24.5	55.4	63.4
4.1	3.8	6.2	44.3	44.9	44.4	43.8	45.8	45.4	45.1	45.8	43.5	40.6	39	37.5	37.7	38.3	38.7	38.3	42.9	39.8	42.3	38.9	39.5	42	40.5	36.3	34.5	27.7	24.4	25.6	29.5	30.4	31.7	31.1
5.5	4.8	9.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19.8	20.7	21.4	73.3	70.7	67.5	57.7	49.5	41.5	47.3	47.6	45.6	44.1	43.2	41.8	42.5	40.6	40.3	40.1	41.7	39.7	40.8	36.4	35.1	36.7	36.6	38.1	33	29.6	25.9	25.5	23.5	26.1	55.4	63.4
4.2	3.8	4.8	50.2	48.3	48.6	47.4	48.1	46.8	46.2	46.2	43.6	40.9	39.2	38.9	39.9	39.3	39	39.2	40.9	38.2	41.7	38.7	36.7	39.7	36.2	34.9	31.3	28.8	26.5	25.6	25.3	25.1	28.7	27.2
4.9	4.7	5.4	44.8	38.3	45.4	48	43.6	46.8	45.4	54.2	50.8	42.6	41.6	45	41.4	40.2	38.6	41.4	38.4	38.8	45	40.5	34.1	35.9	36	33.1	32.2	26.5	26.7	24.8	25.2	26.7	27.8	30.8
19.8	20.6	21.4	75.6	65.4	64.1	55.6	47.2	49.3	44.1	45.2	43.1	38.6	39.3	40.4	41.1	41.9	43	56.5	58.3	54.5	54.5	51.2	50.3	53.5	52.1	49.8	43.9	39.5	34.2	31	35.5	36.4	55.6	63.4
4.2	3.8	4.3	45.1	44.5	44	43.1	44.6	44.7	42.7	43.5	41.2	38.7	38	37.1	38.1	38.5	40.1	41.2	44.7	47.1	46.3	43.6	43.1	44.9	43.7	42.9	38.5	34	31	30.7	33.1	35.4	34.9	36.8

LfF,Perc6

630 Hz	800 Hz	1.0 kHz	1.25 kHz	1.6 kHz	2.0 kHz	2.5 kHz	3.15 kHz	4.0 kHz	5.0 kHz	6.3 kHz	8.0 kHz	10.0 kHz	12.5 kHz	16.0 kHz	20.0 kHz	0.4 Hz	0.5 Hz	0.63 Hz	0.8 Hz	1.0 Hz	1.25 Hz	1.6 Hz	2.0 Hz	2.5 Hz	3.15 Hz	4.0 Hz	5.0 Hz	6.3 Hz	8.0 Hz	10 Hz	12.5 Hz	16 Hz
74.4	93.4	114.2	93.6	74.2	63.6	49.4	46	34.2	30.1	25.6	23.2	20.4	20.7	21.6	22.3	60.3	67.6	54.2	50.6	51.2	48.2	54.3	51.2	48.6	47	49.3	39.8	42.2	44.8	43.6	45.9	68.6
64.7	60.5	55.5	56	59.9	61.1	58.9	52.8	53.8	45.9	45.1	42.7	39.3	33.5	25.6	24.3	55.7	53.9	52.7	53.5	55.5	56.1	53.9	53.7	48.6	49.3	47.8	48.4	45.3	44.2	43.2	44.7	49.5
41.4	46.5	40.7	31.1	30.8	30.7	30.1	29.8	29	28.2	27.5	26.9	26.2	25.6	25.4	25.3	71.9	69.1	60.2	53.9	56.6	51.3	49	39.7	34.9	30.9	26.9	25.9	27.7	25.9	23.5	23.3	25.9
45.3	51.1	45.7	35.5	27.7	20.5	15.1	15.9	16.8	17	18.1	18.8	19.3	20.2	21.3	23.2	62.9	58.3	50.1	43.2	40.5	36.7	38.7	42.9	41.4	37.5	36.1	32.7	33.5	32.5	35	34.8	36.1
55.8	56	48.3	36.1	28.9	22.3	16.1	16.5	17.3	17.1	18	19	19.4	20.3	21.3	22.3	67.2	62.2	53.3	48.1	49.3	46.9	46.2	46.4	50.2	49.8	44.6	48.9	49	46.6	47.5	49.7	47.8
74.2	93.4	114.2	93.6	74.2	63.4	49.2	46	34.2	30	25.2	23.2	20.5	20.8	21.4	22.2	57	48.9	65.1	62.5	62.2	58.1	63.6	58.5	54.5	57.7	54.3	49.4	50.9	51.6	51.8	49.6	43.3
56.6	58.7	58.2	55.3	52.5	48.8	45.2	41.9	37.8	33.8	31.2	27.7	22	17.5	12.2	11.8	45.3	44.5	43.8	44	43	42.3	40.4	39.4	37.5	36.7	35.6	34.8	33.7	33.8	35	36.7	38.8
57	60.2	56.9	54.3	52	48.6	46	42.8	38.8	35.2	31.7	28.6	24.3	17.4	12.4	10	38.8	60.5	58.6	38.6	50.6	42.6	50.4	45.6	41.2	37.8	40.8	38	34.5	38.8	46	44.4	44.4
46.7	50.3	48.7	38.5	38.9	36.9	26.3	22.3	20.5	18	25	19.9	20.7	21.3	21.4	22.9	70.5	62.5	55.1	64	56.1	57.5	52.8	49.5	43.1	42.3	42.2	43.4	39.5	40.7	43.9	45	46.5
74.2	93.4	114	93.6	74.2	63.4	49.2	46.4	34.2	29.8	25.2	23.2	20.6	20.7	21.4	22.7	61.7	61.9	54.7	56.7	50.7	46.5	47.3	45.7	45.6	47.1	46	46.9	46.3	42.6	40.2	43.3	43.8
37.6	38.1	37.4	34.7	31.3	26.7	22.3	19.7	17.5	16	14.5	12.5	10.7	10	10	10	41.6	40.4	41.7	40.2	39.7	37.5	35.3	34.9	33.3	31.7	31.3	31.1	31.2	32.9	34.5	36.5	36.8
33.2	32	30.6	27.1	23.8	18	13.6	10	10	10	10	10	10	10	10	10	35.4	37.4	37.2	42.1	38.8	39	38.2	31.4	41.8	36	36.2	29.6	36.8	26.2	33.2	36.4	38.4
74.2	93.4	114	93.6	74.2	63.5	49.2	47.7	35.7	29.8	25.9	23.6	20.4	20.6	21.4	22.5	64.8	53.5	59.9	56.2	58.3	53.5	50.3	48.1	47.5	41.9	46.9	52.7	49.3	51.6	49.9	49.6	49.9
53.6	56.4	56.6	53.9	51.2	46.5	42.3	38.2	34	29.8	26.6	26.8	18.5	13.5	10	10	42.6	43.4	44.3	45.3	44	42.7	41.5	40.5	37.9	36.7	35.5	34.5	33.7	34.3	34.5	36.4	38.4
33.4	35.8	36.8	34.8	31.4	28.8	25.9	23	31.8	34	28	31.4	14.3	10	10	10	45.7	29.2	35	33.8	40.4	25.8	29.2	41.6	28.2	34.6	33.2	25.2	30.6	35.8	34	37.2	39.8
74.2	93.2	114	93.5	74.1	64.8	49.4	50	38	29.8	26.7	24.1	20.2	20.7	21.5	22.4	59.7	52	55.2	50.7	46.1	43.2	43.2	40.7	38.2	35.3	37	39.6	36.2	36.6	37.2	38.1	39.3
40	41.6	42	38.5	35	30.1	25.3	23.2	21.2	19.2	17.1	15.1	13.1	12.5	11.5	10	46.9	45.7	46.3	45.4	45.4	43.3	41.8	39.7	39.2	36.4	34	33.9	33.7	34.2	35.2	37.4	38.3
35.7	37.1	36.2	32.1	30.4	25.6	23.3	21.3	18	14.8	11.9	10.8	11.6	10.8	10	10	44.3	43.5	45.3	51.3	48.4	46.3	50.1	41.5	33.9	34.1	34.3	32.3	36.3	32.3	31.1	34.9	36.9
74.2	93.2	114	93.5	74.1	63.4	49.2	45.8	34	29.6	25.2	23.2	20	20.4	21.4	22.3	54.4	56	56.8	60.7	60.4	59.6	54	56.4	53.4	56.4	56.6	57.1	54.6	51.5	50.2	50.7	50.9
54.4	56.6	56.1	53.2	50.2	45.8	41.8	38.6	34.3	30.1	26.6	23.4	19.4	17.1	15	11.9	48.4	50.8	50.6	50.6	50.3	49.3	48.9	47.9	47.5	44.6	42.5	40.9	39.4	38	37.3	38.9	48.4
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
74.2	93.2	114	93.4	74	63.4	49.2	45.8	34	29.6	25.2	23.1	19.9	20.5	21.4	22.2	44.8	56.7	48	46.1	42	46.9	45	43.6	41.3	43.4	42.2	37.8	38.2	38.3	38.6	37.5	38.2
39.6	40.5	40	36.7	32.5	28.6	24.8	22.9	21.6	19.7	17.9	15.8	13.3	11.6	10.9	10	48.6	49.9	50	48.3	47.6	45.3	43.9	42.3	39.6	37.8	36.4	34.6	33.9	34.1	34.9	37.3	37.4
41	40.4	40	36.4	32.8	28.6	25	22	19.3	18.3	15.6	12.2	10	10	10	10	46.4	51.7	49.5	50	50.3	49.9	45.7	41.8	40.5	41.9	37.2	34.5	36.6	36.7	39.3	42.5	44
74.2	93.2	114	93.5	74.1	63.3	49.2	46.1	34.2	29.9	25.1	23	20.2	20.5	21.3	22.2	50.5	35.8	37	34	38.3	31.2	37.3	33.7	33	29.4	28.1	26	29.1	28.6	30.4	30.2	32.7
48.7	52.3	52.9	50.5	47	43.4	39.2	35.5	30.6	25.4	20.9	17.2	13.4	10.1	10	11.6	30.2	30.2	31.4	29.9	34.8	33.5	33	34.2	32.4	30.8	29	27.7	28	29.5	31.1	31.6	34.7
53.2	55	54.7	54.1	48.9	44.9	41.3	37.4	33.3	29.3	26.7	27.5	21.3	17.3	12.5	10.9	30.7	36.3	35.9	32.7	43.4	36.3	40.3	32.9	34.5	36.9	35	27.5	30.3	30.9	35.1	36.1	35.3
74.3	93.4	114.2	93.6	74.2	63.4	49.2	46.6	34.4	30.2	25.2	22.8	20.6	20.5	21.2	22.2	40	46.5	40.8	35	44.3	43.8	39.6	44.6	34	35.2	30.4	32.5	33	34.1	33.5	35	38.7
34.8	37.1	36.4	34	30.2	24.6	19.1	15.8	13.3	11	10	10	10	10	10	10	29.8	28.5	32.1	30.9	33.1	33.9	35.2	35.1	33.7	30.9	28.9	28	28.8	29.8	30.2	31	32.5
34.7	38.6	40.7	39.5	36.7	33	27.7	23	19.6	19.6	16.6	13.4	10.4	10	10	10	31	39.4	37.2	41.7	38.6	35.4	32.4	41.9	39.8	32	31.2	30.1	31	32	30.6	30.2	31
74.4	93.6	114.2	93.8	74.4	63.6	49.4	46.6	34.4	30.4	25.3	23	20.5	20.3	21.2	22.6	41.5	35.1	29.9	33.5	35.7	36.5	33.6	34.6	36.1	31.5	38.4	38.3	41.1	40.6	35.4	37.9	36
37.6	41.8	42.6	39.9	36.5	31.2	26.6	22.9	19.4	17.1	14.5	11.7	11.1	10	10	13.5	27	29.6	30.9	28.4	33	33.9	31.8	34.8	31.4	28.5	26.5	26.9	28	30	31.1	31.1	32.9
20.1	19.8	19.5	18.2	18	19	19.2	16.6	15.2	15.4	14.2	12.8	12.2	10.6	10	12.3	29.8	37.2	25	40.3	26.6	42.2	42.4	36	31.2	33.4	26	33.8	36.6	28.4	37.2	29	37
74.6	93.6	114.4	93.8	74.4	63.8	49.5	46.8	34.6	30.6	25.6	22.8	20.8	20.4	21.2	22.1	41.7	31	32.3	32.4	27.5	35.5	34.8	32.9	39.4	35.9	28.4	30.3	30.5	30.2	28.4	29.9	31.6
33.9	33.7	32.7	30	26.1	21.5	16.2	14	10.7	10	10	10	10	10	10	10	31.6	33.4	33.3	31.4	33.9	33.7	34.8	34.1	32.5	30.9	29.6	30.1	30.6	31.3	30.6	30.4	31.6
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	40	28.4	38.4	33.6	36.3	33.9	36	34	39.8	23.8	25	21	33.2	38	29.4	25.6	29.3
74.6	93.6	114.4	93.8	74.4	63.8	49.6	47	34.6	30.6	25.6	23	20.4	20.3	21.2	22	51.6	43.9	36.5	34	34.8	35.3	30.9	30.4	30.6	30.3	27.4	26.7	26.5	28.9	27.9	29.7	32.1
32	35.8	37.3	33.9	31.7	26.8	22.5	19.8	17.2	15.5	13.6	10.8	10	10	10	12.2	27.6	28.6	30	30.6	31.5	32	31.7	32	30.1	27.7	27.2	26.2	26.9	27.9	28.7	29.4	33.5
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
74.6	93.6	114.4	93.8	74.4	63.8	49.6	47.2	34.6	30.8	25.8	22.8	20.8	20.4	21.2	22.1	51.2	42.9	45	36.8	35.4	28.7	37.3	35.5	34.9	32.1	30.6	31.3	30.9	31.9	29.9	30.2	32.4
28.7	29.7	30	27.8	24.3	19.7	14.8	14.6	12	10.4	10	10	10	10	10	10	29.5	30.2	31	30.4	32.6	32.3	31.6	32.7	30.3	27.5	27.2	27.3	28.8	29	29.4	29.6	31
33.3	34.6	32.8	32.1	29.8	27	25	22.2	21.1	20.1	19.6	18.3	16.5	14.4	11	12.2	34	24.2	35	38.4	32.4	29.7	34.2	42	32	33.8	32.2	34.6	32.2	30	28	32.8	25.8
74.6	93.7	114.4	93.8	74.4	63.8	49.6	47.4	34.7	30.8	25.6	22.7	20.5	20.4	21.2	22	52.2	44	43.5	32.8	32.3	32.3	28.6	34.7	32.1	27.7	25.9	23.5	28.3	29.5	31	38.8	37.4
38.8	40.5	40.8	38.2	35.8	31.1	26.1	23.1	20	17.2	15.6	13.7	11.1	10	10	13.3	28.9	27.5	28.4	27.7	31.1	30.7	29.7	29.2	28	26.1	25.1	25.6	26.6	27.7	29.3	30.4	34.2

20 Hz	25 Hz	31.5 Hz	40 Hz	50 Hz	63 Hz	80 Hz	100 Hz	125 Hz	160 Hz	200 Hz	250 Hz	315 Hz	400 Hz	500 Hz	630 Hz	800 Hz	1.0 kHz	1.25 kHz	1.6 kHz	2.0 kHz	2.5 kHz	3.15 kHz	4.0 kHz	5.0 kHz	6.3 kHz	8.0 kHz	10.0 kHz	12.5 kHz	16.0 kHz	20.0 kHz
55	44	48.4	50.4	47.2	43.2	45.1	43.8	36.5	39.2	42	37	38.8	55.3	63.1	74.2	93.2	114	93.4	74	63.2	49.1	45.8	34	29.8	25	22.8	19.9	20.2	21.2	21.9
44.2	47.4	45.6	45.4	48.9	42.6	44.7	39.8	35.3	41.3	44.3	40.5	43.5	47.6	44.4	41.2	35.3	34.1	35.1	37.9	38.7	36.7	33.8	33.1	28.2	25.5	23	19.7	15.1	10	9.9
25.4	27	28.6	27.7	29.5	31.6	27.7	26.3	22.6	21.1	22.5	22.5	22.5	22	22.1	24.7	30.5	28.6	16.8	14.1	14.9	13.8	14.9	16.1	16.3	17.3	18.4	18.8	19.8	20.8	21.8
36.6	36.7	37.7	36.2	35.6	32.1	27.6	28.6	20.2	19.3	21.1	21.1	21.4	19.1	19	20.4	25.1	19.4	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.9	12.5
47.4	48.1	45.6	46.9	46.6	45.1	43.8	42.8	38.4	33	30.1	29.4	28.5	26.5	28.1	31	35.5	30.9	20.7	15.3	14.9	14	14.9	16.3	16.4	17.4	18.5	18.8	19.8	21	22
41.1	42.1	39.5	40.3	44.3	35.3	35.7	31.5	25.1	24.1	25.7	26	26.5	55.1	63	74	93.2	113.8	93.4	74	63.2	49	45.8	34	29.8	24.9	22.8	20	20.3	21	21.9
38	38.4	37.9	37.3	38.3	38.2	33.4	27.2	22	22.1	24.6	26.3	27.6	28.7	30.1	30.3	33.2	33.4	30.4	27.6	21.9	17.1	14.7	12.3	10	9.9	9.9	9.8	9.8	9.8	9.8
50.1	46	47.4	46.5	46	57.8	51.8	46.8	41.6	35.6	36.2	36.2	38.8	42.6	45.7	49	51.4	49.2	49	45.4	42.4	38.4	35.3	31.6	26.8	22.6	17.3	11.6	9.9	9.8	9.8
43.6	44	46.9	44	40.5	41.2	39.1	35.5	31.9	29.2	25.4	23.1	20.9	18.7	19.7	21.7	24.9	19.1	12.9	12.9	14.6	14	14.8	16.3	16.4	17.2	18.4	18.9	19.9	20.8	21.9
39.6	41.9	44	42.5	37.7	36.1	32.8	30	27.2	22.9	21.8	22.1	23.9	55	63	74	93.2	113.8	93.4	74	63.2	49	46.1	34	29.6	24.9	22.8	20.1	20.2	21	22.1
34.3	37.1	40	37.5	35.4	34.8	31.6	27.4	24.2	21.4	20.6	20.4	21.5	23	25.2	26.7	27.8	27.3	24.1	20.3	15.5	11.6	9.9	9.9	9.8	9.8	9.8	9.8	9.8	9.8	9.8
38.8	37.6	42.8	36.6	45.2	35.2	32.4	27.7	24.6	22.4	21.3	22.4	24.4	30.6	28	28.4	29	28.6	25.8	21.7	15.7	11.4	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8
47.8	48.2	45.9	43.5	43	39.8	37.2	31.8	27.7	25.8	24.1	24.3	24.1	54.9	62.8	74	93	113.8	93.2	73.8	63.2	49	45.6	34	29.4	24.9	22.8	19.7	20.1	21	22.1
38.1	39.9	38.6	38	38.3	36.7	33.9	27.7	22.1	21.2	23.4	25.4	26.7	28.1	28	28.1	31.9	32.3	29.3	26.7	20.9	16.6	14.5	12.6	10	9.9	9.9	9.8	9.8	9.8	9.8
42	41.6	39.4	44.3	44.9	44.7	35.2	28.7	26.2	22.7	25.5	29.1	32.8	32.8	29.2	30.4	32.7	33	30.7	29	23.4	19.6	15.8	18.8	14.2	13.4	14.8	9.8	9.8	9.8	9.8
35.4	41.1	38	35.6	36.2	36.8	32.3	32.4	27.7	24.7	20	19.9	21.9	54.8	62.8	73.8	93	113.7	93.2	73.8	63	49	45.6	33.8	29.3	24.9	22.8	19.6	20.1	21	21.8
35.9	40	40.5	38.6	38	38.1	33.2	30.8	29.4	25.9	25.3	24.5	26	27.3	29	31.1	32.1	32	29	25.5	21.5	17.6	15.2	12.6	10.5	9.9	9.9	9.8	9.8	9.8	9.8
33.7	40.7	42.1	38.3	39.1	38.9	40.3	37.3	35.2	33.2	30.6	27.9	26.1	28.1	29.7	30.5	33.8	33.3	29.9	27.2	23.3	20.7	19.1	16.5	13.4	10.6	9.9	10	9.8	9.8	9.8
49.4	47.3	48.5	46.4	44.3	42.4	39.5	37.8	30.9	27.2	28	27	27.5	54.9	62.8	74	93	113.8	93.2	73.8	63.1	48.9	45.6	33.8	29.3	24.9	22.8	19.5	20	21	21.9
41.6	42.8	40.6	40.7	42.2	38.5	35.4	32	25	22.3	23.8	26.6	28	29.2	29.6	29.8	31.6	32	29.4	26.4	21.8	18	16	13.8	12	10.8	10	9.9	9.8	9.8	9.8
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37.5	39.5	40.4	35.9	34	33.1	29.6	27.6	25.2	22	20.2	21	22.5	54.8	62.8	73.9	93	113.8	93.2	73.8	63	48.9	45.5	33.8	29.3	24.8	22.8	19.4	20.1	20.9	21.8
34.9	37.6	39.3	35.1	35.7	35	31.8	30	27.5	24	23.1	23.3	24.9	26.6	27.3	28.6	28.9	28.6	26.3	23.4	20.3	18	16.4	14.5	12.3	10.2	9.9	9.8	9.8	9.8	9.8
40.6	45.2	45	42	40.8	44	35.8	33.4	31	28.1	26.5	27.9	30.1	33.4	35.2	35.7	36.4	35	32.2	28.5	24.4	20.7	18.3	16	13.1	10.6	9.8	9.8	9.8	9.8	9.8
32.9	33	31	30.5	30.8	29.3	24.7	19.9	19.3	18.3	20.5	21.6	22	54.8	62.8	74	93	113.8	93.2	73.8	63	48.9	45.8	33.9	29.6	24.8	22.6	19.8	20.1	20.9	21.8
34.2	35.5	33.6	32.7	33	32.2	27.1	21.9	21.9	21.1	23.5	24.6	23.7	22.2	19.7	21	20.7	21.6	18.3	14	10	9.9	9.9	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8
35.3	38.9	36.5	40.5	41.5	47.6	44.6	36.7	31.8	29.3	31.5	35.5	36	37.1	38.5	39.3	44.3	47.7	43.7	40.5	34.1	28.5	23.3	19.3	15.1	13.1	11	10	9.8	9.8	9.8
35.6	36.2	36.7	37.2	42.1	36.9	32.2	30.3	25	21.3	20.1	20.6	22.6	55	63	74	93.2	113.9	93.4	74	63.2	49	46.4	34.2	29.9	24.9	22.5	20.2	20	20.8	21.8
30.2	33.4	33.7	31.1	30.8	32.4	29.2	25.5	23.6	21.5	19.2	19.2	18.5	20	20.1	20.3	20.1	19.9	17.2	13.6	10	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8
31.3	36.6	36.2	39.8	36.3	36.1	34.9	34.3	27.8	22.8	21.1	21.2	24.5	26.5	28.8	31.9	35.4	36.9	36	31.7	23.4	17.5	12.4	9.9	9.8	9.8	9.8	9.8	9.8	9.8	9.8
34.2	36	34.1	32.8	33.1	33.3	28.8	22.3	17.9	17.3	18.2	19.7	22.2	55.2	63.2	74.2	93.4	114	93.6	74.2	63.4	49.2	46.3	34.2	30.2	25	22.7	20.1	19.9	20.8	22.2
32.8	34.9	31.4	30.7	30.7	28.8	23.5	18.5	16	15.1	17.5	18.4	17.9	15.4	14.6	15.6	16.1	14.7	11.2	9.9	9.9	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	11.3
35.8	35.4	31	29	30	26.6	22.2	19.6	23.3	15.2	19	17	17	15.6	14.2	13.4	13.6	12	11.8	10	9.9	9.9	9.9	9.9	9.9	9.9	9.8	9.9	9.8	9.8	11.1
30.4	34	32.4	30	31.2	30.4	29	25.1	26.4	22.5	19.9	19.8	23	55.2	63.2	74.2	93.4	114.1	93.6	74.2	63.5	49.2	46.6	34.4	30.4	25.2	22.5	20.4	20	20.8	21.8
30.3	34	32.3	30.1	32.5	32.3	30.7	26.7	24	22.1	18.4	17.7	19	21.6	21.6	23.5	17.7	17	14	10.3	9.9	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8
32.2	35.8	30.4	30.6	32.2	32	30.6	26.2	24.2	21.2	15.6	18.6	16.8	20	20.5	24	15	13.9	10.5	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8
31.7	33.2	31.6	32.5	31.4	28.6	27.8	29	21.4	18.4	18.1	20	22	55.2	63.2	74.4	93.4	114.2	93.6	74.2	63.6	49.4	46.8	34.4	30.4	25.2	22.6	20	19.8	20.8	21.6
31.8	34.2	31.5	31.5	30.5	28.4	26.1	21.5	18.6	17.5	18.8	20.4	20.1	18.5	16.4	16.5	16.4	14.8	11.3	10	9.9	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.9
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
29.9	32.9	30.4	28.9	30.4	30.5	30.9	27.3	25.8	22.8	20.3	20.2	23	55.2	63.2	74.3	93.4	114.2	93.6	74.2	63.5	49.3	47	34.4	30.4	25.4	22.4	20.3	20	20.8	21.7
28.9	33.4	30.8	29	30.5	29.2	28.7	24.9	22.6	21.7	19.1	19.7	18.3	18.7	17.2	16.6	14.6	13.8	11.1	9.9	9.9	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8
29.4	36.6	33.6	30.6	30	32.1	28.4	27.2	22.2	21.3	20.2	21	21.2	22.8	25.8	26.2	27.8	29.3	27	23.2	19.8	15.8	14.4	13	12.2	10.8	10	9.9	9.8	9.8	9.8
34.4	35.6	31.8	30.7	31.5	27.4	25.1	20.6	18.5	19.5	21.9	26.7	25.4	55.4	63.2	74.4	93.4	114.2	93.6	74.2	63.6	49.4	47	34.4	30.4	25.3	22.4	20.1	20	20.8	21.7
33.4	34.7	31.1	30.6	30.6	29	27.4	23.3	19.2	19	19.5	21.1	21.3	20.3	16.8	17.4	16.6	16.6	13.8	10	9.9	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8

		Start Time	Measurement T	Leq	LE	Lmax	Lmin	Ly	LN1	LN2	LN3	LN4	LN5
NMP2 Day													
	1	07/03/2023 13:12	00d 00:15:00.0	42	71.6	58.8	28.8	-.-	50.2	45.7	39.4	36.9	30.6
	1	07/03/2023 14:54	00d 00:15:00.0	49.4	79	63.9	24.2	-.-	61.2	52.8	43.2	40.6	26.5
	1	07/03/2023 13:49	00d 00:15:00.0	47.2	76.8	63.2	28.8	-.-	58.9	50.5	42.3	38.9	30.1
	1	07/03/2023 15:38	00d 00:15:00.0	51.7	81.3	65.2	33.2	-.-	61.4	55.4	48.5	41.7	35.4
												39.525	
NMP2 Evening													
	1	07/03/2023 19:09	00d 00:15:00.0	53.7	83.3	62.8	40.5	-.-	60.6	57.7	51.4	44.6	42.3
	1	07/03/2023 19:33	00d 00:15:00.0	55.7	85.3	66.3	40.2	-.-	62.4	59.2	54.3	46.6	42.6
												45.6	
NMP2 Night													
	1	07/03/2023 23:00	00d 00:15:00.0	50.8	80.4	71.7	19.4	-.-	62.8	54.8	34.1	24.4	20.8
	1	07/03/2023 23:20	00d 00:15:00.0	43.6	73.2	58.8	19.1	-.-	56.4	45	26.3	22.1	20.5
												23.25	
NMP1 Day													
	1	07/03/2023 14:33	00d 00:15:00.0	60.4	90	72.6	28.4	-.-	69.6	65.5	52.4	38.7	30.5
	1	07/03/2023 16:14	00d 00:15:00.0	61.6	91.2	71.1	35.8	-.-	68.8	66.1	57.6	43.1	37.3
	1	07/03/2023 13:28	00d 00:15:00.0	57.1	86.7	70.9	23.2	-.-	67.8	62.1	48.4	37.54	25.8
	1	07/03/2023 15:18	00d 00:15:00.0	58.9	88.5	72.7	27.5	-.-	68	64.2	49.3	38.9	30.2
												39.56	
NMP1 Evening													
	1	07/03/2023 20:35	00d 00:15:00.0	53.6	83.2	67.4	29.5	-.-	64	58.8	45.5	34.8	31.3
	1	07/03/2023 19:10	00d 00:15:00.0	58.8	88.4	70.4	35.9	-.-	67.8	64.2	51.9	42.6	38
												38.7	
NMP1 Night													
	1	08/03/2023 00:16	00d 00:15:00.0	46.1	75.7	67.4	17.8	-.-	60.8	42.3	27.2	19.6	18.6
	1	07/03/2023 23:00	00d 00:15:00.0	51.1	80.7	69.4	21	-.-	65.4	48.2	34.4	25.3	22.3
												22.45	
NMP3 Day													
	1	07/03/2023 13:34	00d 00:15:00.0	41.8	71.4	58.1	27.1	-.-	52.4	46.2	35.3	30.9	28.4
	1	07/03/2023 15:15	00d 00:15:00.0	39.4	69	55.8	26.5	-.-	49.7	43.2	33.6	30	28.5
	1	07/03/2023 14:14	00d 00:15:00.0	42.8	72.4	60.9	27	-.-	53.3	46.9	36.6	31.6	29.1
	1	07/03/2023 16:03	00d 00:15:00.0	46	75.6	70.7	31.5	-.-	59.3	43	36.1	33.7	32.4
												31.55	
NMP3 Evening													
	1	07/03/2023 19:31	00d 00:15:00.0	39.4	69	55.6	31	-.-	49.1	42.1	36.4	33.8	32.2
	1	07/03/2023 19:57	00d 00:15:00.0	39	68.6	58.6	30.6	-.-	50	40.1	35.5	32.7	31.6
												33.25	
NMP3 Night													
	1	07/03/2023 23:43	00d 00:15:00.0	31.5	61.1	55.9	25.5	-.-	39	33	30.3	28.3	26.7
	1	07/03/2023 23:19	00d 00:15:00.0	42	71.6	78.5	26.5	-.-	45.6	33.6	30.1	28.5	27.3
												28.4	
NMP4 Day													
	1	07/03/2023 13:53	00d 00:15:00.0	50.9	80.5	74.8	34.8	-.-	61.8	53.9	45.2	39.2	36.3
	1	07/03/2023 15:34	00d 00:15:00.0	44.1	73.7	67.1	32.2	-.-	54.6	45.8	39.6	36.1	34
	1	07/03/2023 14:35	00d 00:15:00.0	45.7	75.3	62.1	25.5	-.-	56.4	49.9	39.3	32.1	27.9
	1	07/03/2023 16:22	00d 00:15:00.0	47.4	77	63.9	31.6	-.-	59.3	50.3	39.6	34.9	33.2
	1	08/03/2023 14:55	00d 00:15:00.0	57.7	87.3	81.4	35.1	-.-	69.9	58.8	49.9	41.3	37.2
												36.72	
NMP4 Evening													
	1	07/03/2023 20:16	00d 00:15:00.0	45.9	75.5	64.5	26.1	-.-	60.3	45.8	34	30.3	27.4
	1	07/03/2023 19:51	00d 00:15:00.0	47	76.6	65.3	30.3	-.-	59.2	49.8	36.9	32.9	31.3
												31.6	
NMP4 Night													
	1	08/03/2023 00:03	00d 00:15:00.0	32.5	62.1	44.5	24	-.-	39.2	34.6	32.8	25.9	24.9
	1	07/03/2023 23:37	00d 00:15:00.0	33.1	62.7	54.5	24.1	-.-	40.4	36.1	28.8	25.7	24.9
												25.8	
NMP5 Day													
	1	07/03/2023 14:13	00d 00:15:00.0	53.9	83.5	75.2	23.3	-.-	67.2	54	45.5	28.7	25.1
	1	07/03/2023 15:53	00d 00:15:00.0	46.6	76.2	69.9	30.6	-.-	58.3	49	37.9	34.2	32.2
	1	07/03/2023 16:41	00d 00:15:00.0	49.2	78.8	71.9	32.2	-.-	59.9	52.8	43.1	38.7	35
	1	07/03/2023 14:57	00d 00:15:00.0	48.2	77.8	66.1	27.3	-.-	59.9	51.6	42.3	31.9	29
												33.375	
NMP5 Evening													
	1	07/03/2023 20:13	00d 00:15:00.0	40.5	70.1	54.4	26.1	-.-	49.8	44.3	37.5	32.3	28
	1	07/03/2023 20:37	00d 00:15:00.0	40.1	69.7	55.3	27.8	-.-	51.1	42.9	36.4	30.8	28.7
												31.55	
NMP5 Night													
	1	08/03/2023 00:28	00d 00:15:00.0	26.1	55.7	42.5	18.4	-.-	36.4	29.4	22	19.8	19.1
	1	07/03/2023 23:57	00d 00:15:00.0	32.5	62.1	61.6	18.9	-.-	43.1	34.8	26	20.8	19.8
												20.3	

Noise monitoring 01.09.2021 and 02.09.2021 – Monitoring Point Locations

Figure 1. NMP locations

Noise monitoring 01.09.2021 and 02.09.2021 – Daytime field notes
Weather: 17 - 18˚C, Zero to Light Winds

NMP 1

Dominant noise sources:

- Road Traffic
- Birdsong

Other noise sources:

- Dogs Barking Intermittently
- Industrial Machinery
- Airplane

NMP 2

Dominant noise sources:

- Road Traffic from adjacent main road
- Activity from shop (Idling car, lorry, tractor engines), other human activity from shop,
- Cows bawling in field across from shop.
- Birdsong

Other noise sources:

- Dogs Barking Intermittently
- Industrial Machinery from pitch development.

NMP 3

Dominant noise sources:

- Road Traffic
- Birdsong
- Background Industrial

Other noise sources:

- Dogs Barking Intermittently
- Crows
- Beeping machinery
- Local Road Traffic

NMP 4

Dominant noise sources:

- Road Traffic on adjacent road and from main road during quieter times
- School activity and kids and parents shouting/talking in car park and school yard.
- Lorry idling in mushroom factory across road and hum from plant.
- Conveyer belt from back of truck in mushroom factory

Other noise sources:

- Dogs Barking Intermittently
- Aircraft flying overhead intermittently
- Activity in nearby shop

NMP 5

Dominant noise sources:

- Light road Traffic
- Tractor passed on road
- R179, constant but low level
- Birdsong
- Chatting from road workers
- Grass in field rustling in breeze

Other noise sources:

- Dogs Barking Intermittently
- Machinery from the pitch development
- Resident at receptor arrived home via car at 16.46, over cattle grid and pottered around outside in their garden and had quiet conversations.
- Cars passing along the road at 16.53 and 16.55.

Noise monitoring 01.09.2021 and 02.09.2021 – Evening field notes
Weather: 10 - 16˚C, Zero to Light Winds

NMP 1

Dominant noise sources:

- Road Traffic

Other noise sources:

- Dogs Barking Intermittently
- Fox Noises
- Some minor birdsong
- Child on motorized bicycle at 19.21 on R179

NMP 2

Dominant noise sources:

- Road Traffic from adjacent main road
- Activity from shop (Idling car, lorry, tractor engines), other human activity from shop,
- Cows bawling in field across from shop.
- Birdsong

Other noise sources:

- Dogs Barking Intermittently
- Industrial Machinery from pitch development.

NMP 3

Dominant noise sources:

- Road Traffic
- Background Industrial

Other noise sources:

- Dogs Barking Intermittently
- Crows
- Beeping machinery
- Local Road Traffic
- Livestock shuffling in adjacent field

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NMP 4

Dominant noise sources:

- Road Traffic on adjacent road and from main road during quieter times
- Lorry idling in mushroom factory across road and hum from plant.
- Conveyer belt from back of truck in mushroom factory

Other noise sources:

- Dogs Barking Intermittently
- Aircraft flying overhead intermittently
- Activity in nearby shop
- Birdsong intermittent

NMP 5

Dominant noise sources:

- Very light road Traffic
- Birdsong
- People walking/running on adjacent road
- Chatting from road workers

Other noise sources:

- Dogs Barking Intermittently
- Machinery from the pitches to distant south

Noise monitoring 01.09.2021 and 02.09.2021 – Nighttime field notes

Weather: 9-16˚C, Zero to Light Winds

NMP 1

Dominant noise sources:

- Road Traffic

Other noise sources:

- Loud Truck
- Electric Bike
- Cows
- Industrial Machinery
- Low music (from one of the houses)

NMP 2

Dominant noise sources:

- Road Traffic from adjacent main road
- Activity from shop
- Cows bawling in field across from shop.
- Birdsong
- Rustling of treelines

Other noise sources:

- Garage (Pump?) Noise
- Background Industrial Noise
- Fox Noise
- On last of nighttime readings, a constant but low level engine/pump was noted to the distant east (source unknown)

NMP 3

Dominant noise sources:

- Road Traffic
- Background Industrial

Other noise sources:

- Dogs Barking Intermittently
- Beeping machinery

NMP 4

Dominant noise sources:

- Road Traffic on adjacent road and from main road quieter times
- Rustling trees

Other noise sources:

- Dogs Barking Intermittently

NMP 5

Dominant noise sources:

- R179 traffic, constant but low level
- Birdsong
- Cows in adjacent field

Other noise sources:

- Engine roar to distant south (presumed from main road)

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File	Date	Name	Duration	Status	LAeq	LAFmax	LAFmin	LCeq	LCFmax	LCFmin	LAF,Perc4	LAF,Perc6	LCF,Perc4	LCF,Perc6	Lfeq 1.0 Hz	LfFmax 1.0 Hz	LfFmin 1.0 Hz	LfF,Perc4 1.0 Hz	LfF,Perc6 1.0 Hz
NOR131_2706951_210901_0001.NBF	(2021/09/01 13:22:13.00)	VOID	(0:0:6.0)	N/A	54.2	58	51.9	64.9	69.8	61.5	55.5	52.6	67.5	62.3	-	-	-	-	-
NOR131_2706951_210901_0002.NBF	(2021/09/01 13:22:32.00)	VOID	(0:0:18.0)	N/A	112.5	112.5	112.5	112.5	112.5	112.5	112.6	112.4	112.6	112.4	-	-	-	-	-
NOR131_2706951_210901_0003.NBF	(2021/09/01 13:24:37.00)	CAL	(0:0:10.0)	N/A	114	114	113.9	114	114	114	114	113.8	114	113.8	-	-	-	-	-
NOR131_2706951_210901_0004.NBF	(2021/09/01 13:05:12.00)	NMP2 Daytime	(0:15:0.0)	N/A	56.8	68.4	44.3	68.1	85.5	51.1	60.5	49.8	71.3	61.5	-	-	-	-	-
NOR131_2706951_210901_0005.NBF	(2021/09/01 13:50:25.00)	VOID	(0:0:12.0)	N/A	63.4	82	38.1	66.1	82.7	50	64.5	42.5	68.9	52.8	-	-	-	-	-
NOR131_2706951_210901_0006.NBF	(2021/09/01 13:30:46.00)	NMP5 Daytime	(0:15:0.0)	N/A	38.1	55.6	30.2	57.8	77.2	42.2	40.6	33.5	60.8	46.5	-	-	-	-	-
NOR131_2706951_210901_0007.NBF	(2021/09/01 13:48:57.00)	NMP4 Daytime	(0:15:0.0)	N/A	51	81.4	38.7	65.3	85.3	55.7	52.8	41.6	68.3	58.4	-	-	-	-	-
NOR131_2706951_210901_0008.NBF	(2021/09/01 14:12:47.00)	NMP2 Daytime	(0:15:0.0)	N/A	57.9	69.8	39.3	65.5	81.5	52.7	61.9	44.9	69	57.3	-	-	-	-	-
NOR131_2706951_210901_0009.NBF	(2021/09/01 14:32:17.00)	NMP5 Daytime	(0:15:0.0)	N/A	39.1	63.9	28.1	56.7	76.4	44.4	39.1	32	58.2	48.1	-	-	-	-	-
NOR131_2706951_210901_0010.NBF	(2021/09/01 14:50:50.00)	NMP4 Daytime	(0:15:0.0)	N/A	53.1	77.6	42.7	65.4	80.6	55.9	55.7	45.9	68.3	60.1	-	-	-	-	-
NOR131_2706951_210901_0011.NBF	(2021/09/01 21:18:28.00)	NMP2 Evening	(0:15:0.0)	N/A	57.9	71.3	25.2	61.5	77.8	40.2	63.1	32	66	44.8	-	-	-	-	-
NOR131_2706951_210901_0012.NBF	(2021/09/01 21:37:09.00)	NMP5 Evening	(0:15:0.0)	N/A	35.8	52.5	27.5	47.3	72.1	40	38.7	30.2	49.9	43.2	-	-	-	-	-
NOR131_2706951_210901_0013.NBF	(2021/09/01 21:54:36.00)	NMP4 Evening	(0:15:0.0)	N/A	41	63.9	28.7	52.3	70.7	43.3	40.2	30.3	51.7	46	-	-	-	-	-
NOR131_2706951_210901_0014.NBF	(2021/09/01 22:13:48.00)	NMP2 Evening	(0:15:0.0)	N/A	56	72.3	27.6	57.9	73.3	41.3	58.7	30.7	60.5	43.8	-	-	-	-	-
NOR131_2706951_210901_0015.NBF	(2021/09/01 22:32:25.00)	NMP5 Evening	(0:15:0.0)	N/A	33.5	54.2	25.3	46.4	72	38.3	36.2	27.3	47.9	41.1	-	-	-	-	-
NOR131_2706951_210901_0016.NBF	(2021/09/01 23:00:09.00)	NMP4 Night	(0:15:0.0)	N/A	42	63.2	32.6	51.8	71.2	45.7	38.3	33.8	51.1	47.5	-	-	-	-	-
NOR131_2706951_210901_0017.NBF	(2021/09/01 23:18:57.00)	NMP2 Night	(0:15:0.0)	N/A	55.2	72.2	25	57.5	74	40.9	56.8	28.7	59	43.9	-	-	-	-	-
NOR131_2706951_210901_0018.NBF	(2021/09/01 23:38:00.00)	NMP5 Night	(0:15:0.0)	N/A	29.7	49.1	25.2	41.9	67.1	37.8	32.1	26.4	42.9	40.1	-	-	-	-	-

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File	Date		Duration	Status	LAeq	LAFmax	LAFmin	LCeq	LCFmax	LCFmin	LAF,Perc4	LAF,Perc6	LCF,Perc4	LCF,Perc6	Lfeq	LfFmax 1.0 Hz	LfFmin 1.0 Hz	LfF,Perc4 1.0 Hz	LfF,Perc6 1.0 Hz
NOR131_2706951_210902_0001.NBF	(2021/09/02 00:02:39.00)	NMP4 Night	(0:15:0.0)	N/A	44.1	67.1	25.4	52	75.6	42.8	33.4	26.6	49.9	45.4	-	-	-	-	-
NOR131_2706951_210902_0002.NBF	(2021/09/02 00:23:38.00)	NMP2 Night	(0:15:0.0)	N/A	48.1	69.7	24.6	51.6	72.4	39.1	46.9	26.2	50.5	41.9	-	-	-	-	-
NOR131_2706951_210902_0003.NBF	(2021/09/02 00:43:28.00)	NMP5 Night	(0:15:0.0)	N/A	31.3	49.5	25	43.1	70.1	37.4	33.4	26.4	43.8	40	-	-	-	-	-
NOR131_2706951_210902_0004.NBF	(2021/09/02 01:02:30.00)	NMP4 Night	(0:15:0.0)	N/A	34.2	50.2	32.4	48.9	71.2	45.5	34.7	33.5	50.1	47.3	-	-	-	-	-
NOR131_2706951_210902_0005.NBF	(2021/09/02 01:18:35.00)	VOID	(0:0:3.0)	N/A	34.7	38.4	33.6	50.2	52.1	48.2	35.4	33.8	51.1	49.8	-	-	-	-	-
NOR131_2706951_210902_0006.NBF	(2021/09/02 01:20:57.00)	NMP5 Night	(0:15:0.0)	N/A	32.5	61.4	26.8	48.2	80.7	38	32.4	28	45.2	41	-	-	-	-	-
NOR131_2706951_210902_0007.NBF	(2021/09/02 16:38:28.00)	CAL	(0:0:9.0)	N/A	114.1	114.1	114	114	114.1	114	114.2	114	114.2	114	-	-	-	-	-
NOR131_2706951_210902_0008.NBF	(2021/09/02 16:44:39.00)	NMP5 Day	(0:15:0.0)	N/A	39.2	61.1	30.5	58.1	77.2	45.7	41	33.8	61.9	49.3	-	-	-	-	-
NOR131_2706951_210902_0009.NBF	(2021/09/02 19:18:05.00)	CAL	(0:0:10.0)	N/A	114	114	114	114	114	114	114.1	113.8	114.1	113.8	-	-	-	-	-
NOR131_2706951_210902_0010.NBF	(2021/09/02 19:10:35.00)	NMP1 Evening	(0:15:0.0)	N/A	54.9	68.2	27.4	58	70.7	40.4	60.2	32.8	62.8	45.3	-	-	-	-	-
NOR131_2706951_210902_0011.NBF	(2021/09/02 19:13:56.00)	CAL	(0:0:4.0)	N/A	114.1	114.1	114.1	114.1	114.1	114.1	114.2	114	114.2	114	-	-	-	-	-
NOR131_2706951_210902_0012.NBF	(2021/09/02 19:34:15.00)	CAL	(0:0:11.0)	N/A	114	114.1	114	114	114.1	114	114.1	113.8	114.1	113.8	-	-	-	-	-
NOR131_2706951_210902_0013.NBF	(2021/09/02 19:36:23.00)	NMP3 Evening	(0:15:0.0)	N/A	45.5	71.7	25	53.8	78	39.9	43.8	30.3	53	43.8	-	-	-	-	-

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File	Date		Duration	Status	LAeq	LAFmax	LAFmin	LCeq	LCFmax	LCFmin	LAF,Perc4	LAF,Perc6	LCF,Perc4	LCF,Perc6	Lfeq	0.4 Hz	0.5 Hz	0.63 Hz	0.8 Hz	1.0 Hz	1.25 Hz	1.6 Hz	2.0 Hz	2.5 Hz	3.15 Hz	4.0 Hz	5.0 Hz	6.3 Hz	8.0 Hz	10 Hz	12.5 Hz	16 Hz	20 Hz
NOR140_1658766_210902_0001.NBF	(2021/09/02 00:10:02.00)		(0:0:3.0)	N/A	38.5	46.4	34	-	-	-	40.4	35.2	-	-		39.6	31.7	42	44.3	42.9	39.4	8.9	0.6	2.7	4.8	5.3	36	40	1.1	.3	1.3	1	2
NOR140_1658766_210902_0002.NBF	(2021/09/02 00:18:10.00)	CAL	(0:0:21.0)	N/A	114.3	114.3	114.2	-	-	-	114.4	114.2	-	-		52.5	49.4	47.5	38.7	45.6	41.3	1.9	5.1	0.4	39	3.6	5.8	3.2	7.8	.2	35	6	5
NOR140_1658766_210902_0003.NBF	(2021/09/02 00:20:07.00)	NMP3 Night	(0:15:0.0)	N/A	32	45.8	21.7	-	-	-	33.8	25.4	-	-		46.3	46.7	45.7	44.5	44.7	43.6	2.7	.3	9.3	6.3	4.6	4.3	1.8	5.3	.5	4.7	1	3
NOR140_1658766_210902_0004.NBF	(2021/09/02 00:35:10.00)		(0:0:5.0)	N/A	33.7	40	26.2	-	-	-	37.9	27.1	-	-		41.2	42.2	36.3	36.9	39.7	37.8	9.4	5.8	7.1	7.5	0.3	5.8	1.7	1.7	.2	5.9	9	2
NOR140_1658766_210902_0005.NBF	(2021/09/02 00:44:46.00)		(0:0:20.0)	N/A	114.3	114.4	114.3	-	-	-	114.4	114.2	-	-		57.8	52.3	46.6	41.7	38.7	37	35	6.9	.2	4.3	0.7	3.1	1.2	35	.3	4.2	8	2
NOR140_1658766_210902_0006.NBF	(2021/09/02 00:45:52.00)	NMP1 Night	(0:15:0.0)	N/A	45.3	67.5	20.4	-	-	-	40	22.5	-	-		44.3	46.7	42.1	41.7	42.2	40.4	8.6	9.7	7.1	6.5	7.8	5.1	1.1	1.3	.5	5.3	2	1
NOR140_1658766_210902_0007.NBF	(2021/09/02 01:00:54.00)		(0:0:1.0)	N/A	30.2	33.7	26.6	-	-	-	32.6	27	-	-		44	45.7	43	37.2	25.5	41.6	39	8.9	5.7	4.7	3.1	3.7	0.5	0.4	.5	2.8	6	5
NOR140_1658766_210902_0008.NBF	(2021/09/02 01:08:33.00)		(0:0:20.0)	N/A	114.3	114.4	114.3	-	-	-	114.4	114.2	-	-		69.2	64	55.5	50.9	44.2	42.1	1.1	2.8	8.9	39	5.1	4.2	5.7	1.1	.3	4.6	3	3
NOR140_1658766_210902_0009.NBF	(2021/09/02 01:09:34.00)	NMP3 Night	(0:15:0.0)	N/A	30.6	51.4	22.7	-	-	-	32.6	26.4	-	-		48.9	45.8	43.8	43.7	42.5	40.3	9.3	40	6.7	4.3	3.3	3.2	3.5	3.5	.3	4.5	6	1
NOR140_1658766_210902_0010.NBF	(2021/09/02 01:24:36.00)		(0:0:4.0)	N/A	33.7	38.4	29.3	-	-	-	36.7	29.8	-	-		39	38.2	37.8	33.3	38.4	38.6	3.5	5.5	8.1	2.1	1.1	2.1	.8	5.7	4	5.7	5	4
NOR140_1658766_210902_0011.NBF	(2021/09/02 01:34:32.00)	CAL	(0:0:21.0)	N/A	114.3	114.4	114.3	-	-	-	114.4	114.2	-	-		82.3	78.4	72.9	57.1	55.4	44.1	41	42	6.6	7.4	.1	40	7.8	7.2	.3	5.6	6	8
NOR140_1658766_210902_0012.NBF	(2021/09/02 01:35:39.00)	NMP2 Night	(0:15:0.0)	N/A	32.3	52.3	25.4	-	-	-	33.5	28	-	-		55.4	45.7	42.1	42.4	42.8	41.8	9.2	6.6	4.8	1.9	2.4	1.7	.5	2.7	.7	5.1	8	1
NOR140_1658766_210902_0013.NBF	(2021/09/02 01:50:41.00)		(0:0:0.0)	N/A	-	52.3	25.4	-	-	-	33.5	28	-	-		-	-	-	-	-													
NOR140_1658766_210902_0014.NBF	(2021/09/02 14:07:06.00)	CAL	(0:0:10.0)	N/A	114.1	114.1	114	-	-	-	114.2	114	-	-		79.1	76.9	67.5	58.7	59.3	68.9	4.8	5.6	4.9	4.6	5.5	7.3	.5	3.6	.2	9.6	7	9
NOR140_1658766_210902_0015.NBF	(2021/09/02 14:09:13.00)	NMP2 Day	(0:15:0.0)	N/A	57.4	75.4	42.2	-	-	-	61.3	47.5	-	-		72	72.7	71.8	71.7	72.5	72	70.4	1.1	0.5	8.2	7.2	4.9	3.5	.7	.7	7.2	3	4
NOR140_1658766_210902_0016.NBF	(2021/09/02 14:24:15.00)		(0:1:5.0)	N/A	54.9	61.6	43.6	-	-	-	58.8	45.9	-	-		73.6	73.2	71.6	71.4	71.8	74	71.7	3.9	71	8.6	68	5.4	.8	.1	.8	3.9	7	5
NOR140_1658766_210902_0017.NBF	(2021/09/02 14:36:26.00)	NMP1 Day	(0:15:0.0)	N/A	58.7	70.5	32.2	-	-	-	63.8	39	-	-		66.2	68.7	68.1	69	69.1	68.6	7.9	7.7	6.3	5.3	3.9	1.7	9.8	3.1	.6	4.7	3	1
NOR140_1658766_210902_0018.NBF	(2021/09/02 14:51:29.00)		(0:1:1.0)	N/A	54.5	68.4	38	-	-	-	55.4	39.6	-	-		66	66.3	66.4	55.6	67	66.4	6.9	5.6	64	2.2	1.6	0.9	3.7	.5	.1	9.5	4	7
NOR140_1658766_210902_0019.NBF	(2021/09/02 14:59:08.00)	NMP3 Day	(0:15:0.0)	N/A	42.2	55.9	30.3	-	-	-	45.4	35.8	-	-		61.5	65.2	65.1	69	68.2	63.1	2.4	9.7	9.4	6.4	5.1	1.8	0.6	3.1	.7	5.4	7	2
NOR140_1658766_210902_0020.NBF	(2021/09/02 15:14:10.00)		(0:3:16.0)	N/A	42.6	52	34.5	-	-	-	45.2	38.5	-	-		63.7	61.4	63	62	61.7	62.6	1.1	1.9	59	6.8	5.1	2.8	0.8	5.6	.7	45	6	3
NOR140_1658766_210902_0021.NBF	(2021/09/02 15:27:45.00)	NMP4 Day	(0:15:0.0)	N/A	55.1	83.7	33.3	-	-	-	52	35.7	-	-		68.5	68	68.5	67.7	67.3	66.5	5.6	4.3	2.1	9.9	7.8	5.1	3.9	.2	.4	7.8	7	4
NOR140_1658766_210902_0022.NBF	(2021/09/02 15:42:47.00)		(0:1:0.0)	N/A	36.2	45.6	33.7	-	-	-	37.8	34.6	-	-		66.1	67.5	66	66.8	63.9	62.3	63	4.1	3.1	9.6	1.3	5.7	2.5	.1	.7	3.4	4	5
NOR140_1658766_210902_0023.NBF	(2021/09/02 15:47:52.00)	NMP5 Day	(0:15:0.0)	N/A	44	68.2	30.8	-	-	-	40.3	33.3	-	-		70.1	70.8	70.8	71.3	70.7	70.6	9.5	8.1	7.3	5.8	3.7	2.5	0.4	3.5	.8	3.6	1	8
NOR140_1658766_210902_0024.NBF	(2021/09/02 16:02:54.00)		(0:0:2.0)	N/A	36	40.5	33.2	-	-	-	39.6	33.4	-	-		66.9	60.5	64	59.7	55.7	61.5	6.1	8.2	2.8	9.9	5.2	2.7	2.6	52	.1	5.1	2	1
NOR140_1658766_210902_0025.NBF	(2021/09/02 16:07:51.00)	NMP2 Day	(0:15:0.0)	N/A	57.5	69.1	38.9	-	-	-	61.6	44.8	-	-		71.5	73.1	72.8	72.9	72.6	71.6	71.4	1.1	0.4	9.1	68	66	1.2	2.5	.2	3.5	4	6
NOR140_1658766_210902_0026.NBF	(2021/09/02 16:22:53.00)		(0:0:52.0)	N/A	54.8	64.6	39.4	-	-	-	60.8	42.1	-	-		63.2	67.7	71	68.9	71.8	71.8	9.9	8.6	69	6.8	5.9	3.3	0.4	3.7	6	5.7	1	8
NOR140_1658766_210902_0027.NBF	(2021/09/02 16:29:26.00)	NMP4 Day	(0:15:0.0)	N/A	45.6	62.1	32.6	-	-	-	47.7	35.3	-	-		67	67.9	67.6	67.1	65.1	64.7	4.2	2.2	0.8	7.8	5.4	54	2.5	0.5	.3	5.8	1	8
NOR140_1658766_210902_0028.NBF	(2021/09/02 16:44:28.00)		(0:0:35.0)	N/A	46.1	51.4	40.5	-	-	-	48.5	42	-	-		69	76	69.1	65.3	66.2	64.3	2.5	0.5	0.2	8.1	4.6	2.8	0.5	48	.6	4.4	3	5
NOR140_1658766_210902_0029.NBF	(2021/09/02 16:46:40.00)		(0:0:10.0)	N/A	113.6	113.6	113.6	-	-	-	113.7	113.4	-	-		79.7	73.5	67.5	64.5	63.2	64.9	6.1	8.4	6.7	5.1	66	2.2	9.9	5.7	.4	7.4	2	5
NOR140_1658766_210902_0030.NBF	(2021/09/02 16:47:20.00)	CAL	(0:0:11.0)	N/A	114.1	114.1	114	-	-	-	114.2	114	-	-		80.4	78.8	75.9	71.4	61.8	62.1	0.1	9.1	7.2	7.4	5.8	5.7	1.5	2.2	.1	9.3	1	6
NOR140_1658766_210902_0031.NBF	(2021/09/02 19:10:08.00)		(0:0:8.0)	N/A	111.5	113.6	107.7	-	-	-	113.2	108.8	-	-		90.2	87.2	77.7	76.2	71.3	63.8	6.8	7.7	45	2.5	5.7	2.1	7.5	0.5	9	2.1	8	6
NOR140_1658766_210902_0032.NBF	(2021/09/02 19:10:30.00)	CAL	(0:0:9.0)	N/A	114	114.1	114	-	-	-	114.2	113.8	-	-		67.1	65.9	69.3	67	70.6	68.9	5.2	7.1	1.9	56	3.3	3.2	3.1	52	.9	3.5	6	5
NOR140_1658766_210902_0033.NBF	(2021/09/02 19:11:49.00)	NMP4 Eve	(0:15:0.0)	N/A	47.5	66.7	31.9	-	-	-	50.8	33.7	-	-		59.2	57.8	57.3	54.9	54.6	52.5	1.9	9.7	7.6	5.9	3.7	0.8	0.4	3.4	.1	1.6	8	9
NOR140_1658766_210902_0034.NBF	(2021/09/02 19:26:51.00)		(0:0:27.0)	N/A	45.9	54.7	35.1	-	-	-	51.2	36.5	-	-		62.6	62	66.3	50.8	54.2	60	6.7	6.7	2.3	0.8	9.1	5.1	43	43	.5	1.5	6	3
NOR140_1658766_210902_0035.NBF	(2021/09/02 19:30:36.00)	NMP5 Eve	(0:15:0.0)	N/A	37	53	28.5	-	-	-	39.6	31	-	-		43.1	47.3	44.7	41.4	39.8	38.2	7.7	6.6	5.6	4.9	5.1	3.5	3.1	3.5	.3	7.4	0	9
NOR140_1658766_210902_0036.NBF	(2021/09/02 19:45:38.00)		(0:0:3.0)	N/A	36.2	38.8	34	-	-	-	36.8	34.9	-	-		43.8	41.3	37	39.5	36.7	31.7	7.7	5.6	4.5	7.5	5.8	0.6	.5	2.7	5	3.6	9	2
NOR140_1658766_210902_0037.NBF	(2021/09/02 19:48:25.00)	NMP4 Eve	(0:15:0.0)	N/A	45.8	61.9	31.8	-	-	-	48.7	33.3	-	-		53.1	46.1	50.7	49.6	42.6	41.7	8.2	7.9	36	5.6	5.6	4.1	3.9	5.6	.9	1.3	1	3
NOR140_1658766_210902_0038.NBF	(2021/09/02 20:03:28.00)		(0:1:42.0)	N/A	50.3	64.4	32.5	-	-	-	53.2	33.3	-	-		48.7	50.1	50.2	48.4	44.5	40	8.7	7.3	6.6	5.7	5.5	3.2	3.7	1.7	.4	42	5	5
NOR140_1658766_210902_0039.NBF	(2021/09/02 20:10:37.00)	NMP2 Eve	(0:15:0.0)	N/A	55.2	67.9	28.8	-	-	-	60	34.4	-	-		56.3	54.4	54.1	53.5	52.8	51.6	1.3	0.4	8.3	6.1	4.3	2.5	0.2	3.6	.3	0.7	7	2
NOR140_1658766_210902_0040.NBF	(2021/09/02 20:25:39.00)		(0:0:54.0)	N/A	46.8	60.6	26.2	-	-	-	49.1	27.9	-	-		45.2	45.5	46.4	48.5	45.2	45.3	4.8	1.2	0.7	0.6	3.6	4.7	3.8	3.7	.9	5.2	2	4
NOR140_1658766_210902_0041.NBF	(2021/09/02 20:28:25.00)	CAL	(0:0:20.0)	N/A	114	114	113.9	-	-	-	114	113.8	-	-		95.3	94.5	92.2	88.7	83.3	77.5	75.6	7.7	3.1	54	0.5	7.3	5.1	1.4	.3	2.3	3	7

RECEIVED: 11/04/2023

																														LfFmax														
25 Hz	31.5 Hz	40 Hz	50 Hz	63 Hz	80 Hz	100 Hz	125 Hz	160 Hz	200 Hz	250 Hz	315 Hz	400 Hz	500 Hz	630 Hz	800 Hz	1.0 kHz	1.25 kHz	1.6 kHz	2.0 kHz	2.5 kHz	3.15 kHz	4.0 kHz	5.0 kHz	6.3 kHz	8.0 kHz	10.0 kHz	12.5 kHz	16.0 kHz	20.0 kHz	0.4 Hz	0.5 Hz	0.63 Hz	0.8 Hz	1.0 Hz	1.25 Hz	1.6 Hz	2.0 Hz	2.5 Hz	3.15 Hz	4.0 Hz	5.0 Hz	6.3 Hz	8.0 Hz	.0 Hz
48.5	42.8	43.5	42.8	42.7	44.2	46.2	35	26	25.1	27.4	26.7	26.8	26.1	28.4	29.4	28.5	27.7	29.5	28.6	23.3	23.9	21.4	19.3	18.5	16.5	14	12.1	9.7	14.5	43.2	37.9	45.8	47.4	45.6	42.1	45.2	45.1	37.7	39	42	39.1	45.6	43.9	44.3
36.7	35.6	31.6	34.1	35.6	34	29.3	30.3	25	21.1	22	23.5	55.4	63.3	74.5	93.6	114.3	93.8	74.4	63.7	49.5	47.3	34.6	30.7	25.6	22.6	20.1	20.1	21	21.8	65.7	57.2	57.8	47.2	51.7	49.2	48.8	53	50.9	46.4	47.2	45.5	44.9	44.4	40.6
36.1	35.9	33.9	35.1	39.5	34.6	31.1	32.2	27	23.1	22.6	22.1	26.3	24.2	25.1	23.9	24.9	22.7	19.1	15.6	12.6	11	10.2	9.1	8.3	7.6	6.7	5.8	5	5.6	65.8	64.7	62.6	62.5	57.6	67.5	72.2	65	53.5	50.2	46.6	44.1	43.9	45.3	47.5
34.2	33.3	35.6	34.1	36	32.3	29.7	26.9	27.3	24.3	23.3	21	21.5	22.1	22.5	23.3	22.9	23.4	24.6	23	22.1	21.8	19.7	18	17	16.1	13.9	12.5	10.4	6.7	44.4	44.8	40.2	41.3	44.3	42.2	42.6	39.1	42	42.4	36.1	40.7	38.7	38.6	41.8
37.5	38.8	33	33	28.4	26.3	22.8	21.2	20	20.5	21.7	23.2	55.4	63.4	74.5	93.6	114.3	93.8	74.4	63.7	49.5	47.4	34.6	30.6	25.5	22.6	20.1	20.1	21	22	69.2	63.5	59.9	52.8	43.8	42.3	41.4	43.1	45.6	41.8	39.8	38.5	45.5	44.5	40
39.2	40	39.4	37.5	37.5	39.8	31.3	26.7	23.7	23.8	25.8	26.8	29.4	33.1	37.3	39.8	38.9	37.3	34.9	31.3	27.2	23.8	20.1	17	14.7	13	11.1	9.6	11.7	5.8	65.4	71.1	65.4	66.3	68.2	66.3	58.7	50.6	54.1	60.5	66.1	60.5	56.2	57.5	55.6
38.3	33.7	35.5	31.5	33.2	27.4	18.4	19.9	22	23.4	22.4	22.3	21	21.3	20.9	22.5	22	21.8	19.2	15.5	15.5	14.2	11.4	11.2	9.8	8.7	7.4	6.3	5.5	4.8	46.8	47.8	45.6	39.7	31.6	43.4	[illegible]	32.5	37.5	36.4	38.6	37.8	32.8	34.1	36.6
35.1	33.7	31.3	33.2	34.2	31.1	27.1	26.9	20.6	18.7	20.2	22.7	55.5	63.4	74.5	93.6	114.3	93.8	74.4	63.7	49.5	47.4	34.6	30.7	25.6	22.5	20.4	20.2	21	21.9	76.9	74.6	67	62	50.2	49.7	49.7	51	45.7	45.2	43.7	41.7	43.8	39.6	41.4
34.6	32	31.6	34.5	35.5	33.7	30.2	31.8	24.6	20.9	20.7	22.2	23.7	24.2	28.6	18.8	18.1	17.2	15.3	14.2	13.6	11.8	11	9.6	9	8.3	7	6	8	4.6	71.9	70	60.2	69.5	64.1	52.2	50.5	53.7	48.8	46.6	44.2	43	42.6	42.9	45
36.3	31.7	29	33.2	36	33.2	30.1	29.5	28.2	21.6	20.6	21.1	29.2	24.7	28.3	22.4	22.7	21.6	22.2	23	20.9	18.7	17.6	16.5	15.2	14	11.6	9.6	7.7	5.6	42.7	41.1	43.2	41.8	45.5	45.3	39	41.8	46	39.1	37.2	39.7	36.7	40.1	39.8
36.9	37.7	33.3	40.1	32.5	34.6	35.1	31.9	31.1	29.4	22.8	25.1	55.4	63.4	74.5	93.6	114.3	93.8	74.4	63.7	49.5	47.4	34.6	30.7	25.6	22.6	20.2	20.1	21	21.8	91.1	88.6	87.3	77.7	70.7	59.6	48.5	53.1	46.5	49.7	53.1	54.3	50.6	49.5	47.5
36.4	36.6	35.9	38.5	35.6	34.6	33.1	29.8	26	21.8	21.6	24.7	29.2	24.8	23.7	22.9	23.3	21.8	20.4	18.4	16.2	14.5	12.9	11.5	10.2	9.3	7.8	6.5	6.3	4.8	79.7	73.1	63.7	68.3	70	69.8	68.2	64.7	50.8	51.2	49.1	44.6	41.1	43.9	46.5
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	79.7	73.1	63.7	68.3	70	69.8	68.2	64.7	[illegible]	51.2	49.1	44.6	41.1	43.9	46.5
56.7	55.8	53.9	59.7	54.6	49.9	49.4	50.4	50	46.7	47.5	46.2	55.3	63.2	74.2	93.3	114	93.5	74.1	63.5	49.2	46.9	34.3	29.7	24.7	22.4	20.1	19.8	20.7	21.6	86.6	86	78.8	74.6	74.4	73.7	69.1	71.6	72.8	71.4	76	76.8	77.4	72.2	72.2
54	56.7	52.4	54	54	51.6	51.7	51.7	47.2	44.4	42.5	41.3	45.4	45.1	48.5	50.3	50.9	49.5	47.7	44.5	40.7	37.6	34	30.1	26.9	21.9	17	15	9.1	6.1	87.4	87.1	86.5	88.1	89.2	88	85.8	88.1	86.5	86.4	85	83.3	80.7	80.2	79.6
53.3	51.4	50.5	53.3	57.5	50.4	48.7	49	44	45.2	44.9	33.5	36.9	38.7	42.7	47.3	49.3	47.1	45.5	43.3	39.5	35.5	32.3	29.2	26.2	22.5	18.3	15.8	14.5	9	81.7	83.9	79	78.5	79.2	82	81.6	83.3	84.5	79.4	[illegible]	74.9	77.6	77.4	75
51.4	50.6	51.8	58.7	56.6	53.3	48.5	46	40.3	38.9	41.1	43.8	45.2	49.2	51.3	53.4	52.8	50	46.8	42.8	39	35.7	31.9	27.5	23.5	20.4	18.3	13.5	10.7	7.9	82.2	86.1	84.2	86.7	83.6	87.3	85.2	88.1	86.3	85.4	[illegible]	81.9	79	77.6	77.7
47.1	48.2	46.2	48.2	45.6	43.1	41.1	37.8	37.4	31.4	32.4	34.5	39	42.4	44.6	48.3	49.1	47.4	43.8	38.8	35.5	33	29.6	26.3	24.4	23.5	22.7	22.2	20.8	17.3	74.8	74.6	74.9	75.1	76.5	74.7	77.7	75.6	75	74.1	[illegible]	[illegible]	74.7	69.6	66.1
44.4	45.2	46.8	47.2	47	41.2	38.9	35.1	30.7	28.3	27.6	29.7	31.7	33.2	34.2	36.3	36.4	33.8	30.3	25	20.9	17.6	14.7	14	14	10.5	7	6.5	6.6	4.5	79.9	87.1	87.9	93.5	93.1	87.1	85.5	83.8	84	78.9	79.5	[illegible]	77.5	74.5	70.7
43.2	48.3	47.5	44.7	46.6	39.2	35.3	33.6	30.8	26.8	26.1	28	31.2	35.3	36	37.2	36.4	33.2	29.1	24.3	20.4	20.8	20.5	15.7	13.6	13.8	12.6	12.2	10.6	7.7	76.3	74.8	79.3	78.2	76.9	77.7	79.3	80.8	75.1	74.2	75.1	72	72.1	67.5	65.4
51.6	55.1	56.8	61.7	56.4	55.6	53.7	52.9	52	48.7	45.4	44.3	45.6	45.2	45.3	46.2	46	46.1	45.9	43.9	42.4	38.4	33.9	29.7	25.6	21.9	17.4	13.6	10.8	5.9	82.1	80.6	85.5	86.4	82.4	85.7	85.2	85.5	80	77.7	76.4	75.3	73.7	69.9	69.3
45.7	42.6	41.6	56.4	41.9	39.1	39.6	36.1	36.7	31.6	28.3	28.6	28.5	28.9	29.3	27.8	25.8	23.6	20.8	20	18.6	17.4	15.5	13.5	12.5	11.5	9.5	8.4	10.7	4.7	77.1	78.6	75	78.4	73	72.5	78	78.9	79.7	72.8	76.6	68.8	66.6	64.6	63.1
46.6	46.6	48.4	50.8	48.3	43.1	42.6	44.7	38.2	36.5	32.3	32.6	32.9	32.7	34.8	33.4	34	35.4	35	32.9	31.2	29.1	27.9	26	21.9	19.2	17.9	16.6	16.4	12.6	82.9	83.9	83.4	87.3	87.2	87.6	84.8	84.3	84.2	82	79.6	81.5	76.4	78.4	72.9
42.7	50.3	41.3	52.8	38	38.7	36.9	29.5	27.3	24.3	23.4	23.1	25.6	25.7	26.9	27.3	26.1	24.8	22.7	21.4	20.1	22.9	22.7	17.5	23	26.4	11.7	9.4	9	4.9	70.5	64.2	70.7	63.3	62.1	65.1	70.9	71.5	66.3	64.6	61.3	57.8	56.1	56.8	57.3
54	52.1	53.1	57.2	54.7	52	49.2	48.1	45.6	44.2	40.6	35	37	42.1	46.7	49.9	51.8	50.7	48.1	44.8	40.9	36.1	32	29.1	24.6	20.4	16.6	12.5	9.8	6.6	87.2	90.3	88.2	86.7	86.8	86.1	85.9	87.4	89	86.3	86.9	84.4	82.5	82.9	81.3
49.5	51.1	51.5	56.2	66.7	54.2	49.9	48.4	45.3	43.2	38.2	32.4	38.2	39.8	44.1	47.8	48.3	47.3	45.2	42.5	38.5	34	31.1	29	27.6	26.9	25.5	24.2	22.4	19	72.4	80	84.1	80.1	83.4	83.3	82.3	82.7	84.2	83	79.6	73.5	70.8	71.2	68.1
49.7	50	49.5	55.5	48.2	42.9	43.5	42.4	41.6	37.8	36.1	34.5	36.7	36.6	39.2	38.7	37.6	35.9	33.3	31.1	29.7	25.4	22.9	20.1	16.2	13.1	9.4	6.7	5.9	3.8	81.3	83.9	82	82.1	79.8	81.3	81.6	80.5	77.4	76.1	74.7	72.7	76.2	74.4	71.5
46	41.2	40.9	53.8	44	40.8	40.4	42.2	38.4	32.7	32.3	30.5	36.3	36.7	42.8	41.6	34.9	32.1	26.7	26	30.4	24.7	22.6	22.2	17.3	14.3	11.5	9.9	7.6	4.7	76.9	84.4	77.1	75.6	73.7	71.9	71.6	69.2	71.2	67.8	63.5	62.2	61.8	58.6	55.5
60.5	60.6	60.9	62.8	62.5	57.5	51	51.6	49.1	48.2	45.2	44.3	55.4	63.1	73.8	92.9	113.6	93.1	73.7	62.9	48.7	45.8	33.8	29.4	26.5	22.8	20	20.1	20.9	21.7	84.8	83.5	72.2	70.4	70.2	72	74.3	77	75.8	75.2	76.4	72.8	69.3	63.1	62
48.4	48.9	48.3	56.6	51.7	49.3	47	44.6	41.8	40.6	38.6	38.5	55.2	63.1	74.2	93.3	114	93.5	74.1	63.4	49.2	46.2	34.2	29.6	25.3	23	20.4	20.6	21.2	22.1	86	86.1	85.1	82.2	73.6	70.9	69.9	64.2	63.9	65.4	62.6	63.6	60.3	57.6	58.1
39.5	35.1	35.1	48.9	39	35.4	38.5	37	34.7	33.8	34.5	34.3	52.6	60.5	71.5	90.6	111.3	90.8	77.2	96.8	78.3	86.2	79.1	75.3	72.2	67.5	63.7	58.6	53	46.5	96.8	96.4	88	81.6	80.5	77.3	68	56.6	59.5	52.6	51.1	41.6	35.6	42.3	40.1
47.2	44.1	42.5	55.2	46.2	43.2	42.8	40.1	38.2	35.7	35	35.9	55.3	63.1	74.2	93.3	114	93.5	74.1	63.3	49.2	46.6	34.2	29.6	25.1	22.8	20.2	20.3	21.2	22.1	72.2	71.2	74.5	72.5	77.7	79.8	72.6	77.7	73	63.5	68	61.6	62.3	60.2	63
45.4	47.9	52.1	56.4	50	48.2	48.2	42.9	39.7	41.1	39.6	38	38.3	38.9	38.9	40	40.1	38.2	36.2	34.4	32.6	29.2	26	23	21.3	16.9	11.7	8.9	6.5	7.9	80.5	79.3	77	73	73.9	75.6	70	70.8	68.5	68.2	63	59.6	58.3	57.7	59.7
47.3	49.9	49.4	56.5	50.6	45.1	43.9	43.3	41.6	41.6	40	38	38.6	38.6	37.9	37.4	36.3	34.6	33.3	32.8	32.4	31.3	27.4	21.9	18.9	15.9	13.4	11.3	8.2	6.1	71	68.7	72.7	67.2	72.5	70.2	64	65.3	60.5	58.9	57.1	54.6	51.6	53.7	50.6
42.4	43.8	45	47.9	46.9	41.8	38.1	34.8	31.3	28.1	25	22.8	24.9	27.7	28.7	29.6	28.3	27.2	27.1	24.2	21.8	19	18.6	15.3	15.6	19.9	11.9	9.9	8.3	7.3	66.6	74.1	71.5	68.7	64.5	56.7	55.9	52.9	53.6	54.5	51.3	49.1	47.3	47	52.9
39.3	39.3	36.9	44.8	36.5	36.7	34.8	30.1	25	22	18.9	21.6	29.1	32.3	28.8	31.1	27.4	24.2	22.1	17.8	15.4	14.4	14.2	11.5	9.6	9.2	8.8	7.2	5.3	6.2	47.4	44.9	40	44.2	43.1	36.1	32.7	38.6	39	42.2	39.6	36.1	36.1	37.5	40.2
51.8	53.6	52.9	57.9	53.9	47.4	48.3	43.8	41	38.6	37.8	37.2	36.2	36.7	37.1	37.8	38.3	36.7	34.6	32.4	29.2	25.5	22.7	18.6	15.3	12.9	11.2	9.2	7	5.8	77.8	63.4	77.5	75.3	70	71.5	64.9	66	58.3	49.6	52.1	49.5	52.1	55.4	56.8
47.2	46.1	46.7	57.1	51.3	46.3	44.6	43.3	40.5	40.5	41.3	38.9	38.8	40.3	41.1	43.7	44.5	41.9	39	36	30.8	26.4	22.6	25.4	28.8	17.7	12.5	11	6.5	8.2	61.7	64.2	65.5	63.8	60.2	54.9	52.3	45.6	44	45.4	44.4	43.1	42.8	45.7	50.6
45.6	46.8	48.8	52.2	49.8	49.8	48.6	46.6	46.1	43.7	38.7	31.8	33.4	37.1	41.2	46.4	49.4	48.9	46.5	42.8	38.8	34.2	30.2	26.3	22.8	19.1	16.2	11.2	7.7	6.3	79	77.6	70	67.4	67.9	65.6	66.6	68.5	65.1	63.1	62	60.6	58	56	52.8
38.3	39	41.7	46.7	43.5	37.5	36.2	33.9	29.8	25.6	18.8	19	23.1	27.4	32.6	39.7	41.6	40.4	36.9	32.7	30.6	26	21.9	19.9	19.4	19.1	17.8	16.9	14.3	11	56.1	57.1	55.1	58.3	56	53.8	55.2	49.5	52.6	50	49.2	45.8	44.4	42.3	44
44.1	45.8	46.8	48.5	51.3	45.4	46.6	48.2	47.9	49.8	46.2	41.7	55.2	63	74.1	93.2	113.9	93.4	74	63.2	49.1	46.4	34.2	29.8	25.1	22.9	20.3	20.3	21.1	21.9	102.9	103.8	103.8	102.7	99.9	89.5	89	87	76.9	70.8	66.6	58	53.2	53.3	50.4

LFmin

12.5 Hz	16 Hz	20 Hz	25 Hz	31.5 Hz	40 Hz	50 Hz	63 Hz	80 Hz	100 Hz	125 Hz	160 Hz	200 Hz	250 Hz	315 Hz	400 Hz	500 Hz	630 Hz	800 Hz	1.0 kHz	1.25 kHz	1.6 kHz	2.0 kHz	2.5 kHz	3.15 kHz	4.0 kHz	5.0 kHz	6.3 kHz	8.0 kHz	10.0 kHz	12.5 kHz	16.0 kHz	20.0 kHz	0.4 Hz	0.5 Hz	0.63 Hz	0.8 Hz	1.0 Hz	1.25 Hz	1.6 Hz	2.0 Hz	2.5 Hz	3.15 Hz	4.0 Hz	5.0 Hz
47.7	45.1	45.9	53	47.6	46.9	47.5	46.1	48.1	50.9	38.5	31.5	32.2	33.2	31.4	31.5	30.5	31.4	32.7	31.8	34.5	40.5	41.3	29.6	34.3	28.5	26.3	24	22.6	19.5	18.2	14.5	16.4	30.3	15.4	32.8	39.3	39	35.1	28.6	32.2	26.8	31.6	24.8	29.2
40.9	42.8	37.4	41.5	40.5	37.1	40.1	40.5	38.9	33.5	35.2	29.7	30	36.2	33.8	55.5	63.5	74.5	93.6	114.3	93.8	74.4	63.7	49.5	47.5	34.7	30.9	26	22.9	20.5	20.7	21.5	22.4	15.7	[illegible]	28.6	13.2	23	22.2	24.9	24.5	20.4	16.2	23.3	20.5
47.6	49.9	44.7	45.5	47.9	48.7	48.3	59.3	48.3	46	48.7	38.6	37.1	35.3	35.7	39.2	40.5	40.9	40.3	41.6	39.6	36.4	37.5	37.3	36	38.6	30.3	30	26.3	25.5	22.1	19.2	14.9	4.1	2.8	9.1	6.9	10.3	9.8	11.6	15	13.2	9	7.6	14.5
41.5	42.8	36.3	40.6	36.6	39.5	37.8	38.9	37.5	33.2	29.9	31.5	28.2	27.9	25.3	25.7	26.3	26.9	30.2	28.2	29	34.1	32.2	31.6	31.5	26.8	24.9	24.3	23.2	20.5	19.2	16	11.2	32.1	34.3	23.9	19	20.8	28.3	35.5	29.6	23.8	22	19.5	25.1
40.1	44.9	41.7	43.9	45	39.1	40	36.1	33	31.9	34.1	31.3	31.8	37.5	32.8	55.7	63.8	74.6	93.7	114.3	93.8	74.4	63.7	49.5	47.5	34.7	30.8	25.9	23	20.6	20.5	21.5	22.4	36.7	31.7	22.5	15.3	20.1	13.7	18.9	12.2	20.8	12.2	13.5	17.5
59.7	65.5	64.7	62	60.4	61.5	61	62.7	65.1	57.7	52.2	43.4	42.5	44.7	48.6	52.2	57.7	62.7	63.6	61.7	59.4	56.9	54.4	50.7	47.5	44.5	41.2	37.7	33.9	30.8	30	27.4	23.7	-5.7	3.3	7.2	8.1	7.5	8.9	6.3	11.9	11.2	6.5	7.1	6.8
36.2	38.9	36.1	41.2	36.8	37.5	35	35.8	29.9	22.8	24.8	24	25	25.6	23.3	23.6	25.7	25.9	25.8	26.5	26.7	24.8	20.1	19.7	19.6	15.7	15.5	14.3	13	11.5	9	7	5.5	34.5	38.7	36.6	32.6	16.2	37.4	35.1	25.7	33.2	31.8	22.1	26.3
41.3	40.9	37.1	39.6	39.3	39.7	43.2	45.4	42.2	31.4	33.4	28.5	29.4	33.5	26.7	55.5	63.5	74.6	93.7	114.4	93.8	74.4	63.8	49.6	47.5	34.7	30.9	25.9	22.7	20.8	20.7	21.4	22.2	46.7	36.2	32	19.2	31.7	2.4	24.4	17.1	21.2	21.8	17.3	18.4
47.7	52	49.4	44.7	40.7	44.4	47.4	48	47	39	42.5	45.1	43.9	41.1	35.9	37.3	36.8	37.2	35.7	37.1	37	39.8	43.4	45.2	40.5	40.8	35.1	36.8	36.5	30.4	28	24.1	18.5	4.9	-0.9	12.9	8.2	6.6	5	9.1	6.2	12.3	9.8	13.5	12.3
39.7	40.3	34.9	41.2	37.1	34	37.3	39.4	35.7	33.4	32.7	30.5	28.1	24.7	24.5	32.1	29.1	30.7	28.8	26.8	27	28.9	30.8	29	25.5	24.5	22.9	21.6	20.5	17.9	15.1	11.9	7.9	29.7	31.4	30	20.1	[illegible]	28	20.5	22.3	21.8	8.2	18.7	21.5
41.9	44.1	45.4	42	41.9	40.1	45	41.8	41.8	49.9	47.7	51.4	50.7	39	38.1	55.6	63.4	74.5	93.7	114.4	93.8	74.4	63.7	49.5	47.5	34.7	30.9	25.9	22.9	20.8	20.6	21.4	22.2	59.9	47.9	30.9	16.6	17.1	[illegible]	25.6	14	26.7	22.8	18	14.9
49	53.8	50.7	55.6	51.9	54.4	55.9	50.7	46	47.9	43.2	40.8	42.3	40.6	41.7	38.6	37.3	43.5	42.3	47.1	46.4	44.6	43.9	42.1	42.2	39.9	40.1	38.5	33.4	31.8	26.2	22.9	25.1	4.8	8.9	9.5	7.9	11.1	[illegible]	11.3	5.1	10.6	6.7	10.6	7.6
49	53.8	50.7	55.6	51.9	54.4	55.9	50.7	46	47.9	43.2	40.8	42.3	40.6	41.7	38.6	37.3	43.5	42.3	47.1	46.4	44.6	43.9	42.1	42.2	39.9	40.1	38.5	33.4	31.8	26.2	22.9	25.1	4.8	8.9	9.5	7.9	11.1	[illegible]	[illegible]	5.1	10.6	6.7	10.6	7.6
67	70.3	66.1	63.9	65.7	62.1	66.7	65.4	58.8	58.6	60	58.4	54.4	58.1	56.8	56.5	63.7	74.3	93.4	114.1	93.6	74.2	63.6	49.3	47	34.5	30	25	22.7	20.5	20.3	21	21.9	50.3	54.4	52.9	48.8	55.9	63.2	54	50.1	54	48.9	52.8	51.3
75.1	72.5	70.7	70.7	74.1	74.1	71.5	74.5	72.7	70.3	73.6	69.5	66.6	62.6	61.9	68.2	63.3	71.5	73.4	63.3	66.8	65.2	62.5	59.5	53.5	50.7	52.6	48.6	42.9	37.6	40.5	31.1	26.4	21.6	27.7	29.2	36	37.9	39.5	28.5	[illegible]	34.4	32	33.3	25.3
70.4	71.5	69	67.8	65.7	66.2	62.8	73.7	59.7	60.6	59.8	54.3	59.3	59.7	44.3	49.9	45.6	50.8	56.5	57.1	54.8	53.2	52.2	49.7	41.4	43.4	44.4	41.3	36.9	31.8	29.9	27.5	23	45.1	49.9	50.2	51	46.5	50.4	43.7	[illegible]	45.2	39.9	37.3	37.2
73.8	74.2	69	68.8	68.7	69.9	84	75.6	76.2	64.5	63.3	58.2	57	61.3	63	63	69	66	65.3	65.9	62.6	58.6	54.3	51	49.5	47.1	43.4	40.3	48.8	46.5	34.5	34.3	32.1	22.7	20.4	16.9	27.9	18.8	20.6	22.9	[illegible]	20.6	19	20.3	20.8
59.5	64.1	66.3	65.5	63.7	59.9	60.2	59.2	56.9	55.9	52.2	53	42.8	44.4	48.9	55	57.9	59.4	63.7	63.6	62.5	59.6	53.1	49.8	48.4	45.5	40.6	38.3	35.4	36.1	35.5	35.2	32.6	34.7	28	35.1	39.9	45	43.3	37.8	[illegible]	[illegible]	36.8	37	35.2
71.6	62.5	65.8	55.3	56.3	58.3	60.2	63.1	56.1	51.4	51.5	44.6	42.5	41.6	46	48.7	48.7	46	50.4	51.6	49.8	49.9	43.1	39.3	29.7	31.5	35.1	39.6	30.9	28.6	28.4	26.5	23.2	18.2	13.9	13.8	19.3	18.2	16.1	13.5	12.1	[illegible]	10.8	15.5	13.2
67.8	58.6	58	53.2	57.9	57.4	60.8	63.2	54.5	47.9	48.7	50.4	39.6	37	38.6	44.4	49.6	47.9	48.2	47.4	43.9	40.1	38.8	34.4	34	36.6	34.1	34	34.6	34.6	35.1	33.4	29.6	22.6	26.7	29.8	27.4	24.1	20.9	22.1	18.2	17.8	22	18	16.2
69.2	70.4	70.4	77	76.1	82.2	85.2	85.8	83	82.2	83.5	78.7	78.6	74.2	74	76.4	74.7	73.4	73.7	74.3	71.1	75.1	74.5	73.3	69.4	61.9	56.1	52.3	49.3	43.7	39.1	34.3	33.3	16.3	23.1	16	19.2	13.7	13.9	17.8	17.1	9.4	12.3	16.2	13.9
62.6	65.1	66.7	64.9	61.7	49.4	58.3	57.6	53.8	48.8	50.6	46.3	43.9	38.8	39.7	46.9	37.3	36.8	34.6	32.7	34.3	28.2	29.6	28.4	27.4	26	26.5	26.8	26.1	24.2	21.7	20.5	15.4	38.3	34.8	38.6	35.3	42.3	22.2	32.6	26.7	33.8	28.3	30.1	23.6
73.2	72.3	68.1	66.8	66.3	71.1	66	70.2	64.8	70.1	72.3	63.8	64.3	60	60.3	58.6	54.9	57.5	55.1	57.3	59.5	61.1	58.1	57.7	54.9	53.4	53.2	47.2	43	41.8	40.8	41.5	39.8	22.7	23.8	23.3	16.1	10.9	21	20.3	19.2	17.1	20.5	11.8	19.3
51.4	54.1	51.5	48	52	45.4	53.8	41.4	40.9	39.3	31.6	30.3	27.1	25.5	25.5	29.5	30.3	31.4	32	32.5	31.4	31.3	29.2	27.2	33.4	33.2	21.4	33.3	36.7	15.6	13.4	12	7.5	58.2	52.3	53.1	50.9	40.5	53.2	56.4	53.1	52.5	48.7	44.7	41.1
77.3	80.8	73	77.6	77.6	68.2	79.6	72.5	71.5	67.1	64.5	61	59.6	59.5	53.6	50.2	57.6	61.1	63.7	64.5	63.2	60.7	57.6	53.9	51.4	52.2	52.2	39.8	39.5	37.5	36.6	35.2	31.5	32.5	34.7	34.4	33.7	34	39.9	34.1	32.5	32.2	31.2	31.8	28.8
68.4	70	64.8	61.9	64	64.1	68.6	79.5	68.4	60.4	60.8	57.8	56.5	51.4	41.6	51.8	50.2	56.1	58.4	58.3	58.7	57.3	54	51.1	46.1	43.9	43.3	43.4	43.1	42	40.4	38.4	34.6	41.6	36.6	49.9	49.6	46.5	37.6	42.8	37.7	32.1	36.7	35.9	28.2
70.3	66.9	73.2	74.5	74.4	71.9	73.5	73	64.2	61.2	61.8	59.3	58	57.2	52.3	56.8	56.3	57.5	57.5	55.1	54.1	52	51.7	48.4	41	40.5	34.3	31.8	27.2	26	23.3	21.2	16.8	22.1	21.3	1.8	13.7	22.8	13.8	14.1	20.2	18	16.9	18	15.5
54.3	54.6	67.3	65.2	57	50.7	62	63.6	56.4	50.6	52.5	50.4	49.4	46.9	41.6	44.1	42.2	49.9	46.6	38.7	35.6	31	29.3	33.5	27.9	26.2	26	22.9	22.6	23	23.5	17.8	13.9	53.1	49.6	40.1	40.5	29.8	42.4	44.7	33.1	37.8	38	32.6	32.5
67.5	69.8	67	68.4	70.9	74	71.4	71	65.4	59.4	59.9	56.2	55.4	54.8	56	61.6	71.7	75.9	92.9	113.6	93.1	73.7	63.4	49	46	34.7	32.6	36.2	26.8	25.2	22.2	24.7	22.7	62.2	59.9	56.1	34.8	49.5	47	48.5	52.8	45	48.5	43.2	44
55.2	57.8	55.5	55	57	55.2	61.9	66.5	59.6	58	53.7	50.6	51.2	50.2	53	56.2	64.1	74.4	93.4	114.1	93.6	74.2	63.5	49.2	46.3	34.5	30.2	30.8	27.3	26.3	25.2	22.9	23.4	51.8	59.4	56.3	46.3	33	37.2	36.2	44	39.5	40.6	41.9	43.7
46.2	53.2	54.7	53.1	47.2	42.2	55.1	48	42.4	46.1	45.6	40.7	45.2	49.3	50.8	57.6	65.3	74	92.8	113.6	93	79.6	100.3	80.5	88.6	83.9	78.3	75.7	70.7	67.1	62.3	57.2	51.1	71.9	64	60.6	59.3	52	46.1	27.3	24.7	22.3	21.9	13	17.4
58.5	57.3	55.7	55.7	52.7	50.5	57	53.3	48.8	47.6	43.7	43	42.5	47	52.1	60.2	65.2	74.4	93.3	114	93.5	74.1	63.4	49.2	46.7	34.3	29.8	25.7	23.1	20.7	20.8	21.6	22.8	48.7	46.6	54.2	47.7	33	42.3	42.9	48.4	45.2	35.3	36.5	34.5
60	64.5	66	67.3	67.5	76.8	74	72.8	70.2	73.9	63.4	57.4	69.2	64.2	58.8	59.3	59.3	58	58.8	57.1	57.2	55	55.1	59.7	52.4	48.5	49.7	47.5	43.5	38.8	35.7	31.6	33.2	2.1	7.4	9.6	8.9	8.4	14.1	7.6	8.7	13.2	10.3	10.2	13.6
52.7	62.3	61	60.5	59.1	59.8	64.5	61	55.5	55	55.4	52.8	53.5	50.6	47.9	51.1	48.9	48.7	47	46	42.6	42.9	43.6	44.5	42.9	39.1	32.9	30	26.8	24.9	21.4	18.4	17.6	42.4	42.9	46.8	35.7	25.1	19.1	31.7	27.8	12.1	19.4	21.2	25.8
56.3	63.3	63.6	63.2	64.2	66.4	65.6	71.8	65.6	59	58.3	55.2	52	50.8	45.5	42	45.2	43.5	45.1	44.2	44.2	49.7	46.8	46.5	39.1	39.2	36.7	37.1	42.2	34.2	33.7	31.2	26.8	2.5	2.5	4.4	4.4	4.4	7.8	6.2	4.5	8.2	9.5	8.9	11
38.2	41	42.8	44	43.6	41.5	47.2	40.1	42.7	41.9	34.3	31.9	31.3	25.9	25.9	31.9	34.8	30.8	33.8	29.7	26.5	29.9	24.5	24	23.7	24.2	20.6	17.9	16	13.9	12.1	8.6	8.4	34.8	33.5	26.5	26.7	22.5	21.3	14.3	32.1	21.9	24.6	26.1	18.5
61.8	66.9	71.9	72.1	77.3	78.3	78.6	75.9	66	68.7	62	58.1	59	55.7	58.6	55.9	55.8	56.9	56.7	55.8	53.1	50.7	49.3	48.6	44.5	47.3	42.2	40	38.2	35.3	38.3	38.5	22.7	-4.9	-4.1	5	6.7	8.8	5.2	10.7	0.7	5.1	12.7	8.6	13
59.6	64.1	66.3	63.5	65.7	61.5	71.4	66.9	65.6	55.5	57	54	56	56.7	54.2	52.7	55.4	56.3	59.4	59	56.5	53.8	51	45.5	41.1	36	43	46.9	37.6	31.2	32.2	19.4	16.7	20.5	8.8	13.7	11.4	17.7	13.9	17	12	13	13.5	18.8	18.4
58.8	65.2	70.4	64	65.2	67.6	70.7	66.8	68.6	68.3	67.3	65.4	65.4	57.8	53.7	50.4	56.1	57.1	61.5	65.3	64.3	60.7	57	55.3	52.3	51.4	46.2	44.9	43.2	39.6	34.7	31	27.3	5.4	10.2	7.9	9.8	14.2	11	16.4	12.3	14.5	14.2	15.7	8.4
43.8	46.2	46.2	46.8	46.8	54.3	56.2	59	50.3	49.5	49.8	46.7	42.7	33.9	29.6	32.2	36.8	44.4	53.6	54.4	56	53.7	47.7	45.8	43.2	39.3	35.8	37.9	37.5	35.9	37.6	32.2	27.3	25.8	22.6	24	19.6	18.1	17	24	24.9	17.4	18.5	16	19.2
48.9	56	58.2	55.8	59.3	60.1	57.4	63.8	58.4	56.2	59.4	59.1	63.6	59	56.7	57.5	63.6	74.2	93.3	114	93.5	74.1	63.3	49.1	46.5	34.3	30	26	23.3	20.8	20.7	21.6	22.6	67.1	55.3	58.2	49.7	27.6	32.8	29.8	29	28.3	33.1	29.1	22

																																				LfF,Perc4								
6.3 Hz	8.0 Hz	10 Hz	12.5 Hz	16 Hz	20 Hz	25 Hz	31.5 Hz	40 Hz	50 Hz	63 Hz	80 Hz	100 Hz	125 Hz	160 Hz	200 Hz	250 Hz	315 Hz	400 Hz	500 Hz	630 Hz	800 Hz	1.0 kHz	1.25 kHz	1.6 kHz	2.0 kHz	2.5 kHz	3.15 kHz	4.0 kHz	5.0 kHz	6.3 kHz	8.0 kHz	10.0 kHz	12.5 kHz	16.0 kHz	20.0 kHz	0.4 Hz	0.5 Hz	0.63 Hz	0.8 Hz	1.0 Hz	1.25 Hz	1.6 Hz	2.0 Hz	2.5 Hz
28.6	26.6	25.6	31.5	34	34.3	40.6	37.9	37.6	36.9	37.6	39.8	39.6	29.2	23.2	20.9	24.6	22.4	23.7	22	24.1	26	24.8	23.7	22.1	19.8	14.8	12	9.2	8.2	5.9	5.6	5.6	4.8	5.4	10.3	42.1	36.8	45.2	46.4	44.6	41.2	43.6	44.2	34.6
23.1	22.9	20.6	24.2	26.4	23.3	29.6	28.5	23.9	27.7	27.6	27.2	25.6	25.3	20.2	16.3	18	20	55.4	63.3	74.4	93.5	114.2	93.7	74.3	63.6	49.4	47.2	34.5	30.4	25.3	22.1	19.5	19.7	20.5	21.4	56.2	54.1	51	42.9	49.5	44.7	45.2	49.3	44.6
14.2	14.9	17.9	18.9	20.9	18.7	23.6	22.7	22	23.7	23.7	22.2	21.9	20.4	18.7	15.1	14.8	13	13	12.5	12	9.4	7.4	5.7	4.3	3.4	3.1	3.5	3.8	4.3	4.5	4.5	4.3	4.1	3.7	3.4	49.4	49.1	48.5	48	47.9	46.4	43.8	44.4	42.6
22	23.2	27.1	23.9	28.3	23.7	26.2	25.1	29.5	29.1	28.4	27.7	25.8	23.3	24.1	19.3	19.9	17	14.7	16.6	17	15.1	13.7	12.8	13.1	7.5	6.5	7	5.7	6.2	5.8	5.9	5.2	4.7	5	3.6	43.9	44.4	39.1	40.5	43.1	41.7	41.6	37.7	40.4
18.7	17.5	21.5	24.1	25.7	25.2	30.4	31.8	22.3	23.4	21.5	16.6	16.4	14.7	14.4	16.1	17	20.3	55.4	63.3	74.5	93.6	114.3	93.8	74.4	63.7	49.5	47.3	34.6	30.3	25.2	22.3	19.7	19.6	20.6	21.6	61.1	57.2	51.4	46.1	42	40.3	38	40.6	41.7
8.7	13.8	15.4	19.1	21.7	20.4	25.7	25.9	21.7	22.4	21.1	17.7	12.5	11.1	11.7	13.3	13.3	12.9	11.6	9.6	8.6	7.1	6	6	4.4	3.2	3	3.6	3.8	4.3	4.4	4.4	4.3	4.1	4.5	3.2	[illegible]	44.1	44	43.1	44	42.8	42.1	43.3	40.6
27.5	23.6	24.4	30.2	33.1	30	35.1	27.1	32.2	29	29.5	23.6	14.1	14.5	19.3	20.7	19.3	20.3	19.2	17.8	15.4	19.2	18	16.9	13.2	9.3	8.5	7.2	6.2	6.7	6.1	5.5	5.1	4.8	4.6	4.4	46.6	47.7	45.4	39.5	31	43.3	40.4	30	36.6
19.1	20.2	20.4	26.4	26.5	23.1	28	25.1	21.2	25.6	24.3	21.9	23.1	23.7	16.5	14.4	16.7	19.4	55.4	63.3	74.5	93.6	114.3	93.7	74.4	63.7	49.5	47.2	34.6	30.6	25.2	22.1	19.9	19.7	20.5	21.5	74.6	69.8	60.4	56	47.7	46	45.6	46.5	42.9
11.2	15.3	17.5	16.8	18.7	19.5	20.4	19.8	17.1	24.2	22.8	21.1	21.8	23.7	16.1	13.5	14.2	14	13.9	12.7	16.3	9.8	8	6.7	4.4	3.2	3.1	3.3	3.8	4.3	4.3	4.4	4.2	4.1	4.1	3.3	47.5	46.5	47.2	46.5	46	43.9	42.9	43.6	40.3
21.5	28.5	24.6	28.8	25.5	25	29.8	26	23	28.7	31.7	31.2	26.9	26	25.3	17.6	17.1	18.7	23.3	21.8	26.6	16.7	16.6	14.8	10.8	8.6	7	5.9	5.4	5.5	5.1	5.7	4.8	4.6	4.4	4.1	42.1	[illegible]	41.3	37.6	41.5	42.8	37.3	40	43.8
17.7	20.3	22.9	24.5	27.6	29.2	30.5	30.7	26.1	33.1	25.2	30	30	26.9	22	15.3	17.2	20.9	55.4	63.3	74.4	93.6	114.3	93.7	74.3	63.6	49.4	47.2	34.6	30.6	25.4	22.3	19.7	19.7	20.6	21.4	86.8	83.9	[illegible]	72.9	57	46.8	44.7	47.1	39.2
10	10.8	15.4	16.7	22.5	25.5	23.5	23.5	22.8	24	23.8	21.2	23.4	19.7	17.5	12.7	12.8	17.4	17.9	17.6	16.8	14	11.9	10.7	8.2	5	4	3.8	3.9	4.4	4.5	4.3	4.3	4.1	3.7	3.2	45	44.3	44.2	43.3	44.3	42.1	40	39.3	38.3
10	10.8	15.4	16.7	22.5	25.5	23.5	23.5	22.8	24	23.8	21.2	23.4	19.7	17.5	12.7	12.8	17.4	17.9	17.6	16.8	14	11.9	10.7	8.2	5	4	3.8	3.9	4.4	4.5	4.3	4.3	4.1	3.7	3.2	45	44.3	[illegible]	43.3	44.3	42.1	40	39.3	38.3
50.7	43	41.3	40.6	51.5	44.4	47	43.5	42.5	47.9	44.3	40.6	39.5	44.8	45.5	41	38.5	32.3	55.1	63.1	74.2	93.3	114	93.5	74.1	63.5	49.2	46.8	34.2	29.5	24.4	22	19.7	19.5	20.4	21.2	84.2	82.4	73.1	72	72.1	71.7	67.1	69.6	67.2
30	26.8	26.6	32.2	44.6	37.8	35.5	35.8	30.1	32.9	32.1	37.1	39.8	38	32.8	27.9	26.2	22.4	24.6	26.7	29.2	29.6	30.1	31.8	32.5	32.2	30.5	28.8	25.9	21.8	17	12.3	8.3	5.9	4.4	3.7	75.8	76.7	75.9	75.5	76.2	76	74.3	74.9	73.8
37	34.6	36.7	36.1	48.6	39.4	35.7	33	37.5	43.9	39.1	42.4	40.9	40.4	35.8	29.8	29.1	24.6	26.9	28.5	30.5	32.1	32.4	33.3	33.8	33.5	31.9	29.4	26	21.2	18.8	15.2	9.8	6.7	5.6	3.2	78.9	76.4	75.7	75.7	75.7	78.5	76	78.7	74.1
16.6	22.6	24.4	27.8	33.7	32.1	29.1	30.8	29.2	30.4	27.1	24.1	19.4	15	13.8	16.8	17.4	19.8	22.3	23.3	22.6	22.4	22.7	21.2	18.1	15	11	7.9	7	6.4	5.3	5	4.7	4.3	3.9	3	70.2	72.7	71.9	72.8	[illegible]	72.1	72.2	70.6	69.8
34.1	28.5	29.6	30	39.6	32.5	32.5	32.7	31	32.7	26	25.6	20.7	19.3	15.1	18.2	19.7	22.5	25.6	26.3	27.9	30.8	29.2	28	25	18.6	13.5	10.2	9	8.7	7.4	6.8	5.7	5.2	4.6	3.7	69.6	70.6	71.1	70.1	[illegible]	70.9	71.5	69.9	67.8
17.9	17.4	21.1	24.9	29.3	27	26.9	29.8	30.4	29.3	27	21.9	22.1	17.7	15.8	14.8	16.9	17.2	19.2	20.5	21.9	22.7	21.8	20.5	17.7	12.3	10	7.7	6.5	5.4	4.9	4.7	4.3	4.1	3.8	3.1	64.9	65.9	64.7	64.6	64.2	62.8	61.4	60.5	58.7
18.2	18.3	20.2	25.9	31.8	29.5	33	31.9	28	30.1	27.9	25.2	22.9	19.4	16.8	16.6	17.5	19.9	22.1	24.3	26.6	27.6	27.6	24.9	21.1	16.1	11.6	9.2	7.2	5.7	5.1	4.9	4.4	4.3	3.9	3.1	67.7	66	64.5	64.9	64.9	65	62.8	60.5	61.8
13.2	18.5	17.6	27.5	35.3	31	33.4	31.1	36.4	46.2	38.2	32	32.4	29.6	28.6	26.2	22.5	24.6	22.8	21.5	22	21.6	20.4	18.6	15.8	14.2	12.4	10.2	7.9	6.3	5.3	4.9	4.2	4.2	5.5	2.9	73	72.4	71.9	71.5	70.8	69.3	68.2	66.9	65.1
22.3	23	25.8	29.2	39.1	32.7	31.2	31.3	36.5	54.3	38.3	33.1	33.3	30.7	31.7	28.1	23.8	23.8	23.1	22.9	22.9	21.1	20.7	19.6	16.8	14.9	13.3	11.1	8.8	6.8	6	5	4.4	4.2	4.9	3.1	70	71.3	69.8	70.8	68.3	67.1	65.7	67.7	62.8
21.1	21.1	21.3	24	37.5	29.2	30	27	28.7	36.3	30	27.6	26.6	22	19.3	16.8	14.7	17.1	20.1	20.3	22	21.6	20.3	18.6	15.9	13	11.8	9.5	8.3	7.7	7.1	6.3	5.2	4.7	6.3	3.4	74.5	74.7	75.2	75.5	74.8	74.3	73.2	72.2	71
35.1	34.8	38.7	32.9	43.7	35.3	38.5	46.2	37.6	51.8	35	34.7	34.7	25.9	22.8	21.7	21.2	21.2	22.8	22.4	23.9	24.7	23.4	21.6	18.8	17.2	17.1	17.1	16.4	15.6	14.2	12.6	10	7.7	6.6	4	70	63.3	68.6	62.4	60	64.4	70	70.8	65.2
28.1	27.1	25.6	29.7	43.1	37	31.6	32.6	32.3	32	32.3	30.8	29.9	26.6	24.3	21.9	19.5	20.3	23.8	27	29.5	31.4	31.1	27.7	25.5	22.7	20	18.8	17.6	14.7	11.9	8.7	6.1	4.7	4.1	3	74.8	76.4	75.9	76.9	76.4	75.6	75.2	74.9	74.2
23.6	27.4	31.2	29.3	48.9	37	32.8	34.5	33.2	38.3	33.4	36.7	37	29.1	27.4	23.8	22.5	22.2	25.8	27.3	30.5	34.3	29.8	27.7	26.2	24.6	23.3	23.1	22.2	18.2	15.9	12.3	7.5	5.3	4	3	66.8	71.4	74.5	73.2	75.8	77.7	74.1	71.3	70.7
19.3	17.6	22.3	25.2	36.8	29.8	28.7	30	33	47.7	35.7	32.2	33	30.4	27.7	26.4	24.2	22	21.8	21	21.1	20.6	20.2	18.3	15.8	13.4	12.2	9.7	7.5	6.2	5.5	4.8	4.3	4	4.3	3	71.4	70.9	71.4	71	69.4	68.3	68	65.3	64.1
30.5	27	30.4	28.2	40.7	32.5	30.2	32.1	35	50.9	36.8	34.7	33.7	34.5	31.6	26.8	27	25.6	29.3	29	31.3	29.8	29.7	28.5	23.5	23.3	27.4	22.4	20.5	20	14.8	11	7.1	4.7	4.4	3.1	73.2	81	73.8	69.4	70.7	68.1	66.6	64.9	64.4
37.8	41.9	43.4	43.5	50.2	44.7	41	43.4	43.3	50.7	47.5	40	42.7	42.7	39.6	35.4	30.9	28	54.7	62.6	73.7	92.8	113.5	93	73.6	62.9	48.7	45.7	33.7	29	24.3	22.2	19.2	19.5	20.2	21.3	83.7	76.6	71.3	68.6	68.1	68.6	71.3	74.2	72.2
38.2	35.9	38.5	38.1	41.4	37.6	39	39.7	39.3	51.7	40.3	35.4	38.9	38.6	35.8	34.1	32.3	26.6	55.1	63.1	74.2	93.3	114	93.5	74.1	63.4	49.2	46.2	34.1	29.3	24.6	22.6	19.8	20	20.8	21.7	85	84.1	81.2	77.3	65.9	68.3	63.7	62.8	61.5
14.9	16.8	15.3	13.7	17	17.5	24	21.1	25.6	40.2	28.7	25.5	32	28.8	27.1	28.5	26	23.2	47.7	55.6	66.7	85.8	106.5	86	73.6	75.7	57.8	65.9	56.7	47.9	40.8	29.3	23.7	21.7	22.3	23	95	92.6	80.8	80.6	77	68.4	62.6	54.2	45.4
32.4	37.2	37.3	33.3	34.2	33.3	36	35.1	36	51.9	38.5	33.2	37.3	35	33.6	32	29.3	24.1	55.1	63	74.1	93.2	114	93.5	74	63.3	49.1	46.5	34.2	29.3	24.7	22.4	19.7	19.8	20.7	21.7	71.2	69.9	73.2	71	75.8	75.8	70.2	72.1	67.6
15.3	15.7	17.5	20.9	28	24.1	29.7	31.4	33.9	47.3	36.2	31.3	33.4	30.7	26.3	24.8	23.1	23.5	23.4	21.8	20.5	20.2	19.6	18.9	16.8	14.2	12.2	8.9	6.6	5.6	5	5	4.8	4.7	3.9	3.7	60.5	58.8	59.8	57.4	55.1	54.1	54.7	51.7	49.8
24.8	27.3	20.3	29.4	31.2	32	34.1	38.2	37.7	48.4	38.9	35.9	35.4	32.8	29.7	27.9	25.6	26.5	26.2	24.7	24.5	24.1	23.7	23.4	21.5	20.4	17.4	16.4	13.3	9.5	7.5	6.3	5	5.6	4	3.7	66.5	66.1	70.5	64.9	69.2	65.6	61	61	57.3
13.5	13.8	17	20.1	17.9	22.9	24.5	25.2	28.1	32.9	28.6	28.1	27.9	21.1	17.1	13.3	10.8	11.8	16.7	17.9	19	19.8	18	15.8	13.5	10.9	9.1	6.3	5.1	5.4	5.2	5.3	5.7	4.8	4	4.4	44.4	43.8	43.1	42.3	42.5	41	40.6	39.8	38.8
22.8	23.4	26.6	25.2	29.3	28.9	34.2	32.9	31.9	41.6	30.6	31.3	29.2	26.2	20.6	17.6	16.1	18.2	25.5	28.5	26.2	28	25.5	21.4	17.4	13.6	9.9	6.4	5.7	5.6	5.5	5.7	6.5	5.3	4.2	5.3	46.7	44.1	39.5	43.1	40.3	35.3	31.1	37.9	38.3
13.7	15.3	17.8	23.3	27.5	26.2	29.3	29.6	35.2	48.6	36.3	33.2	32.2	31	32.3	26.9	22.3	22.9	22.7	20.6	19.7	19	18.2	17.4	15.8	13.6	11.7	9	6.6	5.7	4.7	4.7	5.6	4.9	3.8	4.9	48	47	45.4	44	43.3	40.7	40.2	39.7	39.2
16.2	14.8	18	22.4	30.4	27.4	32.7	33.1	35.8	50.8	37.2	33.5	33.9	31.3	32.7	28	23.5	23.9	23.7	22.3	21.5	19.9	19.4	18.8	17.3	15.4	13.2	10.6	7.4	6.2	5.3	5	5.5	5	4	4	51.8	52.7	50.2	49.3	43.7	41.5	41.8	40.8	40.1
14.4	16.5	17.6	20.7	22.6	25.5	24.6	26	27.2	29.4	28.8	26.6	25.5	22	19.6	15.5	10.4	10.1	13.8	16	17.6	21.1	19.4	18	13.4	9.8	8.8	7.4	6.1	6	5.5	5.2	5.7	4.7	3.9	4	57.9	57.3	58	57.6	57	55.9	55.5	53.8	52.2
17.8	15.9	18.3	23.5	24.5	23.6	28.1	29	29	29.9	28.2	26.8	26.2	21.7	20.5	15.8	10.5	10.9	13.2	15	15.5	16.5	16.5	14.7	12.5	10.6	9.1	7.8	7.4	6.6	5.8	5.5	6.4	4.9	4.1	3.7	48.7	49.8	50.6	53	49.6	48.8	49	45.5	44.2
28.5	25.4	35.1	30.7	31.4	30.1	31	31.2	31.5	38.4	35	30.2	33	33.6	31.3	29.8	23	22.8	55	63	74.1	93.2	113.9	93.4	74	63.2	49	46.3	34.1	29.6	24.8	22.6	19.7	19.7	20.7	21.6	100.8	100.7	97.8	92.2	85.4	83.8	76.8	71.9	58.6

RECEIVED: 11/04/2023

3.15 Hz	4.0 Hz	5.0 Hz	6.3 Hz	8.0 Hz	10 Hz	12.5 Hz	16 Hz	20 Hz	25 Hz	31.5 Hz	40 Hz	50 Hz	63 Hz	80 Hz	100 Hz	125 Hz	160 Hz	200 Hz	250 Hz	315 Hz	400 Hz	500 Hz	630 Hz	800 Hz	1.0 kHz	1.25 kHz	1.6 kHz	2.0 kHz	2.5 kHz	3.15 kHz	4.0 kHz	5.0 kH	6.3 kH	8.0 kH	10.0 kH	12.5 kH	16.0 kH	20.0 kH	LfF,Perc 0.4 Hz	0.5 H	0.63 H	0.8 H	1.0 H
36	39.8	38	44.4	42	42.7	44.5	43.6	42.6	52	45.8	45.3	44.3	44.3	45.8	48.1	36.6	27	26.4	28.4	28.6	27.6	28.4	29.6	30.8	29.4	30.2	33.6	31	27.	28.6	25.	22.9	22.6	20.2	17.	15.	12.	15.	32.	19.	35.	40.	39.
43.3	42.7	40.3	42.5	41.3	38.5	38.2	39.9	35.2	39	37.9	33.8	36.3	38.3	36	31	32.4	26.9	22.5	22.4	24.4	55.6	63.4	74.6	93.6	114.4	93.8	74.4	63.8	49.6	47.4	34.8	30.8	25.8	22.8	20.	20.	21.	22.	34.	40.	34.	27.	35.
39.7	38.1	37.8	38.3	38.6	38.6	37.8	40.3	34.9	38.8	38.5	36.7	37.9	39.9	36.7	32.6	33.7	28.9	25	24.7	24.4	28.8	26.7	27.6	26.3	26.7	24.5	21.	17.3	14.	1	10.5	10	10	10	10	1	1	1	31.	30.	31.	30.	33.
40.9	34.5	39.3	37.3	36.4	37.1	39.3	40.1	34.7	37.3	35.4	38	35.7	37.8	33.8	31.3	28.1	29.3	25.1	24.7	23.6	23.8	24.7	25.4	26.5	26.9	27.3	28.4	27.3	26.9	26.9	24.7	22.3	21.9	20.5	18.5	[illegible]	13.	1	34.	36.	30.	23.	28.
37.8	34.8	36.4	36.7	38.6	36.1	37.3	41.1	38.1	40	41.2	35.7	35.9	30.8	28.9	25	22.7	21.7	21.6	21.8	24.1	55.6	63.4	74.6	93.8	114.4	93.8	74.5	63.8	49.6	47.4	34.8	30.7	25.7	22.8	20.4	[illegible]	21.	22.	43.	38.	32.	24.	30.
37.1	35.6	35.6	36.1	35.9	36.8	37.6	41.7	39.7	40.6	41.5	40.8	37.3	35.9	32.3	25.7	23.3	24.2	25.3	27.9	27.6	28.8	29.6	29.2	32.7	33.9	32.4	30.	24.9	21.	19.	17.7	16	14.5	13.4	11.4	1	14.	1	28.	2	29.	28.	30.
35.4	36.6	37.8	31.8	33.5	35.6	35.6	38.4	34.8	39.8	36	37.2	32.6	35.2	29.3	18.6	20.6	22.9	24	22.6	23.1	22.9	23.4	23.2	24.4	24.8	25.2	23	19.4	18.	16.8	14.6	14.6	13.6	12.4	1	1	1	1	38.	39.	38.	32.	1
43.2	39.4	37.4	38.8	37.5	36.7	37.7	38.5	34.1	37.4	36.2	34.6	35.7	37.4	33.6	28.8	27.9	22.2	20	20.8	23.8	55.6	63.4	74.6	93.8	114.4	93.9	74.6	63.8	49.6	47.4	34.8	30.9	25.8	22.7	20.6	20.	21.	22.	53.	44.	37.	27.	37.
37.9	36.8	36.8	36.9	36.8	36.5	37.6	38.7	34.8	37.3	34.7	34.7	37.2	38.4	35.9	32	33.6	26.7	22.6	22.3	24.6	26.4	26.5	31.6	21	20.4	19.8	16.5	12.	10.5	10	10	10	10	10	10	1	11.	1	29.	29.	30.	30.	30.9
37	35.4	37	34.8	38	37.3	37.7	37.8	33.4	39.2	33.8	31.6	35.8	37.7	34.4	31.8	30.8	29.2	23	22	22.8	31.2	26.2	29.4	25.4	25.6	25.6	27	28.8	26.	23.6	22.4	21.8	19.4	18.	15.8	1	10.	1	31.	32.	3	2	32.
37.4	37.9	38.5	41.7	40.8	41.2	38.9	40.5	40.9	39.3	39.6	35.8	42	34.6	36	35.4	31.9	27.6	21.9	22.6	25.3	55.6	63.4	74.6	93.8	114.4	93.8	74.5	63.8	49.6	47.4	34.8	30.9	25.8	22.7	20.5	20.	21.	2	66.	55.	48.	40.	30.
35.6	35.3	35.1	34.8	36	37.9	38.1	39.7	40.7	38.6	39.3	39.1	41.4	38.7	37.3	34.8	31.7	27.7	21.8	22.6	27.4	33.1	26.3	25.5	24.4	24.7	23	20.8	18.	16.9	15.	13.	11.7	10.5	10	10	1	1	1	27.	27.	2	28.	3
35.6	35.3	35.1	34.8	36	37.9	38.1	39.7	40.7	38.6	39.3	39.1	41.4	38.7	37.3	34.8	31.7	27.7	21.8	22.6	27.4	33.1	26.3	25.5	24.4	24.7	23	20.8	18.	16.9	15.	13.	11.7	10.5	10	10	1	1	1	27.	27.	2	28.	3
69.4	70.2	72.6	71.2	68.8	69	64.9	64.2	60.2	60	59.2	57.7	64.2	58	53.8	52.8	53.2	51.6	50	51.6	49.6	55.6	63.3	74.4	93.4	114.2	93.6	74.	63.6	49.4	47	34.4	29.8	24.8	22.6	20.	20.	20.	21.	5	60.	57.	5	61.
72.1	70.9	68.5	67	65.1	62.9	60.7	61.8	56.9	56.5	60.6	55.5	57.1	56.8	54	53.7	52.6	49.4	48	44.9	38.3	41.8	46.1	49.9	53.2	55.1	53.5	51.4	48.	44.	40.7	36.4	32.	28.8	23.5	17.	11.	10.	1	54.	[illegible]	56.	56.	57.
72.2	72.5	71.4	68.8	67.7	65.5	64	62	58.1	56.2	54.4	53.4	56.1	58.6	53.2	50.7	52.2	46.8	49.4	49.2	36.6	39.1	41.8	46.1	51.2	53.6	51.8	49.6	47	43	38.9	34.9	31.6	28.8	26	22.4	2	17.	12.	57.	[illegible]	61.	62.	61.
68.5	67.4	65.5	63.4	61.6	59.4	58	57.9	55.4	54.6	53.8	55	57.9	60.4	56	52.4	49.6	44	42.4	42.9	45.2	48	51.5	55.5	58.6	58.1	55.2	51.9	47.8	44	40.6	36.4	31.9	27.6	23.	18.7	14.	11.	1	46.	47.	48.	49.	49.
66.5	66.4	63.5	61.7	59.4	57.2	53.9	53.9	50	49.4	48.1	48.3	52.7	48.1	45.2	43.3	39.1	36	34.8	35.4	36.7	40.3	44.5	44.6	48.3	49.4	47.9	43.9	40.3	36	33.3	31.5	28.	28.6	28.8	28.2	26.	25.	22.	54.	50.	[illegible]	5	54.
57.1	55.2	52.5	48.9	46.3	44.4	46.7	49.6	46.2	47.8	48.6	50	51	50.2	45.2	43.4	39.8	35.4	32.5	30.9	32.4	34.7	36.1	37	39.5	39.7	37.1	33.5	28.5	24.4	21.	17.6	14	12.8	10.5	10	1	1	1	43.	4	[illegible]	41.	40.
58	54.2	52.3	49.6	46.3	44.1	44.4	48.3	45.2	46	52.8	52.6	48.8	46.7	42	39	36.4	30.9	29.3	28.7	30.5	34	39	38.9	39.9	38.9	35.7	31.9	26.6	23.	25	24.3	17.6	13.4	13.8	10	1	1	1	45.	44.	43.	42.	41.
63.3	60.8	58.8	56.4	54	51.8	50	52.4	50	54	57.6	55.1	60.9	55	49.3	49	46.3	45	43.8	43	42.4	41.6	42.4	42.8	43.9	44.4	43.2	41.9	39.5	36.8	32.6	28.9	24.7	21.3	18.7	14.9	11.	10.	1	45.	45.	45.	43.	43.
63.9	61.8	59.4	56.4	55.2	52.9	51.3	51.9	45.2	46.5	43.6	43.9	57.1	42.8	40.7	41.3	37.4	38.3	32.8	29.5	30	29.2	31.3	32.5	30.1	27.7	25	23.	22.8	21.4	20.	18.	16	14.8	13.5	10.4	1	11.	1	49.	52.	53.	4	50.
69.3	67.9	66.5	64.4	62.1	59.7	56.9	55.6	51.6	49.3	48.6	48.1	51.8	45.6	41.2	39.2	35.5	31.7	28.5	27	27.7	29.6	32	33.9	33.3	31.7	30.1	28.6	26	24.6	23	21.8	20.4	18.6	16.6	14	12.	13.	1	50.	5	51.	50.	49.
63.8	60	56.4	55.2	55.8	52.6	48	52.5	48	46.4	51.3	43.4	53.4	39.4	39.6	38.2	30.7	28.2	25.4	24.1	24.6	27.2	27.8	28.8	29.4	28.3	28.4	25.	24.4	23.4	26	27	20.	29.4	32	14.6	12.	10.	1	6	55.	55.	5	49.
73.1	72	69.6	67.9	66.3	63.8	62.1	62.4	59.1	57.2	55	56.6	59.7	58.5	55.4	53	51.7	49.2	47.9	43.8	37.5	40.7	45.8	50.2	53.5	55.9	55.1	52.3	48.9	45	39.9	35.8	31.5	27.8	23.2	17.9	12.	1	1	5	55.	56.	56.	56.
68.2	70.6	69	64.5	63.1	60.4	60.1	59.7	54.3	53.1	55.5	56.9	59.6	71.3	57.6	55.9	53.4	51	48.3	43.3	36.7	43.1	44.9	49.4	53.4	54.4	53.5	50.5	47.5	43.	39.4	36.	33.3	30.7	28.8	26.8	25.	24.	21.	52.	49.	56.	57.	56.
61.1	59.7	56.7	54.1	52.7	50.2	48.5	52.2	48.8	53.6	48	48.9	56.2	47.5	44.8	45.2	45.6	43.8	38.7	36.6	35.6	39.8	39.1	42.7	41.4	39.3	37.8	34.4	32.6	32.5	28.4	26	23.	19.3	15.9	11.6	1	1	1	49.	49.	48.	49.	46.
62.7	59.2	57.2	54.2	52.7	49.2	47.9	51.5	44.2	44.3	42.7	42.6	54.8	42.8	41.8	42.2	44.1	40.4	33.1	33.7	32.5	39.4	39.9	45.9	44.6	36.6	33.5	28.	27.4	32	26.	24	23.4	19.	16.4	15.4	13.	1	1	59.	62.	56.	5	5
69	71	65	63.4	58.6	58.6	60.4	64.6	62	64.6	64.7	61.9	66.2	67.7	63	54.8	55.3	52.7	52.6	49.2	48.2	56	63	73.8	93	113.6	93.2	73.8	63	48.8	45.9	34	29.5	26.7	23	20.	20.	21.	21.	69.	65.	60.	5	52.
63.1	59.4	61.3	58	56	55.1	52.9	53.6	52.2	51.2	52.5	51.4	58	53.6	53.2	49.8	46.5	44	43.2	40.8	39.6	55.4	63.2	74.4	93.4	114.2	93.6	74.	63.6	49.4	46.4	34.	29.8	26.	23.	21.	20.	21.	22.	64.	6	59.	53.	37.
49.6	39.5	35.7	30.4	31	30.9	31.2	37.9	32.8	42.1	38.4	39.1	52.8	43.1	39.1	41	40.2	37.6	34.7	33.9	28.1	54.3	62.2	73.3	92.5	113.2	92.7	79.4	100.	80.5	88.5	82.7	78.	74.9	70.5	66.9	62.	56.	50.	78.	68.	69.	63.	57.
60	64.6	58.4	58.8	57	53.7	54.5	49.4	48.3	49.6	47.7	45.2	56.4	50.4	47	45.1	41.8	40	37	36.8	38	55.3	63.2	74.2	93.4	114.1	93.6	74.	63.4	49.	46.8	34.4	29.8	25.	23	20.5	20.	21.	22.	5	52.	61.	56.	45.
46.8	45.3	43.3	41	40.4	41.4	44	46.8	44.9	47.7	49.4	51.6	56.5	50.3	48.6	47.5	45.8	42.9	42.5	42	40.5	40.6	41.5	42.1	42.7	43.3	41.6	39.8	37.	33.6	31.	28.8	24.5	19.7	16.5	1	1	1	1	32.	31.	31.	32.	32.
55.3	54.1	51.8	47.3	48.5	45.1	45.1	46.6	45.7	48.6	52.5	52.7	59.1	54.4	48.2	47.4	46.2	45.5	46.3	45.8	43.1	44.1	43.5	42.7	42.9	41.8	40.1	38.4	36.7	36.9	36.8	33.9	27.7	24.7	21.5	18.7	16.	12.	1	52.	51.	53.	48.	42.9
37.6	38.4	36.8	36.5	36.8	38.2	40.3	42.2	41.6	42.2	42.5	44.3	49.1	43.4	39.9	37.8	34.3	30.6	26.8	23.3	23.7	26.8	30.3	31.4	32.8	31.4	30	28.7	26.4	24.	22.	20.8	17.8	18.	20.	10.8	1	1	1	28.	27.	2	26.	28.
41.1	38.6	34.5	34.8	36.3	37.7	36.3	40.1	39.9	42	41.2	39.1	46.2	39.3	37.7	35.5	31.1	25.9	21.5	19.2	22.5	31	33.6	29.8	31.9	28	25.3	22.7	20.	18.	19.5	19.9	16.7	13.9	12.7	11.5	1	1	1	37.	35.	3	31.	27.
38.6	38.7	37.2	36.6	37.6	40.1	43.4	47.2	47.6	56.7	54.5	52.6	58.9	51	49.6	48.8	44.2	42.6	41.1	41.4	39.4	37.9	38.9	39.2	40.1	41.5	40.2	37.	34.9	31.	26.6	22.4	19.6	15.6	11.7	10	1	1	1	26.	2	27.	27.	28.
39.2	39.1	36.5	37.4	37.8	40.4	43.2	48.1	48	49.5	47.7	48.9	58.5	52.3	49.2	48.7	46.7	43.4	43.9	43.7	41.3	42.3	42.8	44.4	45.9	47.8	45.1	41.	37.9	34	30.4	25.7	23.6	21.	17.	14.	10.	1	1	30.	27.	28.	29.	3
49.9	47.4	46	43.5	42	41.8	43.6	47.5	48.4	48.5	50.3	52.1	55.4	52.6	51.1	50	48.3	47.4	45.6	41.9	33.6	35.6	40.1	45.2	50.7	53.8	53.7	51.5	47.5	43.5	39	34.4	29.3	25.	20.	14.8	1	1	1	36.	35.	36.	35.	36.
44.4	41.3	37.5	36.6	37.5	38.5	38.5	41.2	41.3	41.1	42	44.9	52.4	42.8	38.2	36.3	29.9	28.1	25.4	21.9	22.1	27.5	32.2	35.7	42.3	44.6	43.6	38.8	36.	33.4	29.	26	24.5	22.5	22.6	21	19.	17.	13.	35.	3	32.	3	32.
55.2	54.5	51.2	49.2	47.3	47.7	45.8	47.4	49	48	49.5	49.1	51.4	55.7	50	51.6	53.7	53.4	55	50.6	44.7	55.3	63.2	74.2	93.4	114	93.6	74.	63.4	49.	46.0	34.	30	25.3	23.	20.5	20.	21.	22.	74.	6	6	56.	4

1.25 Hz	1.6 Hz	2.0 Hz	2.5 Hz	3.15 Hz	4.0 Hz	5.0 Hz	6.3 Hz	8.0 Hz	10 Hz	12.5 Hz	16 Hz	20 Hz	25 Hz	31.5 Hz	40 Hz	50 Hz	63 Hz	80 Hz	100 Hz	125 Hz	160 Hz	200 Hz	250 Hz	315 Hz	400 Hz	500 Hz	630 Hz	800 Hz	1.0 kHz	1.25 kHz	1.6 kHz	2.0 kHz	2.5 kHz	3.15 kHz	4.0 kHz	5.0 kHz	6.3 kHz	8.0 kHz	10.0 kHz	12.5 kHz	16.0 kHz	20.0 kHz
36.6	31.2	33.8	29.2	32.7	27.6	31.2	30.6	29.6	31.6	34.3	35.7	36.4	42.4	39.6	40.2	39.7	39.7	41.4	40.7	31.6	24.2	22.5	25.6	24.5	24.6	23.3	25.6	26.6	25.9	24.6	23.8	20.5	16	13	11	10	10	9.9	9.9	9.9	9.8	10.9
33.1	32	33.2	29	27	29.6	28.3	30.1	30.2	28.9	29	31.3	28.4	33.1	31.8	28	30.8	31.4	31.2	27.3	27.8	22.6	18.9	19.6	21.7	55.3	63.2	74.4	93.4	114.2	93.6	74.2	63.6	49.4	47.2	34.4	30.5	25.4	22.4	19.8	19.9	20.8	21.6
31.4	29.1	31.1	29.5	26.7	25.8	26.2	27.2	28.2	28.4	28.7	30.6	27.6	31.4	31.2	28.9	30.1	31.2	29.8	27.5	25.3	23.6	19.7	19.1	17.6	17.7	18.2	16.2	13.7	13.8	12.4	9.9	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8
31.3	36.7	33.1	27.1	26.5	21.7	28.3	24.9	26.9	30.3	29.3	29.8	27.3	28.9	29.7	31.7	31.1	33.1	30	27.8	25.2	25.2	22.1	21	17.4	16.9	18.6	18.6	18	16.2	16.1	16.1	11.1	10	10.7	9.9	9.9	9.9	9.9	9.9	9.8	9.8	9.8
27.5	28.9	26.5	29.2	24.6	20.5	25.7	25.3	25.7	27.2	30.1	32.5	30.6	33.6	35.4	28.7	27.7	23.8	22.9	19.6	17.4	17.1	18.1	19.1	21.5	55.4	63.2	74.4	93.5	114.2	93.6	74.2	63.6	49.4	47.2	34.5	30.4	25.4	22.5	19.9	19.9	20.8	21.8
29.2	28.2	29.9	27.3	24.3	23.2	23.7	24.6	25.3	27.1	28.4	32.2	30.4	33.6	34.9	29.4	28.8	26.4	23.1	17.8	15.7	17.2	18.1	17.2	17.1	15.9	14.6	12.1	11.9	10.3	10.6	9.9	9.9	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8
39.2	36.6	26.4	34.8	32.5	23.4	27.4	28.8	24.6	25.8	30.6	33.8	31.6	35.8	29.4	33.4	29.3	31.2	25.8	15.8	16.2	21	22.8	20.4	21	19.8	18.6	16.4	20	18.6	17.6	13.8	10.2	10.8	9.9	9.9	9.8	9.8	9.8	9.8	9.8	9.8	9.8
25.1	32.3	30.2	28.6	28.4	28	25.9	27.7	27.1	26.6	30	30.3	27.4	31.2	29.9	26	28.5	27.3	26.3	25	25.3	18.5	16.5	17.9	21.4	55.4	63.2	74.4	93.6	114.2	93.6	74.2	63.6	49.4	47.2	34.6	30.6	25.5	22.3	20.2	19.9	20.8	21.7
29.1	29	29.3	27.1	24.9	24.7	25.2	26.1	26.7	27	27.6	29.2	27.3	30	27.6	25.9	30	29.6	29.5	27.3	28.6	21.1	17.8	18.3	18.7	19.9	19.5	23.3	14.4	13	10.3	9.9	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8
31.5	24	27	23.8	18.5	22.8	23.9	26.4	31.4	28.4	31.2	29.4	27.9	31.7	27.6	25.6	30.3	34.1	32.1	28.2	27.4	26.6	19.4	18.8	19.4	26	22.4	27.4	17.3	18	15.6	11.9	9.9	9.9	9.9	9.9	9.9	9.9	[illegible]	9.8	9.8	9.8	9.8
30.1	31	27.9	29.9	26.5	24.7	23.9	25.3	26.2	29.4	29.7	31	33.2	33.4	34.7	29.7	36.7	28.9	32.7	32.6	29.1	24.2	17.6	18.7	22.6	55.4	63.2	74.4	93.5	114.2	93.6	74.2	63.6	49.4	47.2	34.6	30.6	25.4	22.4	20	19.9	20.8	21.6
27.8	26.9	25.7	25.8	22.1	23	23.4	23.9	25.9	28.2	28.9	30.7	33.1	31.6	31.3	30	31.1	29.8	28.7	29.8	25.5	21.8	17.3	16	21.1	22	22	20.1	17.9	16.3	13.7	11.2	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8
27.8	26.9	25.7	25.8	22.1	23	23.4	23.9	25.9	28.2	28.9	30.7	33.1	31.6	31.3	30	31.1	29.8	28.7	29.8	25.5	21.8	17.3	16	21.1	22	22	20.1	17.9	16.3	13.7	11.2	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8
65.3	59.4	57.2	58.4	53.4	55.6	57.4	54.4	49.4	46.7	49.6	54.9	49.4	49.7	47.5	45.9	51.2	47	42.9	43.8	46.2	47	43	40.1	33.8	55.1	63	74.1	93.2	114	93.4	74	63.4	49.2	46.8	34.2	29.6	24.5	22.2	19.8	19.6	20.5	21.4
57.6	55.6	54.8	54	51.4	49.7	47.7	46	43.9	42.6	42.3	54.6	45.4	43.7	44.8	42	41.7	40.3	45.2	45.2	42.8	37.8	33.1	30.7	28.3	31.2	34.2	36.1	38.4	38.7	38.3	38.4	36.4	33.9	32	29	24.6	21	16.1	10.6	9.8	9.8	9.8
61.3	58.3	58.8	56.2	57	52.3	51.3	48.9	47.9	46.4	43.4	54.5	45.5	43.4	42.8	43.4	48.5	45.6	46	45.3	42.8	38.6	33.5	31.4	27.5	30.3	32.8	34.2	36	36.3	36.2	36.1	35.5	33.6	31.2	27.7	22.5	20.3	16.7	10.7	9.8	10.3	9.8
48.9	46.3	46.7	44.2	42.8	41.3	39.3	38	37.3	37.7	38.5	46.8	40.6	39.9	39.2	38.8	39.5	36.8	32.1	28.4	23.4	21.9	23.2	24.7	26.6	28.3	29.7	30.3	32.1	32.1	30	26.1	20.9	17.1	14.3	12.6	11.1	10	9.9	9.8	9.8	9.8	9.8
54.1	55.1	53.7	51.1	49.1	47.3	44.9	43.6	40.1	37.7	39	46.4	38.5	38.3	37.3	36.4	37	33.3	30.8	27.9	22.8	19.6	21.7	22.4	25.4	28.1	29.7	31	33.1	33.3	30.4	26.9	20.5	15.7	12.4	10.8	9.9	9.9	9.9	9.8	9.8	9.8	9.8
38	36.9	35.9	33.4	32.1	30.8	30	29.5	29.4	31.7	35	39.6	35.6	37.6	38.5	40.5	36.8	33.8	31.6	27.9	23.6	20.2	20.2	21.5	22.8	24.7	26.3	28	29.2	28.6	26.1	22.4	17.6	14.5	11.5	9.9	9.8	9.8	9.8	9.8	9.8	9.8	9.8
39.6	38.7	36.1	34.7	34	31.2	30.7	29.9	30	31.7	33.9	38.9	35.7	38.2	38.8	36.7	36.1	34	30.7	27.8	24.2	21.2	20.7	21.8	23.5	26	28.3	30.9	32.7	31.9	29	24.6	19.6	15.4	12	9.9	9.8	9.8	9.8	9.8	9.8	9.8	9.8
41.9	39.5	38.2	36.5	34.8	33.8	32.4	32	32.1	33.8	36.1	44.2	38.4	41.2	38.9	41.3	56	41.3	38	38.2	34.6	34.4	29.8	26.9	28.2	26.3	26.3	26.5	26.3	25.3	23.2	20	17.5	15.8	14.6	12.5	10	9.9	9.8	9.8	9.8	9.8	9.8
47.4	47.4	41.2	44.7	41	39.7	36.6	36	33.4	34.1	36.3	45.1	37.6	38.6	36.6	38.6	55.5	39.8	36.2	37.1	33.7	34.8	29.8	26.4	26.5	25.6	25.8	25.3	24.7	23	21.1	18.5	16.5	14.9	12.4	10	9.8	9.8	9.8	9.8	9.8	9.8	9.8
49.4	46.8	44.6	43.1	40.8	39.3	38	36.2	35.1	35.9	36.9	46.2	38.7	38.1	35.7	35.1	47	34.9	33	32.1	26.4	23.7	20.9	19.8	21.5	23.6	24.9	25.6	25.6	24.4	22.5	19.4	16.6	14.6	12.4	11.2	10.2	9.9	9.9	9.8	9.8	9.9	9.8
54.2	58.3	55.2	56	50.4	48.1	43	45.4	43.2	40.6	38.6	44.6	36.8	39.6	48.7	38.6	52.2	36.4	37	35.3	28.1	24.9	22.5	21.8	21.8	23.8	23.4	24.9	25.3	23.8	22.2	19.2	17.8	17.5	17.4	16.8	16	14.5	12.7	10.3	9.8	9.8	9.8
56.2	55.6	55.5	53.6	52.2	50.5	48.2	45.7	44.1	42.8	43	53.2	44.7	43	42.3	41.6	43.4	41.5	40.2	37.4	33.8	31.1	28.9	25.9	26	29.9	32.8	35	38.2	38.4	35.4	33.2	30.1	26.9	24.7	22.7	19.3	15.9	12.1	9.9	9.8	9.8	9.8
54.5	53.9	51	48.1	46.3	42.6	40.3	39	37.9	37.6	37.7	52.2	41.3	40	39.2	38	41.4	39.2	41.2	40	33	30.5	28.6	26.1	24.5	28.7	30.4	33.1	37.1	32.5	31.4	29.8	27.3	25.1	24.7	23.2	20.2	17.3	13.6	9.9	9.8	9.8	9.8
44.6	42.6	40.2	38.5	36.5	34.7	33.5	32.7	31.2	33	35	45.3	38	38.5	37.2	38.5	52.8	39.4	36.9	37.9	34.6	34.8	30.5	27.6	25.8	26.1	26	26.2	25.8	24.8	22.5	20.1	18.5	17.1	13.8	11.4	9.9	9.9	9.9	9.8	9.8	9.8	9.8
55.3	50.9	48	45.1	45.9	41.6	41.3	39.2	37	36	35.9	45.9	36.3	36	36	37.9	52.6	38.8	37.4	37.7	37.6	34.5	29.9	29.4	28.2	32.1	32.4	35.2	34.9	32.3	30.1	25	24.4	28.7	23.4	21.4	20.9	15.9	12.3	9.8	9.8	9.8	9.8
52.8	53.5	55.6	53.6	55.6	52.1	50.8	44.2	49.2	48.6	48.1	52.4	48.8	47.9	46.4	46.6	55.2	50.9	43.2	45.3	45.5	41.4	38	34.4	30.4	54.6	62.6	73.6	92.8	113.4	93	73.6	62.8	48.6	45.6	33.6	29.1	24.6	22.4	19.5	19.7	20.5	21.5
48.9	48.4	49.1	45.9	46.8	46.6	47	46.1	44.2	46.9	41.6	44.9	40.8	43.2	41.6	42.2	54.4	42.1	39.3	41.6	40.9	37.5	36.4	34	28.5	55	63	74.1	93.2	114	93.4	74	63.3	49	46.2	34	29.5	24.8	22.7	20	20.2	21	21.8
47.9	31.9	27.2	27.7	27.2	22.4	22.8	20.5	20.5	19.5	19	23.5	22.6	26.9	25	28.7	42.3	31	28.5	34.4	31.9	30.7	30.2	28	25	49	56.9	68	87.2	107.8	87.4	73.8	84.2	67.2	77	70	63.2	57	49	41.8	32.2	25.2	24
51.2	48.8	51.6	48	45.4	40.4	39.6	39.2	39.8	41.4	37.6	39.4	38.5	40.3	37.6	38.3	53.6	41.4	36.6	40.2	38	35.7	33.6	30.9	26	55	63	74	93.2	113.8	93.4	74	63.2	49	46.5	34.1	29.5	24.8	22.6	20	20.1	21	21.8
30.2	30.2	29	27.5	27.8	26.7	27.1	26.8	27.7	29.7	33.7	37.7	34.7	37.6	38	39.4	53.2	40	37.1	38.1	34.8	30.6	28.5	26.7	26.6	25.8	24.7	23.3	22.8	22.3	21.5	18.9	16.1	14.3	11.6	9.9	9.9	9.8	9.8	9.8	9.8	9.8	9.8
36.3	43	39.9	34.3	36.3	32.2	32.8	31	30.8	32	34.3	37.9	36.4	39.3	43.4	41.1	53	41.3	39.2	38.5	35.4	32.3	30.6	28.5	29.1	28.5	28.3	26.7	25.6	26	25.4	23.8	22.1	19.3	17.7	14.6	10.6	9.8	9.8	9.8	9.8	9.8	9.8
26.9	27.3	26.6	25.4	25.5	26.2	25.1	25.3	26.3	28.2	30.3	32.4	32.2	33.4	33.9	34.1	42.2	34.3	33.2	31.9	26.6	21.5	16.7	14.9	16.5	20.8	23	23.5	23.1	21.7	20	16.9	13.9	11.9	9.9	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8
23.5	18.6	32.9	24.3	27.7	29.3	20.1	26.1	27.1	27.9	27.1	33.8	33.1	36.1	34.8	34.1	43.3	32.3	33.7	31.5	28.2	22.4	18.7	16.9	19.8	26.9	30.1	27.6	29.6	26.3	22.6	18.3	14.3	10.3	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8
26.6	27.1	25.9	25.7	26.1	26.3	25.4	25.1	26.5	29.4	32	37.7	35.7	38.1	39.4	40.2	53.7	40.8	38	38.8	35.7	35.2	30.3	25.8	26.2	25.4	23.7	22.8	22.1	21.2	20.3	18	15.6	13.7	10.9	9.9	9.8	9.8	9.8	9.8	9.8	9.8	9.8
27.3	26.9	28.6	26.8	26.5	27.4	26.1	25.6	27.3	29.1	32.1	37.5	34.9	39.2	37.9	39.6	53.6	40.6	38	38.2	35.6	34.8	30.2	25.8	26.2	25.4	24	23.3	22.2	21.1	20.5	18.5	16.7	14.2	11.5	9.9	9.8	9.8	9.8	9.8	9.8	9.8	9.8
35	33.9	33.5	31.8	30.5	30.8	29.2	27.7	27.9	29.1	31.1	34.6	35.4	35.3	35.4	35.9	37.6	35.8	33.7	31.9	27.7	24.8	20.5	17.2	15.9	19.6	22.4	24.6	27.9	28.2	25.1	21.7	19.4	16.7	13.7	11.2	9.9	9.9	9.8	9.8	9.8	9.8	9.8
34.3	33.9	30.7	27.9	30.7	29.8	27.9	26.8	26.6	28	29.2	32.5	33.3	33.9	34.4	33.7	35.1	32.6	30.9	30.3	24.8	23.1	18.5	12.9	13.3	15.4	17.8	18	19.3	20.3	17.8	15.2	13	11.4	10	9.9	9.9	9.8	9.8	9.8	9.8	9.8	9.8
41	38.2	38.8	39	40.4	38	32.6	34.4	35.7	37.8	35.7	36.4	36.1	34.9	34.8	36	41.5	38.5	34.4	36.6	36.2	34.1	33.4	30.3	24.7	55	62.9	74	93.2	113.8	93.4	74	63.2	49	46.3	34	29.6	25	22.8	20.1	20.1	21	21.7

Directory: C:\Users\JohMoran\AppData\Local\Temp\Norsonic\Downloaded Mea File version v1.0/6.1.1.50

File	Date		Duration	Status	LAeq	LAFmax	LAFmin	LCeq	LCFmax	LCFmin	LAF,Perc4	LAF,Perc6	LCF,Perc4	LCF,Perc6	Lfeq 0.4 Hz	0.5 Hz	0.63 Hz	0.8 Hz
NOR140_1658766_210901_0001.NBF	(2021/09/01 12:15:25.00)	CAL	(0:0:10.0)	N/A	114.1	114.1	114	-	-	-	114.2	114	-	-	76.9	75.2	72.8	65.3
NOR140_1658766_210901_0002.NBF	(2021/09/01 12:16:34.00)	VOID	(0:1:19.0)	N/A	67.6	80.8	41	-	-	-	71.8	52.9	-	-	66	66.6	66.5	67.3
NOR140_1658766_210901_0003.NBF	(2021/09/01 13:12:45.00)	VOID	(0:0:20.0)	N/A	48.3	67.2	34.1	-	-	-	48.2	35.[illegible]	-	-	89.4	87.2	84.2	79.1
NOR140_1658766_210901_0004.NBF	(2021/09/01 13:13:29.00)	VOID	(0:0:18.0)	N/A	48.3	61.2	27.3	-	-	-	52.5	29.1	-	-	77.6	74.1	75.1	72.3
NOR140_1658766_210901_0005.NBF	(2021/09/01 13:15:43.00)	VOID	(0:0:16.0)	N/A	55.1	63.8	38	-	-	-	60.1	39	-	-	80.1	77.2	67.9	61.4
NOR140_1658766_210901_0006.NBF	(2021/09/01 13:25:49.00)	CAL	(0:0:10.0)	N/A	114	114.1	114	-	-	-	114.2	114	-	-	63.8	63.1	71.7	73.8
NOR140_1658766_210901_0007.NBF	(2021/09/01 13:26:45.00)	NMP1 Day	(0:15:0.0)	N/A	59.3	71.9	31.6	-	-	-	64.1	39.8	-	-	61.3	62.3	63.1	62.3
NOR140_1658766_210901_0008.NBF	(2021/09/01 13:41:47.00)	VOID	(0:0:3.0)	N/A	61.1	63.9	55.5	-	-	-	63	57.4	-	-	49.5	66.1	63.7	50.4
NOR140_1658766_210901_0009.NBF	(2021/09/01 13:52:34.00)	VOID	(0:0:9.0)	N/A	57.6	75.8	31.2	-	-	-	55.3	32.1	-	-	79.4	73.7	73.7	72.6
NOR140_1658766_210901_0010.NBF	(2021/09/01 13:52:49.00)	CAL	(0:0:12.0)	N/A	114	114	114	-	-	-	114.1	113.8	-	-	74.8	68.9	69.8	71.6
NOR140_1658766_210901_0011.NBF	(2021/09/01 13:53:46.00)	NMP3 Day	(0:15:0.0)	N/A	40.7	50.8	29.7	-	-	-	43.9	34.3	-	-	59.1	58.9	58.2	59.3
NOR140_1658766_210901_0012.NBF	(2021/09/01 14:08:49.00)	VOID	(0:0:1.0)	N/A	36.8	38.5	35.7	-	-	-	37.8	35.9	-	-	43.2	43.5	43.9	46.2
NOR140_1658766_210901_0013.NBF	(2021/09/01 14:17:36.00)	CAL	(0:0:20.0)	N/A	113.9	114	112.9	-	-	-	114	113.8	-	-	76.8	71	72.5	65.9
NOR140_1658766_210901_0014.NBF	(2021/09/01 14:18:27.00)	NMP1 Day	(0:15:0.0)	N/A	57.3	69.3	31.6	-	-	-	62.1	38.7	-	-	61.4	63.6	63.5	64.3
NOR140_1658766_210901_0015.NBF	(2021/09/01 14:33:29.00)	VOID	(0:0:3.0)	N/A	41.9	44.4	40.5	-	-	-	43.4	40.8	-	-	53.2	44.9	42	42.5
NOR140_1658766_210901_0016.NBF	(2021/09/01 14:41:28.00)	CAL	(0:0:25.0)	N/A	113.8	114	112.6	-	-	-	114	113.7	-	-	76.4	72.2	66.9	60.7
NOR140_1658766_210901_0017.NBF	(2021/09/01 14:42:23.00)	NMP3 Day	(0:15:0.0)	N/A	44.2	53.7	34.7	-	-	-	47.4	38.8	-	-	63.3	64.8	64	63.3
NOR140_1658766_210901_0018.NBF	(2021/09/01 14:57:25.00)	VOID	(0:0:4.0)	N/A	41.5	43.9	39.2	-	-	-	42.7	39.4	-	-	53.5	56.3	56.9	56.8
NOR140_1658766_210901_0019.NBF	(2021/09/01 15:07:49.00)	CAL	(0:0:20.0)	N/A	113.9	114	113.8	-	-	-	114	113.8	-	-	66.1	68.2	71	71
NOR140_1658766_210901_0020.NBF	(2021/09/01 15:08:43.00)	NMP1 Day	(0:15:0.0)	N/A	57.4	70	33.2	-	-	-	61.8	38.9	-	-	66.5	66	68.3	68.3
NOR140_1658766_210901_0021.NBF	(2021/09/01 15:23:46.00)	VOID	(0:0:0.0)	N/A	61.8	62.2	61.8	-	-	-	-	-	-	-	60.2	68.1	59.2	72.9
NOR140_1658766_210901_0022.NBF	(2021/09/01 15:38:17.00)	CAL	(0:0:21.0)	N/A	113.9	113.9	113.8	-	-	-	114	113.8	-	-	64.4	63.4	58.5	59
NOR140_1658766_210901_0023.NBF	(2021/09/01 15:38:54.00)	NMP3 Day	(0:15:0.0)	N/A	42.9	56.7	32.5	-	-	-	46.1	36.3	-	-	66.4	66.6	66.2	67
NOR140_1658766_210901_0024.NBF	(2021/09/01 15:53:56.00)	VOID	(0:0:25.0)	N/A	45	48	40.9	-	-	-	46.5	42.5	-	-	60.1	61.2	60.5	60.3
NOR140_1658766_210901_0025.NBF	(2021/09/01 21:18:57.00)	CAL	(0:0:21.0)	N/A	113.9	114	113.8	-	-	-	114	113.8	-	-	66.8	61.1	56.4	55.3
NOR140_1658766_210901_0026.NBF	(2021/09/01 21:19:56.00)	NMP1 Eve	(0:15:0.0)	N/A	53.1	67.5	24.4	-	-	-	58.4	29.3	-	-	48.9	48.3	46.5	45.6
NOR140_1658766_210901_0027.NBF	(2021/09/01 21:34:59.00)	VOID	(0:0:4.0)	N/A	57.7	61.4	48	-	-	-	60.8	51.5	-	-	38.3	42.2	41.1	38.7
NOR140_1658766_210901_0028.NBF	(2021/09/01 21:44:51.00)	CAL	(0:0:17.0)	N/A	114	114.1	114	-	-	-	114.2	114	-	-	60.7	56.2	51.6	49.2
NOR140_1658766_210901_0029.NBF	(2021/09/01 21:45:40.00)	NMP3 Eve	(0:15:0.0)	N/A	38.3	54.7	24.6	-	-	-	42.7	28.4	-	-	44.9	46.2	44.4	44.2
NOR140_1658766_210901_0030.NBF	(2021/09/01 22:00:42.00)	VOID	(0:0:7.0)	N/A	44.2	47.9	41.6	-	-	-	45.8	42.7	-	-	37.7	47.5	44.9	45.9
NOR140_1658766_210901_0031.NBF	(2021/09/01 22:12:06.00)	CAL	(0:0:22.0)	N/A	114.2	114.2	114.2	-	-	-	114.3	114	-	-	50.3	46.7	40	41
NOR140_1658766_210901_0032.NBF	(2021/09/01 22:13:23.00)	NMP1 Eve	(0:15:0.0)	N/A	49.2	66.1	20.4	-	-	-	47.6	24	-	-	45.9	42.5	42.5	40.8
NOR140_1658766_210901_0033.NBF	(2021/09/01 22:28:26.00)	VOID	(0:0:1.0)	N/A	26.7	30.9	22.7	-	-	-	29.7	22.8	-	-	36.5	43.7	33.4	44.7
NOR140_1658766_210901_0034.NBF	(2021/09/01 22:36:34.00)	CAL	(0:0:20.0)	N/A	114.2	114.3	114.2	-	-	-	114.4	114.2	-	-	52.8	38.8	42.6	38.6
NOR140_1658766_210901_0035.NBF	(2021/09/01 22:37:32.00)	NMP3 Eve	(0:15:0.0)	N/A	35.9	48.4	24.2	-	-	-	39.4	28.9	-	-	60.7	55.2	47	46.6
NOR140_1658766_210901_0036.NBF	(2021/09/01 22:52:35.00)	VOID	(0:0:0.0)	N/A	27.2	28.1	26.7	-	-	-	-	27	-	-	44	35.3	44.1	39.5
NOR140_1658766_210901_0037.NBF	(2021/09/01 23:03:22.00)	CAL	(0:0:23.0)	N/A	114.3	114.3	114.2	-	-	-	114.4	114.2	-	-	67.6	66.2	57.5	54.9
NOR140_1658766_210901_0038.NBF	(2021/09/01 23:04:36.00)	NMP1 Night	(0:15:0.0)	N/A	45.2	62	22	-	-	-	42.2	25.3	-	-	46.5	43	42.2	40.5
NOR140_1658766_210901_0039.NBF	(2021/09/01 23:19:38.00)	VOID	(0:0:0.0)	N/A	25.3	27.7	26.7	-	-	-	-	-	-	-	23.9	40.2	47.3	29.1
NOR140_1658766_210901_0040.NBF	(2021/09/01 23:27:37.00)	CAL	(0:0:20.0)	N/A	114.3	114.3	114.2	-	-	-	114.4	114.2	-	-	68.3	65.1	62.5	52.9
NOR140_1658766_210901_0041.NBF	(2021/09/01 23:28:50.00)	NMP3 Night	(0:15:0.0)	N/A	32.7	55.5	21.9	-	-	-	36.3	24.7	-	-	55.9	49.9	48.2	44.8
NOR140_1658766_210901_0042.NBF	(2021/09/01 23:43:53.00)	VOID	(0:0:3.0)	N/A	38.4	42.8	33.4	-	-	-	40	36	-	-	41.5	33.7	41.8	44.8
NOR140_1658766_210901_0043.NBF	(2021/09/01 23:53:46.00)	CAL	(0:0:21.0)	N/A	114.3	114.3	114.3	-	-	-	114.4	114.2	-	-	69.6	61.9	58.7	49.9
NOR140_1658766_210901_0044.NBF	(2021/09/01 23:54:59.00)	NMP1 Night	(0:15:0.0)	N/A	49.7	69.7	22.9	-	-	-	48.6	25.8	-	-	53.4	51.2	41.5	42.6

1.0 Hz	1.25 Hz	1.6 Hz	2.0 Hz	2.5 Hz	3.15 Hz	4.0 Hz	5.0 Hz	6.3 Hz	8.0 Hz	10 Hz	12.5 Hz	16 Hz	20 Hz	25 Hz	31.5 Hz	40 Hz	50 Hz	63 Hz	80 Hz	100 Hz	125 Hz	160 Hz	200 Hz	250 Hz	315 Hz	400 Hz	500 Hz	630 Hz	800 Hz	1.0 kHz	1.25 kHz	1.6 kHz	2.0 kHz	2.5 kHz
60.8	57.9	57.9	58.5	57.2	58	57.3	53.5	50.7	52.3	52	52.1	69.6	56.4	50.2	52.5	54.6	51.7	47.7	49	55.5	49.7	47.5	55.7	50	53.7	58	63.9	74.2	93.3	114.1	93.6	74.2	63.4	49.2
66.6	65.9	65.6	65.2	64.3	62.4	61.6	61.3	58.7	57.2	54.4	54.2	55.2	49.7	52.6	52.7	56.8	55.8	50.3	56.9	57.2	57	52.5	59	59.1	58.3	63.9	63.2	61.4	58	52.1	52.3	55.7	57	55
72.2	67.1	64.3	63.9	60.3	61.1	61.8	60.2	57.1	59.4	57	53.9	52.1	50.7	49	46.7	46.9	48.6	46.1	43.4	41.2	35.8	35.3	36.4	33.4	33.4	39	41.1	41.2	45.8	39.8	30.4	32.1	31	26.5
67.5	61.9	64.2	60.6	55.2	52.1	50	48.6	49.1	48.8	46.9	44	43	43.7	44.5	43.2	41.3	43.6	43.6	41.7	38.7	36.1	33	34.2	31.1	31.5	32	36	41.3	47.1	40.4	28.2	21.2	16.7	13.2
57.9	57.7	60	61.1	62.4	59.6	59.8	62	60.7	61.7	62.6	59	60	57.5	57.8	57.8	55.7	62.2	70.2	53	52	53.4	44.7	44.1	44.2	46.6	44.3	48.1	50.7	52	44.5	32.4	26.1	21.7	17.7
70.5	70.9	69.1	70.8	69.9	66.7	65.7	68.7	67	68.6	64.8	62.3	60.2	58.5	58.2	56.7	55.2	53.6	51.5	49.9	50.7	47.1	44.9	45.3	40.4	40.1	55.4	63.1	74.2	93.3	114	93.5	74.1	63.4	49.2
62	61.3	60.2	59.6	58.4	56.5	54.8	53.1	51.2	49.9	48.9	49.6	51.5	51.6	49.9	50.7	50.1	57.3	59.8	54.5	48.3	47	42	40.4	41.6	46.1	47.5	51.2	52.6	53.3	52.9	50.3	47.5	43.8	40.7
55.6	52.9	57.3	51.5	49.6	47.2	47.5	46.3	43.7	42.9	54.5	51.8	50.9	52.2	50.9	50.7	50.3	53	64.3	55.1	49.8	45.5	40.9	38	39.7	40.8	45.7	49.2	54.3	56.9	54.6	51.4	48.8	45.9	43.3
66.7	70.1	64.6	63.8	61.8	62.2	55.2	60.1	56.6	56.9	55.3	57.6	53.3	50.3	52.3	54.9	51.3	46.7	47.3	43.5	42.4	41	41.8	42.4	43.9	45	38.6	39.8	45.1	55.9	52.8	39.6	37.7	37.2	22.9
65.3	64.7	63.8	60.6	60.2	56.3	54	55.3	54.8	53.3	51.2	51.8	51.9	49.8	48.8	48.3	46.8	42.8	42.9	38	34.8	30.4	28.1	32.6	28.3	32.2	55.1	63	74.1	93.3	114	93.5	74.1	63.3	49.1
57	56.7	55.7	55	53	49.5	46.5	44.4	42.5	42	42.4	44.7	44.9	40.7	44	46.6	44.4	43.8	47.3	46.1	38.4	34.8	31.8	28.8	27	29.3	29.9	33.1	34.2	34.8	34.1	31.3	27.7	23.3	19.4
42.3	46.5	42	37.3	45.9	41.4	39.3	34.3	40.7	34	38.3	41.9	43	42.7	42.1	45.9	42	47.6	38.1	34.5	29.2	27.3	24.3	23.4	25.5	26.4	31.5	29	31	30.8	29.6	26.6	22.8	17.6	12.9
67.3	64.8	67.3	64	65.3	67.8	66.4	66.2	65.5	65.6	67	65.3	62.7	60.1	60.1	56.4	55.3	53.4	51.1	48.8	44.5	41.3	38.5	34.8	30.6	28.9	55	62.9	74.1	93.2	113.9	93.4	74	70.6	54
63.8	63	63.2	61.5	60.1	59.1	57.1	55.5	54.1	51.9	50.3	49.2	50	48.8	50.4	49.7	50.1	58.4	55.9	53.5	47	42	38	36.6	38.9	41.3	42.9	47	49.9	51.3	51.6	48.9	46.2	41.7	37.8
43.6	37	41.4	49.1	38	37.6	38.1	37.5	35.7	39.7	40	45.2	46.4	45.6	44.3	43.4	47.8	48.1	47.8	39.2	32.4	29.4	24.8	27.2	30.4	34.3	34.1	30.7	32	34	34.7	32.5	30.1	25.6	22.3
62.1	55	55.6	57.3	53.8	57.6	57	56.3	57.6	54	53.4	54.2	53.1	51.1	50.6	50.8	50.3	49.2	46.4	44.4	40.9	37.3	33.9	31.6	25.4	26.6	55	62.9	74	93.1	113.8	93.3	74	74.4	57.7
63.3	61.6	60.9	60.2	58.4	56.3	54.3	53.8	50.8	48.4	46.4	46	46.3	43.2	47.1	47.7	46.3	46.8	47.7	43.8	42.1	38.1	34.7	32.3	32.6	32.1	33.3	34.7	36.7	38.2	38.5	35.4	32	27.3	23.1
54.6	54.5	53.3	55.5	51	51.5	50.9	49.4	48.5	41.7	42.2	39.1	45.4	38.6	46	45.6	41.8	41.2	43.1	43.2	40.4	38.6	35.6	35.5	29.1	28.3	32.3	33.3	34.1	35.7	35.1	31.2	29.1	24.8	21.6
71.3	72.7	73.2	72.5	73.2	75.1	69.2	71.3	69.8	70.1	71.2	67.2	67.4	64.4	61.8	59.7	57.4	56.7	55.2	53.9	52.2	49.6	46.1	43.1	39.4	38	55.1	63	74.1	93.2	113.9	93.4	74	63.2	49
68.3	68	66.8	66.3	65.1	63.8	61.6	60.1	58.6	56.2	54.4	52.6	54.5	50.5	50.9	50.7	55.1	52.3	53.8	52.1	46.8	41.4	36.4	35.9	38.2	41.5	43	46.2	50.6	52.1	51.5	48.7	45.6	41.4	37.6
73.8	63.6	63.9	75.8	77.2	73	68.4	70.8	73	70.1	72.2	60.2	63.1	58	62.5	51.8	60.3	54.8	58.3	57.2	61.8	45.9	42.2	43.4	46.4	47.4	52.3	51	52.2	55.1	54.9	54.3	50.8	47.3	46.2
53.1	56.6	53.8	54.2	51.4	54.2	53.5	53.2	51.9	52.2	50.9	48.8	47.8	48.8	47.7	46.3	42.2	40.1	39.6	34.7	33.5	30.9	28.4	28.8	27.1	29.8	55	62.9	74	93.1	113.9	93.4	74	63.2	49
66.9	65.1	63.4	62.7	61.1	59.6	57.6	54.5	52.9	50.3	48.5	46.4	45.2	42.2	44.6	46.2	42.6	44.7	45.8	39.9	37.4	34.2	30.6	28.6	28.2	30.8	32.9	35.3	36	37.1	36.6	33.4	29.8	26.2	23.6
59.8	57.7	55.6	59.3	56.4	52.4	53.9	52.3	49.3	47.1	46.9	47.9	50.2	45.5	51.5	51.9	46.5	47.7	51.1	45.8	41.3	38.2	36.4	32.5	31.5	33	36.2	39.7	38.7	38.9	38.3	34.8	31	26.7	23
48.2	45.3	45	45.1	43.9	41.9	38.3	36.5	36.9	37.1	36.7	36.2	39.2	37.2	38.9	34.8	34.4	34.1	32.2	28.2	24.3	21.7	20.5	22.9	23.2	23.4	55	62.9	74.1	93.2	113.9	93.4	74	63.2	49
46.1	45.5	43.8	44.5	42.6	40.5	38.4	36.9	36.8	37.7	39.3	41	43.7	43.2	43.7	44.4	44.6	47.6	48.1	45.9	45.6	36.7	31.1	32.6	35.2	37	39.9	42.2	45.2	47.7	47.2	44.9	41.7	38.1	34.2
46.5	41.5	42.9	40.6	41.2	40.6	39.7	31.9	38	39.2	40.7	41	42.2	41.6	44.5	45.8	45.5	46.9	53.8	50	43.3	37.9	32.9	35	39.1	39.4	41.9	45.8	48.9	51.4	52.3	50.6	46.7	42	39.1
52.1	55.7	50.2	52.9	50.5	49.7	47.7	46.1	43.8	46.5	44.8	41.7	44.1	41.1	40.9	44	43.2	49.3	44.2	35.4	35.8	28.9	26.6	25.4	24.2	26.6	55.2	63.1	74.2	93.3	114	93.5	74.1	63.3	49.2
46.1	44.8	45.1	45.6	43.2	39.9	37.8	36	36.3	37.1	37.5	38.5	40.1	37.6	42	42.6	40.1	45.1	46.1	38.6	35.5	30.7	28.9	28.5	25.1	29.3	27	28.7	30.8	32.6	32	29.5	26	21.2	17.6
43.5	41.5	44.1	49.2	44.3	41.8	38.7	35.6	37	36.8	36.4	38.1	37.4	35.6	41.5	40.5	43.4	47	39.1	38.6	39.3	33.5	27.8	25.1	23.9	26.9	29.1	31.2	33.3	37.1	38.8	37.5	34.7	29.3	23.5
45	41.7	43.9	45.6	42.8	40	44.5	45.5	47.3	48.6	41.8	45.3	43.2	44	44.8	43.7	42.3	43	43.4	43.6	45	34	28.4	29.6	27.4	29.4	55.3	63.2	74.4	93.5	114.2	93.7	74.3	63.6	49.4
43.8	43.5	41.9	44.4	40.2	37.6	35.2	34.9	35.5	37.6	38.3	38.2	39.3	39.1	41.2	38.9	38.8	42.5	42.9	40	36.1	30.6	25.1	25.3	28.4	29.8	32.2	36	41.2	44.2	43.7	40.9	37.6	33.7	29.6
29.2	45.3	46.7	39.1	35.6	35.7	29.7	37.2	40.3	43.2	40	33.9	39.7	39.7	39.2	34.3	31.4	31.2	30.3	24.8	21.9	23.6	16.8	19.7	19.2	18.8	17	16.8	17.4	17.3	16.5	15.3	15	15	15
39.8	43.6	44.4	42.4	45.6	42	39	37.1	36.8	37.8	36	36	36.5	34.5	38.2	36.8	33.3	34.5	34.3	33.1	30.2	30.3	26.3	32.8	25.8	27.2	55.4	63.3	74.4	93.5	114.2	93.7	74.3	63.6	49.4
47	45.4	45.5	44.5	42.5	39.8	37.9	37.8	38.4	39	37.6	38.6	39.8	37	43.2	40.6	36.1	38.3	39	35.4	31.9	29.6	26.7	25.3	22.9	23.8	28.9	27.3	31	29.5	29	25.9	22.3	17.9	13.4
39.5	38.1	40.1	35.4	42.9	40.1	33.8	26.9	36.5	40.3	31.3	28.2	36.3	35.9	38.2	34.7	32.4	34.6	34	32.5	27.3	24.9	22.5	18.8	19.1	17.8	21.8	21.2	25	16.4	14.2	11.8	9.7	8.5	7.7
43.8	42	41.9	40.4	38.1	38.4	37.1	36.1	35.8	38.1	36.2	34.8	39.2	35.9	38.3	35.5	36.3	34.8	31.4	30.9	31.5	24.8	24.1	26.7	27	26.1	55.4	63.3	74.4	93.6	114.3	93.7	74.3	63.7	49.4
42.4	41.8	41.5	42.1	39.8	37	35.5	34	34.4	35.1	35.4	35.2	39.8	37.1	39.5	37.6	37.9	42.6	41.4	36.7	32.9	27.5	22.5	23.9	26.9	28	30.2	32.7	35.8	39.6	39.9	37.2	34.1	30.6	25.8
31.9	29.5	21.2	38.1	35.6	38.1	39.7	30.9	40.3	39.5	30.6	36.8	42.7	42.7	43.2	33.4	30.6	26.7	29.8	21.5	23.5	21.1	20.8	22.8	26.7	23.8	19.4	19.8	18.4	15.2	12.3	8	7.2	6.1	5.7
47.8	39.9	44.2	44.6	42	40.6	39.8	38.7	38.6	37.9	37	36.7	38.2	36	37.6	34	32.6	34.3	34.8	36.1	33.3	28.4	25.7	29.5	26.1	25.7	55.4	63.3	74.4	93.5	114.2	93.7	74.3	63.6	49.4
45	43.3	42.6	42.7	40	37.3	35.7	35.5	36.5	35.9	35.9	36.1	37.7	35.4	38.8	35.8	34.2	36.6	33.6	32.7	28.7	26.1	24.5	23.3	23.1	22.5	24.6	23.6	25	26	26	23.8	20.8	17.3	14.2
39.7	43	41.8	50.8	46.7	40.4	37.5	42	39.1	37	35.1	37.1	34.8	34.9	41.4	38	32.8	33.8	34.1	31.1	29.9	24.8	24.4	23	23.3	24.3	25.2	28.8	31.1	32.3	31.4	29.8	27.2	24.2	22.5
43.3	45.1	40.1	41.8	39.4	35.5	36.3	36	37.6	38	39.3	52.1	53.7	49.2	49.2	46.4	45.9	48	45.9	43.9	37	33.5	28.3	28	31.9	32.6	55.4	63.4	74.5	93.6	114.3	93.8	74.4	63.7	49.5
42.3	41.7	39.2	39.6	37.6	36.2	35	34.7	35.9	37.3	38.3	40.5	45.2	47.7	54.4	47.5	43.7	45.5	45.8	43.6	38.6	34.6	30.3	32.4	35.8	40.1	39.4	41.3	42.6	43.6	43.1	40.9	38.1	35.3	31.1

3.15 kHz	4.0 kHz	5.0 kHz	6.3 kHz	8.0 kHz	10.0 kHz	12.5 kHz	16.0 kHz	20.0 kHz	LfFmax 0.4 Hz	0.5 Hz	0.63 Hz	0.8 Hz	1.0 Hz	1.25 Hz	1.6 Hz	2.0 Hz	2.5 Hz	3.15 Hz	4.0 Hz	5.0 Hz	6.3 Hz	8.0 Hz	10 Hz	12.5 Hz	16 Hz	20 Hz	25 Hz	31.5 Hz	40 Hz	50 Hz	63 Hz	80 Hz	100 Hz
45.9	34.2	29.9	25.3	23	20.4	20.5	21.4	22.3	86.2	81.6	79.6	78.1	67.8	68	62.8	64	62.3	64.6	64	61.6	57.3	60.3	57.7	58.9	71.2	60.6	54.3	58.5	58.9	58.4	55.9	54.3	61.4
48.6	49.6	42.5	41.9	39.2	36.3	30.1	22.6	24.3	72.7	73.8	77.1	76.6	74.8	75.2	73.6	75.8	74.5	74	74	72.6	72	70	67.8	69.4	64.6	58.5	62.3	64.5	67.9	63.3	66.2	72.7	67.6
26.1	25.5	24.9	24.6	23.9	23.3	23	23	23.3	97.2	97	96.2	93.8	86.7	77.9	77.6	73.9	71	70.8	71.8	68.6	67.5	73.4	71.8	63.5	61.6	60.9	59.7	56.6	58.8	60	57.7	55.4	53.7
13.9	15	15.1	16.3	17	17.5	18.4	19.4	21.3	84.8	81.2	83.6	82.2	78.5	75.7	78.5	76.1	71.5	67.8	62.1	60.1	60.8	62.5	59.7	55.2	51.7	52.7	53.8	52	52.5	50.6	54.5	53.4	49
15.8	16.9	16.8	17.8	18.8	19.1	20.1	21.2	22.1	86.3	86	79.5	70.9	66.8	64.1	69.2	73.5	73.9	71	68.3	70.5	70.6	72	75.7	67.9	74	66.7	66.3	66	66.3	69.4	77.3	59.3	58.2
45.9	34.1	29.9	25.2	23	20.2	20.6	21.2	22.1	67.6	69.4	78	79.9	77	77.5	74.5	78.7	78.3	73.5	73.4	76.1	76.3	78.5	74.4	69.8	68.7	68	69.4	67.7	66.3	62.8	64.5	61	63.7
37.7	34	30.3	28.5	25.5	19.9	16.4	10.5	10.9	75.8	82.1	84.5	80	83.3	79.2	76.2	80	78.1	73.3	75.4	70.2	70.3	70.2	69.6	68.2	70.1	72.9	68.2	68.7	68.2	79.8	80.2	75.1	63
40.3	36	31.9	28.5	24.6	20.2	13.9	9	7.2	54.4	69.7	66.1	57.5	60.5	57.2	60.7	55.4	53.9	51.5	52	49.7	51.7	48.9	59.6	57.3	56.5	54.8	54	55.5	56.1	57.8	69.5	58.3	57.6
19.5	18.4	17.2	22.6	19.5	20	20.8	21.1	22.6	84.4	80.5	82	82.2	78.3	78.1	74.8	73.3	73.6	72.4	62.6	70.6	64	66	65.7	67.6	61.1	58.2	60	62.4	59.3	58.5	53.2	51.2	51
46.2	34.1	29.7	25	23	20.4	20.4	21.2	22.4	80.4	73.1	79.5	82	76.9	77.8	73.4	74.8	74.3	68.1	64.8	64.2	63.4	63.1	58.2	62	60.6	60.8	58.1	55.7	53.1	52.7	56.8	56.5	50.7
17.1	15.1	14	12.4	10.2	8.9	7.7	5.9	7.1	73.1	73.6	73.3	73.2	73.2	76.7	77.3	77.9	75.9	70.3	63	62.7	61.9	59.2	63.7	61.8	60.3	60	56.7	63	59.9	57.7	61	67.7	54.5
9.5	8.1	7.4	7	7.5	6.3	6.4	4.6	5.3	46.6	46.3	48.4	48.7	45	50.6	46.2	42.2	51.1	46.3	42	42.4	43.2	37.9	41.6	45	47.9	46	46.6	49.8	47.2	50.5	41	36.3	31.6
62.3	55	48.1	42	34.6	27.7	22.2	21.4	22.3	87.4	79.5	84.1	73.8	72.9	74.8	73.5	71.2	72.2	77.8	75.3	75.5	75.8	74.6	74.9	73.9	72.3	69.5	70.6	66	64	62.8	61.8	57.4	54
33.8	29.8	26.6	25.2	23.6	17.1	13.9	10.9	8.3	79.6	80.2	79.2	79.4	80.6	80.3	82.6	77.7	78.6	78.3	74.6	75.4	75.2	72.9	74.1	69.4	68.5	71.5	68.5	67.8	70.9	80.9	75.8	72.6	67.6
20.1	28.9	30.2	24.4	26.5	10.9	8	5.5	4.8	56.4	51.5	45.6	46.1	46.1	41.4	45.8	53.5	42	40.3	44.9	43	41.5	43.9	45.7	50.1	51.8	49.7	47.6	47.6	54.4	51.4	51.1	43.1	35.7
67.2	60.2	53.5	48.5	42.4	36.3	28.9	23.4	22.3	87.6	82	79.8	71.4	70.9	62.5	65.6	66.7	60.6	67.7	66.5	65.9	67.3	63.1	64.2	68.4	67.4	64	61.8	61.5	63.6	58	57.8	56.1	53.6
20.8	18.6	16.3	14.5	12.4	10.8	10.2	8.8	7.1	77.7	80.2	81.3	80.6	80.5	79.3	77.2	78.3	78.5	74.8	76.4	78.5	74.1	71.5	69.4	69.3	67.7	64	62.7	62.8	61.4	60.8	61.4	63	63.7
20	17.3	14.1	11.2	10.3	10.8	9.9	8.1	6.6	59.2	63	61.1	60.5	58.9	58.2	57.5	64.4	58.6	59	60.3	56.5	55.9	49.1	47.8	43.7	52.7	44.2	49.6	50.8	46.8	44.3	47.2	47.3	44.6
45.7	34	29.5	25.1	23	19.8	20.3	21.2	22.3	71.1	74.5	76.5	78.8	80	82	83.1	82.4	84	85.8	80.8	82.4	80.1	83.3	81.3	78.3	79.2	76.7	73.6	70.7	67.8	67.8	66.8	64.8	65.4
34.4	30.8	26.7	22.8	20.2	16.6	14.9	12.3	9.5	79.9	77.8	81.6	83.4	85.6	86.3	84.2	83.5	84.6	80.1	78.6	79.2	75.6	73.8	76	69.7	71.3	70.2	67.8	69.8	69.6	70.1	73	68.6	66
44.3	41.9	37.6	34	27.7	21.7	18.1	13.7	9.8	63	66.9	70	77.9	80.4	68.2	68.8	83.7	82.2	73.1	71.6	70.2	73	69.8	72.6	65	66.5	58.9	61.1	56.3	59.6	55.9	57.1	58.3	62.9
45.6	33.9	29.4	25	23	19.6	20.3	21.1	22	75.3	69.3	68.1	67.3	59.3	64	61	62.7	62.1	63	63.4	64.6	63.7	64	64.5	61.7	60.8	64.7	62.8	57.1	54.7	51.1	51.5	47.8	50.6
20.9	19.4	17.4	15.5	13.4	11.1	9.7	8.4	6.8	81.9	80.9	79.7	85.3	82.6	83.2	81	79.6	77.9	79	76.5	76.2	75.3	74.6	71.7	66.8	60.2	56.1	59	61.4	53.3	60.1	62.5	54	51.7
20.3	17.9	15.9	13.5	10.7	8.4	7.3	5.5	4.8	68.1	68.7	70.5	69.2	71.5	62.9	64	68.4	65.9	60.5	66.6	64.8	61.1	57.7	55.9	58.5	57.3	54.2	61.2	64.1	55.1	60.3	61.1	54	50.5
46	34	29.7	24.9	22.8	20	20.3	21.1	22	79.7	74.4	66	68.1	57.2	56.1	52.7	53.8	53.1	52.2	44.4	47.8	45.8	48.5	44.6	43.1	46.8	42.3	44.5	39.8	40.3	39.4	38.2	40.4	38.6
30.8	26.8	22.5	18.5	16.9	11.7	9	6.4	9	71.7	72.1	68.7	65.6	61.3	65.8	58.6	58.5	57.1	56.8	57.1	52.3	54	55.6	56.9	62.4	63.9	63.6	62.7	66	65.3	67	65.2	62.6	69.7
35.1	30.5	26.1	23	21.8	17.1	13.1	9.4	8.5	42.4	46.1	44.6	42.9	48.9	46.1	46.2	45.8	47.2	44.5	43.7	35.8	44.9	45.8	47.7	47.7	48	46	50.5	53.2	52.2	51.8	59.3	54	48.7
46.5	34.2	30	25.1	22.6	20.4	20.3	21.1	22	69.6	67.2	61.2	57.6	57.5	63.4	59.2	58.8	57.9	57.2	56.8	55.7	52.1	56.6	56	50.6	50.2	49.7	46.5	52.1	50.8	55.4	53.4	42.3	43.3
13.6	11.2	9.5	8.3	7.5	7.6	5.7	5.4	9.8	64.2	69.6	59.9	65.5	69	64.2	64.1	60.7	57.3	51.8	47.4	51.6	47	49.1	50.4	56.4	53.8	54.2	58.2	55.9	65.5	64.6	67.8	57.2	54.3
19	15.8	14.8	13.2	11.4	9.3	7.3	5.7	7.3	41	52.5	50.1	49.2	48.4	46.6	50.1	54.9	48.2	47.8	45.6	39.6	41.3	41.5	41.7	43.9	43.1	42	46.3	44.8	48.2	55.7	43.9	43.1	45.9
46.4	34.3	30.3	25.2	22.9	20.3	20.1	21	22.4	59.6	56.2	47.6	47.1	51.3	48	49.2	53.5	50.5	45.5	51.3	54.2	54.4	57.2	49.9	52.5	53.6	57.3	54.2	56.2	53	54.5	55	53.6	56.6
25.8	21.4	16.6	13.3	10.4	10.4	6.8	6	12.7	71.7	64	63.9	63.4	65.1	61.9	57.6	53.1	53.8	50.9	49.1	45.9	45.6	47	51	51.2	53.4	56.9	56.4	57.6	58.7	61.6	64.1	61.4	57.7
13.1	11.6	11.6	10.8	9.3	9.9	7.8	6.5	11.8	39.5	46.3	37.3	46.3	35.1	47.5	49.3	41.1	39.4	37.1	32.3	39.1	43.2	46	42.4	41.2	42.7	42.6	41.7	37.8	33.1	34	33.7	27.2	25.6
46.7	34.4	30.5	25.4	22.6	20.6	20.2	21	21.9	59.7	46.8	49	45.1	48.3	49.7	50	48.5	51.5	47.8	47.7	42.9	43.6	46	43.9	44	41.5	40.4	43.9	42.2	39.3	41.1	40.2	46.7	47.5
11.5	9.6	8.5	7.4	7	9.4	5.7	6	16.2	85	83.6	67.3	71.3	67.1	69.8	66.6	55.3	52.7	51	48.2	48.4	47.7	52.3	50.9	56.3	56.8	52.2	61.2	62.7	53.2	55.1	57.9	49	49.7
7.6	8.6	7.3	7.3	8	7.5	6.4	4.8	6.6	45.8	39	46.6	41.9	42.2	41.1	42.2	38.6	44.5	43.7	37.8	29.9	39	42	34.3	31.6	39.3	38.4	39.7	38.3	35.8	37.8	35.7	34.6	28.6
46.8	34.5	30.5	25.4	22.8	20.2	20.1	21	21.8	75.8	77.5	72	66.8	54.2	50.8	47.6	47.5	43.1	45.2	51.4	46.3	46.6	54.5	47.1	41.4	46.1	41.2	45.3	40.2	40.7	40.8	38.5	36.3	37.9
22	17.8	13.9	11.4	9.2	9	6.7	5.7	11.2	71.7	66.2	64	58.6	63.1	60.8	52.1	53.5	51	45.9	45.8	44	43.7	44.5	44.7	46	48.1	51.1	56.1	62.2	61.7	62.8	62.3	57.7	50.5
6.2	6.5	6.2	5.8	6	6.6	5.4	4.8	9.2	28.1	38.8	46.4	40.5	30.4	27.7	28.9	40.7	34.6	40.5	39.3	29.7	39.4	38.1	37.1	36.8	41	40.8	42.1	34.2	34.7	30.5	29.9	23.6	23.3
47.1	34.5	30.6	25.6	22.6	20.6	20.2	21	21.9	77.5	73.8	74.6	62.1	60.8	51	52	51.4	47.7	48.8	49.4	48.5	45.5	45.1	45	44.3	44.8	43.5	45.1	40.1	38.4	40.8	42.8	49.1	49.9
12.6	11.2	10.3	9	8.1	7.1	5.8	5.2	7.9	81.3	76.1	71.1	64	66.4	60.6	59	53.3	53.2	49.1	49.1	45.6	46.4	45.7	49.5	50.4	50.6	49.7	48.1	46.8	46.6	52.1	45.9	44.7	38.9
19.6	18	16.8	15.6	14.7	13	11.1	8.5	8.5	45.7	39.8	47.8	49.4	44.6	47.6	47.6	55.4	52	43.3	43.2	46.8	42.2	42.4	40.1	42.4	39.5	41.6	46.3	43.2	37.2	37.3	37	34.2	33.7
47.2	34.6	30.6	25.5	22.6	20.3	20.2	21.1	21.8	78.6	76.3	68.1	61.9	51.8	54.2	49.4	48.4	45.6	42.8	46.3	44.6	46.5	46.7	49.1	62.1	65.8	61.1	60.4	58	57.6	60.2	57.6	56	49
27.8	24	19.4	15.9	12.5	9.7	7.3	5.9	9.8	80.7	77.4	65.4	68.4	65.8	65	59.6	53.8	53.5	54.4	51	55.5	56.8	58.3	59.5	64.4	70.8	72	76.3	70.5	66	69.4	69.2	63.1	62.1

125 Hz	160 Hz	200 Hz	250 Hz	315 Hz	400 Hz	500 Hz	630 Hz	800 Hz	1.0 kHz	1.25 kHz	1.6 kHz	2.0 kHz	2.5 kHz	3.15 kHz	4.0 kHz	5.0 kHz	6.3 kHz	8.0 kHz	10.0 kHz	12.5 kHz	16.0 kHz	20.0 kHz	LfFmin 0.4 Hz	0.5 Hz	0.63 Hz	0.8 Hz	1.0 Hz	1.25 Hz	1.6 Hz	2.0 Hz	2.5 Hz	3.15 Hz
61.4	53.6	63.2	60.1	65.8	63.6	67.8	74.9	93.4	114.1	93.6	74.2	63.5	49.3	46	34.3	30.1	28.7	24.2	25.5	23.8	22.7	27.7	53.3	61.2	40.8	45.2	43.7	43.5	52.4	42.1	40.7	41.2
70.5	63.5	67.9	75.5	69.8	77.3	77.7	77.7	76.7	67.2	69.1	69.7	72.9	71.2	65	63.8	60.7	61	56.2	54.2	48.3	43	49.2	36.3	43.5	38.9	44.9	42.6	38.7	40.2	39.1	37.1	36
46.6	53.6	56.4	52.4	53.2	59.8	61.8	60.3	64.4	59	47.8	52.1	50.5	30.8	30.5	29.7	28.7	34.3	27.3	26.5	25.9	25.8	25.5	65	61	44.5	36.2	43.8	40	42.5	28.6	26.4	24.9
47.4	47.5	52	49	49	48.7	51.4	57.5	58.8	52.5	39.5	31.2	30.8	22.7	16.6	17.7	17.4	18.4	19.4	19.5	20.5	21.5	24	57.9	50.6	43.8	29.7	32.2	25.3	29.4	31.4	34.5	33.6
61.7	52.2	53.2	51.1	54.9	52.3	56.5	59.2	62.4	55.4	41.9	40.8	38.6	34.8	23.8	21.9	18.2	22.3	19.3	19.7	20.7	21.5	22.5	59.3	56.7	43.2	40.1	43.3	37.4	38	35.9	40.8	43.8
59.6	57.2	54.3	47.8	51.2	58	63.7	74.2	93.3	114	93.5	74.1	63.4	49.2	46	34.2	30.1	29.3	23.7	20.8	21	21.6	22.6	55	43.9	59.8	55.5	57.7	53.7	59.1	54.9	49	50.6
65.8	59.8	56.2	56.7	66.1	65.9	70	69.8	65.3	64.5	61.3	60.7	59.9	58.2	56.8	53	51.5	50.8	48.9	42.3	38.8	35.7	32.7	13.9	10	19	22.6	17.4	18.6	15.5	17.2	15.2	17.2
49.1	45.6	40.6	42.9	43.9	48.4	52.5	58	61.5	57.6	55.1	52.4	49.9	46.7	43.9	40	36.1	33.2	30	24.8	18.7	13.9	10.3	37.4	58.5	57.5	37.2	47.7	39.2	49.3	43.3	36.2	34.3
55.3	55.7	56	58.3	59.9	52.9	55.3	61.9	74.3	71.1	57.4	55.1	54.9	37.7	32	27.4	22.4	34.1	27.5	29.5	30	23.3	31.2	63.4	56.4	49.7	61.7	48.6	48.8	47.8	42.1	41	37.6
49.9	57.4	61.5	49.6	50.7	56.2	63.6	74.2	93.3	114	93.5	74.1	63.4	49.2	46.3	34.3	29.9	28.3	23.9	22.9	24.5	21.9	23.1	51.7	55.6	50.3	52.8	43.2	39.9	39.3	38.9	38.8	38.8
51.8	51.5	43.8	43.9	47.5	43.2	47.3	46.9	46.9	43.9	42.5	41.9	41	40.5	40.1	38.8	34.4	33	31.8	26.7	25.7	21.6	18.2	18.5	13.2	17	21.1	14.8	12.5	16.5	17.7	8.5	14.7
30.4	27.3	27.6	30.5	28.8	36.6	32.2	33.7	32.5	31.3	27.7	24.2	22.7	16.1	13	10.7	10.3	10.4	12.4	8.6	6.9	5	7.4	34.6	35	36.5	40.9	36	37.4	35.6	30.3	40.7	33
54.2	50.5	46.1	38.9	40.2	55.4	63	74.2	93.3	114	93.5	74.1	87.2	70.3	80.5	73.7	67.1	61.8	55.4	48.8	40.6	31.4	24.9	56.2	36.5	53.3	49.2	44.3	43.4	35.6	40.5	41.6	29.4
62.1	55.9	53.2	54.1	61.8	60.5	66.5	65.8	64.5	64	61.5	59.7	55.5	53.3	48.1	45.9	46.8	50.5	44.4	39.5	36	33	30.2	12	23.3	17.2	22.2	19.6	16.2	18.1	25.4	18.1	14.8
34.7	28.7	29.2	33.3	36.7	36.8	33.1	34.8	37.1	37.3	35.4	32.5	29.2	26.7	25.5	36.2	36.4	30.4	33.4	15.9	10.7	7.2	5.6	43.4	25.4	33.2	28.9	39.3	20.4	27.3	39.5	26.9	29.3
52.7	49.5	52.4	42.9	46	55.8	63	74.1	93.2	114	93.5	74.4	90.6	73.8	84.1	77.1	70.4	66.5	61.1	55.7	48.5	40.5	31.3	49.5	45.4	42.8	37.2	38.9	36.5	34.8	37	21	24.7
50.8	50.7	47	52	48.9	47.5	49.1	46.6	48.6	48.8	48.2	49.2	47.8	41.6	43	40.2	33	31.8	29.8	28	26.5	25	20	10.1	21.5	23.5	21.3	21.6	25.1	17.3	16	19.7	17.8
43.3	39.2	39.3	31	33.4	42.1	36.9	36.4	37.9	38.8	32.8	35.4	30.4	26.1	23.1	20.2	16	13.2	11.5	12.6	11.5	9.8	8.2	38	40.9	40.5	44	45.3	40.6	46.8	40.2	25.6	29.3
61.4	56.8	55.2	51.1	51.5	59.8	66.2	74.6	93.2	113.9	93.4	74.1	63.4	49.4	45.8	36.1	31	29.8	26.7	25.8	23.2	25.1	32.6	35.9	48.5	39.8	49.5	48.7	54.1	44.8	44	47.3	45
61	51.2	54.1	58	63	62.4	65.6	67.8	68.6	65.8	61.6	59.1	56.7	52.4	52.6	57.1	50.6	45.3	48.8	38.7	38	35.8	35.1	23.8	28.9	22.3	27.9	23.4	29	26.7	27.7	22.9	25.1
47	42.8	44.3	46.4	49.6	53.1	52.3	52.7	55.4	55.8	54.3	52	48.6	46.2	45.6	41.9	37.7	33.6	27.3	21.5	17.8	13.5	10.2	61.5	62.8	66.8	75.6	77.7	66.3	67	80.9	79.9	70.7
48.5	44.3	46.6	46.2	49.3	57.6	64	74.2	93.2	113.9	93.4	74	63.3	49.1	45.8	34	29.7	25.6	23.3	20.1	20.7	21.5	22.3	27.3	52.1	44.7	32.2	28.4	40.7	37.3	28.9	32.6	39.3
48.5	45.6	41.8	41	44	45.6	52.3	47.6	51.3	48.4	49.1	51.7	48.2	46.3	42	40.3	42.8	38.3	33.9	30.7	31.5	30	25.8	27.9	27.8	30	23.9	29.6	17.9	23.6	12.2	18.4	16.1
47.6	47.4	41.4	38.3	38.9	44.7	45.4	44.5	43	42.4	38.4	35.2	32.2	30.6	27.8	25.7	23.2	23.5	17.9	14.8	12.6	10.6	9.6	33.7	46.1	43.2	41.8	37.5	40.9	31.2	28.9	34.6	25.5
32.3	28.9	33.8	26.7	27.9	55.1	63	74.1	93.2	114	93.5	74.1	63.3	49.1	46.1	34.1	30.1	25.3	23.2	20.5	20.7	21.6	22.5	42.4	16.7	25.1	25.1	33.3	16.7	32	24.2	20.6	21.7
55.5	48.3	52.4	54	57.2	62.8	63.9	64.6	63	61.4	59	56.1	53.1	50	48.4	45.1	46.9	41.2	41.6	34.7	31.2	25.8	21.9	5.8	7.5	0.1	3.3	10.5	16.9	17.3	12.7	11	14.7
43.4	38.4	40.5	43.3	43.1	46.9	51.1	54.3	56.5	56.2	55.6	49.6	46.4	43.8	40	36.5	33.6	30.7	31	25.2	23	18	14.2	27.1	31.3	31.2	29.9	42.4	34.3	36.7	28.9	28.5	35
37.4	37	41.8	39.6	42.9	55.8	63.3	74.2	93.4	114.1	93.6	74.2	63.4	49.2	46.6	34.3	30.2	25.5	23	20.8	20.7	21.5	22.4	31	41.6	35	28	40.5	39.6	35.7	35	24.7	19.7
47.6	46.9	48.1	40.6	54.7	42	43.8	44.7	45.1	43.8	44	48.5	46.1	48.4	42.1	36.4	37.5	32.8	30.4	26	23.7	28.4	44.7	10.4	-2.8	11	11.2	10.3	11.9	17.3	13.6	17.1	7.9
40	35.4	33.6	28.8	29.4	32.9	35.3	36	40.3	42.4	41.4	42.2	36	33	27.3	26.6	27.3	24.6	23.2	19	15.7	12.9	12	27.4	36.5	33.8	38.5	34.9	31.9	21.1	39.6	37	27.3
44.9	39.3	38.9	37.9	39.2	55.5	63.3	74.4	93.5	114.2	93.7	74.3	63.6	49.4	46.5	34.4	30.5	25.5	23.1	21	20.5	21.5	22.8	36	29.9	21.6	26.4	21.5	26.9	22.4	23.9	24.5	25.8
52.2	45.8	44.3	45.1	47	50.2	54.5	61	62.2	62.2	58.8	56.8	53	49	45.1	41.1	38.3	37.3	31.9	37.9	24.7	20.9	33	8.5	5.8	7.1	1.9	7.1	16.3	12.7	14.5	15.7	10.8
25	18.5	21	21.8	21.3	19.1	19.5	20.5	20.2	20.1	19.2	19.6	20.9	20.7	18.7	17.7	17.4	17.1	16	14.9	12.7	9.5	12.9	29.4	36.6	24.8	39.5	26.3	41.8	41.4	35.1	30.6	33.2
44.9	41.2	53.8	45.6	45.6	56	63.9	74.6	93.6	114.3	93.7	74.3	63.7	49.4	46.8	34.5	30.7	25.7	23	21.1	20.8	21.5	22.3	33.9	28.3	16.9	20.6	22.4	29.5	27.1	23.8	34.3	27
46	45.1	46.2	38.9	36.6	41.2	44.5	45.5	44.2	44.6	39.7	42.9	39.5	37.8	37.6	38.1	37.1	30.4	24.7	23.6	20.9	32.3	51.3	3.7	10.8	4.2	8.7	11.9	14.6	16.6	14.2	17.5	13.1
26	24.8	21.6	20.5	19.6	23.6	22.2	25.8	19.3	15.7	15	13.6	11.9	11	10.2	12.6	9.4	9.5	10.2	9.1	7.2	5.4	7.7	38	28.1	38	33.3	35.3	33.1	36	32.2	39.7	21.5
37.6	40.1	45	47	45	56.2	65.2	74.6	93.6	114.3	93.8	74.4	63.7	49.5	47	34.5	30.7	26.4	23.1	20.9	20.6	21.4	22.2	44.3	36.9	17	24.3	28.2	26.7	23.8	23.4	21.5	23.4
46.3	37.2	42.7	42.1	45	48.9	52.1	56	58.2	56.4	55.4	52.3	48.2	43.3	40.3	38.1	32.9	32.6	28.6	27.3	25.8	24.1	24.4	0.8	1.9	7	12.6	11.3	11.8	9.4	14.3	15.8	13.8
22.4	24	23.2	25.9	24	20.9	23.2	21.5	17.8	17.7	10.9	16.9	12.1	8.8	7.9	6.8	6.8	6.3	6.9	7.3	5.7	4.9	10.3	26.3	35.9	45.2	37.6	26.3	24.1	26.5	39.6	32.6	39
39.8	40.9	49.8	45.2	40.3	55.6	63.5	74.5	93.6	114.3	93.8	74.4	63.7	49.5	47.2	34.6	30.7	25.9	22.9	21	20.6	21.5	22.3	37	33.9	42.1	30.9	29.3	21.7	30.3	29	25.8	23.9
36.5	38.1	39.4	40	39.6	39.9	42.9	43.3	43.7	46.4	49.9	48	46.3	43.1	39	38.5	40.5	37.4	32.7	29.8	23.9	26.8	27.5	5.2	8.1	8.1	9.8	10.3	10.3	11.2	7.2	12	11.3
28.2	29.5	28.3	28.6	27.8	29.2	31.7	34.3	36.9	34.9	35.2	33.6	33.1	33.7	26.6	25.7	22	20.2	19.3	17.6	15.4	12	13.3	29.8	21.1	32.5	36.4	30.5	25.2	32.2	37.9	26.6	30.1
47.3	38.4	38.6	41.5	42.9	55.7	63.5	74.5	93.6	114.3	93.8	74.4	63.7	49.5	47.3	34.7	30.8	25.8	22.9	20.8	20.7	21.5	22.3	40.4	35.8	36.6	21.6	13.3	21.4	23.3	26.2	25.2	21.5
57.6	53.6	57.6	60.3	64.2	65.1	65.2	66.3	64.5	62.2	60.1	57.3	54.3	50.8	47.8	45.6	41.9	37.5	33.5	26.6	26.3	21	19.4	6.5	1.4	4.6	6.3	13.2	13.2	12.8	9.5	12.7	7.3

RECEIVED: 11/04/2023

4.0 Hz	5.0 Hz	6.3 Hz	8.0 Hz	10 Hz	12.5 Hz	16 Hz	20 Hz	25 Hz	31.5 Hz	40 Hz	50 Hz	63 Hz	80 Hz	100 Hz	125 Hz	160 Hz	200 Hz	250 Hz	315 Hz	400 Hz	500 Hz	630 Hz	800 Hz	1.0 kHz	1.25 kHz	1.6 kHz	2.0 kHz	2.5 kHz	3.15 kHz	4.0 kHz	5.0 kHz	6.3 kHz	8.0 kHz	10.0 kHz
46.8	34.6	35.3	40.4	38	42.9	67.8	53.1	38.5	44	47.2	42.6	40.1	41.9	39.7	34.2	32.5	31.3	33.9	33.2	55.2	63.1	74.2	93.3	114	93.5	74.1	63.4	49.2	45.8	34.1	29.7	24.9	22.6	19.7
34.9	40	37.7	37.4	32.5	39	42	39.5	40.7	40.1	36.9	40.2	38.4	39.8	34.1	29.8	33.1	32.3	29.5	29.6	31.4	30	28.8	25.7	26.8	28.2	29.1	28.5	28	25.2	22	19	16.4	13.8	10.8
18.9	15.9	20.4	16.2	13.6	17.6	21.3	17.1	20.4	16.4	20.3	20.8	24.3	17.1	20.2	19.5	17.3	20.5	20.4	20.6	18.7	19.1	20.3	28.7	25.9	14.9	13.2	14	7.8	8.1	8.6	8.9	9.8	10.5	11.5
31.7	26.6	26.9	24	28.4	29.9	31.7	30.7	33.4	32.8	33.1	31.8	29.8	22.3	23.6	16.5	14.9	19.3	19.1	18.1	16.7	17.2	17.6	23.8	18	7	3.5	2.4	3.2	3.7	4.2	4.8	6.1	4.8	5.5
36.9	43.8	44.1	40	40.7	41	41	37.8	43.3	39.8	42.3	40.8	38	36.8	37.1	33.9	29	25.8	26.5	24.8	23.4	25.5	29.1	34.2	29.1	19	13.7	14.2	13.2	14.5	15.9	16.2	17.2	18.3	18.5
48.6	41.1	39.3	46	45.7	42.6	40.5	32.7	35.6	32.2	35.4	40.3	30.8	31.1	28.3	22.1	18.1	21.8	23.8	23.6	55.1	63	74.1	93.2	114	93.5	74.1	63.3	49.1	45.8	34.1	29.7	24.7	22.7	19.8
20.8	19.7	17.2	20.3	23.2	24.9	27.9	28.7	29.8	28.9	27.9	27.9	26.7	24.1	17.2	13.7	13.7	15.9	18.8	19.9	20.5	21.1	21.3	23.1	24.7	20.2	17.4	14.4	11.4	9.2	7.9	7.1	6.1	5.5	5.6
34.7	34.1	33.5	34	43.9	40.7	39.8	44.7	43.8	44.7	44.7	45	49.2	46	45.6	39.8	34.4	35.6	34	37.7	40.8	43.6	46.8	50	47.7	47.5	44.5	41.7	37.9	34.7	30.1	25.2	21.1	16	11.2
37.7	41.2	34.9	31.6	33.4	41.5	42.2	39	40.4	40.3	41.9	37	36.4	35.7	32.2	27.4	27	23.6	19.7	19.3	17.3	18.3	19.7	23.7	18.1	12.2	12.2	14.1	13.3	14.2	15.9	16	17	17.4	18.6
41.7	36.1	41.5	34.7	35.5	38.8	38.4	30	36.8	39.8	39.4	35	32.3	30	27.3	24.1	20	20.1	20.5	22.2	55.1	63	74.1	93.2	113.9	93.4	74	63.3	49.1	46.1	34.1	29.5	24.8	22.7	20
10.3	16.9	18.7	21.7	22.4	26.1	26.7	24	28.2	30.2	31.2	27.7	28.6	25.4	20.5	19	17	14.1	14.3	15.6	17.7	18.9	21	21.9	20.7	18.2	15.7	11.4	8.6	6.5	6	5.2	5.1	4.9	5.4
35.2	27.6	36	23.9	31.1	34.3	37.2	38	36.7	40.6	35.4	44	34.1	31.2	26.4	24.1	21.6	20.5	21.7	23.7	29.6	27.1	27.7	28.2	28.2	25.2	21.4	15.2	11.2	8.3	6.8	6.2	5.9	6.2	5.1
34.4	37	39.4	31.3	28.7	36.8	39.6	40.5	38.3	35.8	36.7	38.7	34.8	27.6	23.8	20	20.4	20.9	21.1	21.4	54.1	62	73.1	92.2	112.9	92.4	73.6	63	49	45.7	34	27.7	24.7	22.6	19.5
13.7	13.2	19.4	20.4	21.7	25.4	27.2	29.9	28.9	30.3	27.5	29.2	26.8	23.1	18	14.8	15.2	16.6	18.2	19.9	21.3	19.6	18.7	20.2	20.8	19.1	16.8	14	12.3	11.2	8.6	6.6	6	5.8	5.6
32	24	29.7	33.8	31.2	33.7	36.7	39.3	40.8	37.1	43.4	43.2	43.6	33.7	27.1	24.8	21.6	23.7	27.7	31.3	31.6	28.2	29.7	32.3	32.2	30.3	28.4	23	17.8	15.2	17	13.5	10.8	12.4	7.1
22.5	20.3	24.5	31.5	21.7	28.6	30.5	30.1	32.5	30.4	29.6	32.2	30.6	28	27.3	23	21.9	16.4	17.3	20	53.6	61.6	72.7	91.8	112.5	92	73.6	62.9	48.9	45.6	33.9	27.4	24.7	22.7	19.2
16.4	17.4	17.6	22.4	23.1	25.5	27.7	26.5	31.1	31.3	28.1	31.2	29.9	27.7	24.4	22.5	20.1	20.2	19.4	20.9	22	23	25.7	26.2	25.8	23.6	21	18.1	13.2	10.4	8.5	7.3	6.9	6.3	5.5
29.1	30.5	34	25.1	26.5	29.9	33.9	28.2	37.9	40.4	34.1	37.1	35.6	37.5	35.6	32.1	31.9	28.5	26.7	24.4	26.5	28.6	29.2	32.3	32.7	28.9	26.7	22.4	20.2	18.8	16	13	10.2	9.3	9.6
40.2	49.9	47.7	41.5	44.6	44.1	47.5	45	40.3	43.7	41.7	37.9	38.6	33.8	35	25.9	22.5	25.2	23.8	24.8	54.9	62.9	74	93.1	113.8	93.3	73.9	63.1	49	45.5	33.9	29.3	24.7	22.7	19.3
22.5	22.5	18.8	23.7	23	25.9	37.9	33.6	33.6	32.5	32.1	34.3	29.4	25.3	22.2	17.3	16.4	18.5	20.2	22.3	23.1	22.5	23.3	25.3	26.4	23.9	20.2	15.1	11.5	9.7	8.3	7.5	7.2	6.8	6.3
69.8	66.9	71.3	68.3	71.8	63.2	64.7	58.3	56.8	54.2	58.1	54.6	52.2	57.2	62.3	45.2	41.8	43.4	45.3	48.2	52.4	51.1	51.9	54.3	54.9	53.8	51	47.8	46	45	41.5	37.4	32.7	26.7	21.2
34	29.7	29	32.5	34.2	32.7	32.1	31	36	35.4	32.3	30.6	30.2	27.4	25.4	23.1	19.8	18.4	19.1	21.1	54.9	62.8	74	93.1	113.8	93.3	73.9	63.1	48.9	45.6	33.9	29.2	24.7	22.6	19.1
18.4	21	19.6	22.2	21.8	25.6	28	24.3	28.1	29.9	24.6	28.9	27.3	25.7	23.3	21.6	19.4	18.5	18.3	20	22	22.3	23.1	24.1	23.6	21.1	18.9	16.5	14	13.1	11.6	9.8	7.8	6.7	5.7
18.6	27.4	26	28.6	33.2	37.2	38.1	36.4	39.4	39.3	37.8	35.3	40.2	32.2	29.6	28.5	23.8	23	25.5	26.9	31.2	32.8	33.4	34.2	33	30.6	26.4	23.1	19.7	17.3	14.9	11.9	9.4	7.3	6.2
16.9	16.8	17.7	21.4	23.4	24.6	29.3	27.3	29.7	26.5	25.7	27.2	25.5	21.4	18.1	16.6	15.9	18	18.7	19.9	54.9	62.9	74	93.1	113.8	93.3	73.9	63.1	49	45.9	33.9	29.5	24.6	22.5	19.6
17	11.5	14.2	17.7	18.6	21.1	25.6	26.2	24.8	25.5	24.2	23.7	24.6	20.8	16.6	16.7	15.2	17.9	20.1	18.7	17	14.7	15.7	13.3	13.4	10.6	6.2	3.9	3.5	3.9	3.9	4.4	4.6	4.7	4.8
33	24.3	26.7	27.8	32.3	34.5	30.8	32.7	35.2	35	35.9	39	45.9	42.2	34.2	27.5	26.6	30.5	33.3	33.3	35.2	37.3	37.6	40.9	43.4	39.3	36.9	30.4	26.6	22	17.9	13.5	11.5	8.4	7.7
20.2	26.3	26.1	26.6	25.2	30.7	33.3	29	28.6	32.3	32.8	34.3	32.5	28.6	26.5	22.5	18.5	17.6	18.5	20.8	55.1	63	74.1	93.2	114	93.5	74.1	63.3	49.1	46.4	34.2	29.8	24.7	22.3	19.9
15.2	12.9	17.2	18.3	16.9	19.4	21.9	22.2	24.3	25.6	24	24.1	26.8	24.4	21.1	18.3	16.9	15	14.6	14.1	14.2	15.4	14.7	13.6	13.6	10.7	7.8	4.9	3.4	3.6	3.8	4.3	4.3	4.6	5.7
26.6	26.8	27.3	27.2	25.4	26.6	27.1	27.7	32.7	32.5	37.1	33.9	33.3	31.9	31	25.2	20	19.3	19.3	22.6	25.2	26.1	30.7	34.2	35.8	34.5	30.4	22.7	16.7	11.8	8.3	5.8	5.1	5.2	6.2
31.4	33	33.7	36.6	30.1	31.2	28.5	27.7	32.4	29.5	27.9	29.5	30.1	25.3	18	14.8	14.1	16	17.7	21	55.3	63.2	74.3	93.4	114.1	93.6	74.2	63.5	49.3	46.3	34.3	30.1	24.9	22.6	19.9
13	14.3	16.4	13.2	20.6	18.7	23.7	23.8	24.5	24.4	23.3	24.2	22	17	13.2	10.2	10.2	12.5	13.7	13.3	11.1	9.7	9.7	9	7.6	5.1	4.1	3	3.1	3.4	3.7	4.4	4.4	4.5	6.6
26	31.6	36.3	28.1	36.7	28.4	36.6	32.8	35	30.3	28.3	29.6	26.3	21.5	19.4	22.6	14.8	18.4	16.5	16.8	15.5	13.6	13.3	13	11.7	11.6	8.8	6.6	6.1	6.5	5.7	6	5.9	5.8	7.8
21	23.9	24.5	25.5	20.6	20.3	25.1	27	29.5	26.1	24.8	27.8	26.7	25.6	23	23.3	20.9	17.3	18.3	21.5	55.3	63.2	74.4	93.5	114.2	93.7	74.3	63.6	49.3	46.6	34.4	30.3	25.1	22.3	20.2
12.8	17.6	18	18.7	17.4	20.9	22.7	22	26.7	23.5	24.1	24.9	26.5	24.4	20.2	17.8	16	15	13.3	14.9	14.6	15.6	14.8	11.7	11.7	7.6	6.1	3.9	3.2	3.5	3.8	4.2	4.5	4.5	6.2
24.8	19.1	31.2	37.8	29.3	24.3	28.7	31.8	35.7	30	30.4	31	31.8	29.8	25	23.5	20.2	15.4	18	16.7	19.8	20.2	23.6	14.8	13.5	10.2	7.7	6	5.1	5.4	6.4	5.7	5.8	6	6.5
23.3	18.3	21.3	21.7	22.5	22.8	27	28.8	24.8	27.3	29.6	27.3	25.8	24.8	26.6	18.7	16	15.5	18.3	20.5	55.3	63.3	74.4	93.5	114.2	93.7	74.3	63.6	49.4	46.8	34.4	30.3	25	22.4	19.6
14	11.1	14.2	17.2	19.5	19.8	23.2	23.7	25.8	24.1	24.7	22.8	22.8	19.8	16	12.7	12.3	14.2	16.7	16.3	13.3	10.6	10.6	10.7	7.7	4.6	3.5	2.6	3.3	3.6	4	4.2	4.4	4.5	5.4
36.8	26.8	36.7	35.5	34.9	35.8	38.3	35.5	40.3	33.8	32.9	28.8	28.9	22.4	21.1	21	22.6	22.4	23.4	23.3	20.1	21.7	20.2	16.5	15.8	9.6	14.2	10	7.5	7.2	6.5	6.5	6	6.4	6.9
22.6	23.7	27.2	25.4	22.4	25.7	29	24.5	30.4	27.5	26	26.4	27.4	28.2	24.9	22.5	20.4	18.2	18.8	21.7	55.3	63.3	74.4	93.5	114.2	93.7	74.3	63.6	49.4	47	34.5	30.3	25.2	22.3	20.1
11.1	11.4	16.6	16.6	18.6	20.7	20.1	21.3	24.3	23.2	22.8	23.9	23.7	22.9	20.1	18.9	17.2	15.2	15.9	13.4	14	13.1	12.3	9.4	8.5	4.8	3	2.7	3	3.3	3.7	4.3	4.3	4.5	4.6
29.9	31.1	30.8	26.9	24.7	30.6	22.9	28.2	30.8	31	28.4	26.1	30.2	26.8	25.9	20.8	19.5	18.2	18	20.1	21.1	21.2	22.1	26.6	28.3	25.7	21.7	17.7	10.8	8.9	8.7	9.5	7.8	6.2	6.3
17.3	16.5	21.2	25.1	25.1	31.8	29.3	29.5	29.6	28.4	26.1	28.5	23.6	21.4	18.5	15.1	16.5	19.8	23.9	24	55.4	63.3	74.4	93.6	114.3	93.7	74.3	63.6	49.4	47.1	34.5	30.3	25.2	22.2	19.8
8	11.7	13.2	15.1	19.1	19.9	23.3	23	27	23	23.6	24.5	22.3	19.2	18	13.9	14.3	14.5	16.4	17.7	14.3	12.9	13.3	11.7	10.5	7.9	4.4	2.9	2.9	3.5	3.9	4.3	4.5	4.7	4.9

RECEIVED: 11/04/2023

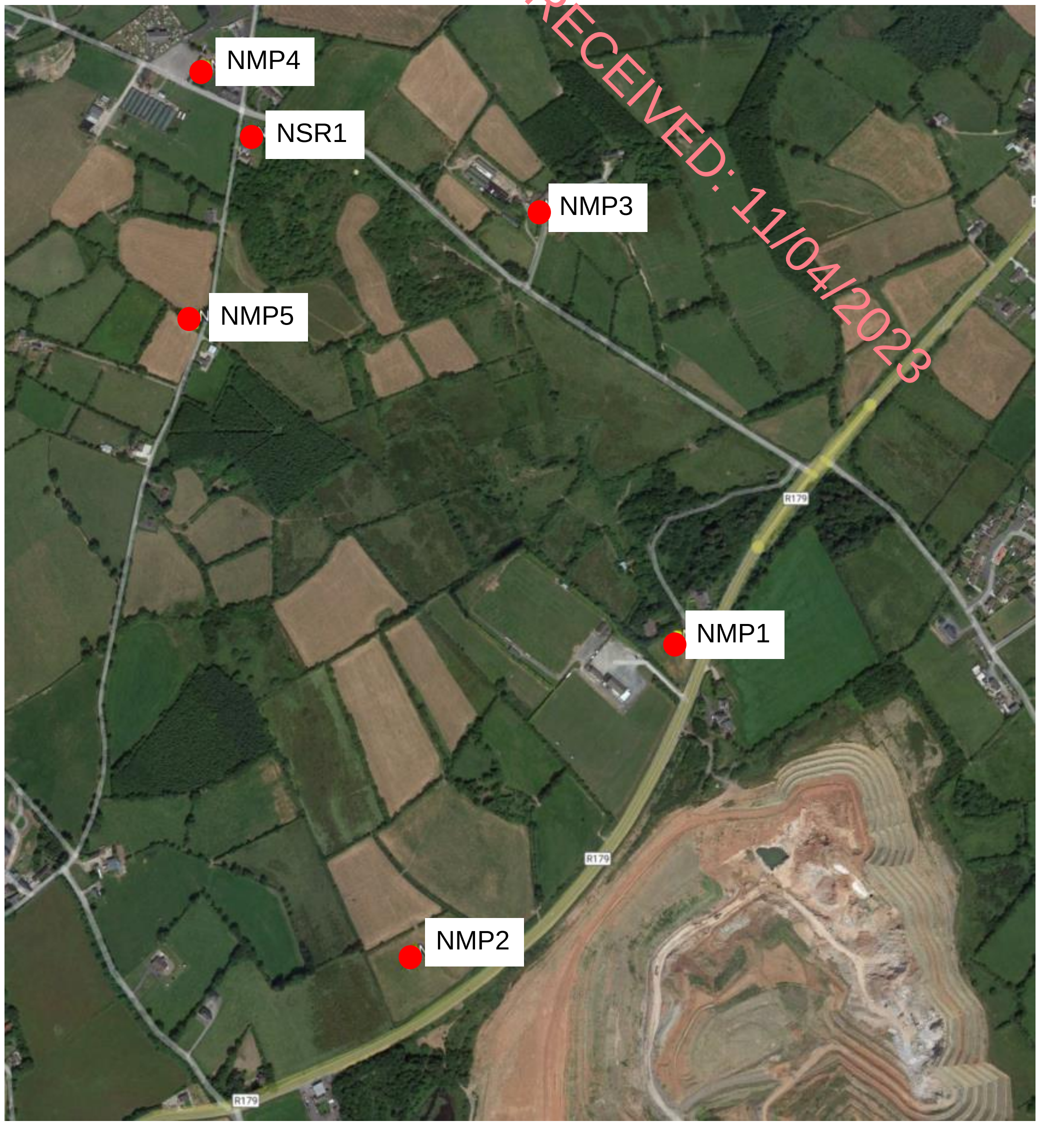
12.5 kHz	16.0 kHz	20.0 kHz	LfF,Perc4 0.4 Hz	0.5 Hz	0.63 Hz	0.8 Hz	1.0 Hz	1.25 Hz	1.6 Hz	2.0 Hz	2.5 Hz	3.15 Hz	4.0 Hz	5.0 Hz	6.3 Hz	8.0 Hz	10 Hz	12.5 Hz	16 Hz	20 Hz	25 Hz	31.5 Hz	40 Hz	50 Hz	63 Hz	80 Hz	100 Hz	125 Hz	160 Hz	200 Hz	250 Hz	315 Hz	400 Hz	500 Hz
20	21.1	21.7	82.2	79.4	78	71.6	65.8	63	60.8	61.6	60.7	62.4	61.8	57.8	54.6	56	55.8	55.8	70.6	57.5	53	55.1	57.1	53.9	50.4	51.5	59.6	53.4	51	59.2	53.6	56.4	61	65.1
9	5.9	5.2	69.9	70.5	70.7	71.5	70.6	69.4	69.6	69.2	69.2	66.6	65.6	66.1	63	61.7	58.6	57.3	58.2	52.8	55.5	56	62.4	58.9	52	56	61.5	61.1	56.3	63.3	62.3	62.8	68.1	67.3
12.5	12.6	15	95.1	93.1	89.7	82.1	75.8	73.3	66.7	69.3	65.1	66	67.7	65.4	61.9	60.8	60.1	59.1	56.9	55.5	53.5	50.7	52	53.5	51.3	48.5	46	41.3	36.5	35.5	33.9	31.4	34.1	37.5
5.5	4.3	11	82.7	79.1	80.7	78.4	73.8	64.5	65.9	60.9	56.3	53.9	52.7	51.7	53.1	49.3	48.4	46.2	45.9	47.3	48.1	46.9	44.9	46.9	48.9	46.5	44.9	42.4	37.1	34.5	34.1	34.1	35.4	40.1
19.6	20.7	21.8	84.6	82.7	70.4	65.8	61.3	61.4	64	59.4	65.2	60.4	64.7	68.2	64.9	67.2	66.2	64.1	61.2	61.8	61.6	61.4	59.1	67.3	75.7	56.5	55.5	58.3	49.1	48	49.1	52.1	49.5	53.4
20.1	20.8	21.7	66.2	67.8	74.9	78.1	75.2	75	72.1	76.2	75.4	71.3	71.7	74.3	71.8	73.5	69.5	66.5	65.3	63.9	62.5	60.1	60.2	58.8	56.3	54.3	54.2	51.3	48.7	49.7	44.6	44.1	55.7	63.2
6.2	4.1	5.9	65.1	66	66.7	66	65.1	65	64.2	63.2	61.7	59.8	57.6	56	54.4	52.9	52.4	53.1	54.3	54.4	53.7	54.3	53.5	58.6	62	57.3	52.9	50.9	45.5	45	45.7	48.4	50.3	53.5
7.6	4.7	5.1	53.6	68.9	65.8	55.5	58.8	55.6	60	54.4	52.4	50	50.8	48.5	48.2	46	58.6	55	54.8	54.2	53.3	52.8	51.6	55.6	67.4	57	52.4	48	43.8	39.4	41.2	42.2	47.5	51.9
19.7	19.8	21.7	83.5	78.2	79.1	76.8	69.4	75.5	69.7	68.7	63.6	66.3	58.6	65.7	61.7	61.8	59.4	63.5	57.7	54.1	56.6	59.1	55.3	48.1	50.7	46.3	45.7	41.7	45.5	46.5	46.9	45.5	41.5	41.5
20	20.8	21.9	79.2	72.4	75.4	77.1	70.9	69.5	70.3	63.3	63.8	60.7	57.3	60.1	59.5	56.9	55.3	56.1	55.9	53.1	52.2	51.1	49.4	46.6	47.3	42.4	38.4	32.9	30.3	27.7	26.3	27.6	55.2	63.2
4.7	4	4	63	63	62.3	63.5	61.4	59.9	58	57.8	55.5	52.2	50.4	48	45.1	45.1	45.2	47.8	48.3	43.8	47.5	49.5	47.7	47.4	51.6	46.3	42.9	39.1	35.5	32.8	30.4	31.5	33.3	36.5
5.5	4.2	4.1	46.4	46	48.2	48.2	44.5	49.2	45.2	41	49.4	44.8	41.6	38.4	42.4	36.8	40.6	44.2	47.2	45.6	45.2	49.2	44.8	49.4	40	35.7	30.2	28.6	26.2	24.4	27.2	27.6	33.4	30.4
19.9	20.8	21.9	80.3	76.6	76.6	70	70.1	69.3	71.2	68.3	69.9	71.6	71.2	70.8	69.8	69.8	71.9	69.6	66.7	64.3	63.6	60.6	58.8	57.9	55.3	53.4	48.7	45.4	42.9	39.1	34.4	31.7	55.2	63
4.9	4	4	65	67.1	68.2	68.2	67.6	66.6	66	65.3	64.2	62.6	60.2	58.2	55.9	54.4	52.5	51.4	51.3	50.4	51.6	51.6	51.9	57.1	58.2	55.7	49.3	44.9	41.1	39.9	42.2	43	45.3	49.2
6.5	4.4	3.9	55.6	50.5	45.2	45.4	45.3	40	44.4	52.8	41	39.2	39	42	40	43.1	43.4	47.8	49.8	48.2	46	45.6	49.6	50.2	50	41.4	34.2	31.4	26.5	28.2	31.6	35.6	35.2	32.4
19.9	20.7	21.6	81.6	78	68.3	65.6	66.3	59	59.8	62	58.3	62.8	62.1	61.2	63.1	58.7	57.7	58	56	55	54.6	55.6	54.2	53	49.8	47.3	44.2	40.1	35.9	30	25.9	25.1	55.2	63
4.9	4.1	3.5	67.4	68.8	67.8	67	66.6	65.3	64.7	63.2	61.7	59.6	57.1	54	51.4	48.9	47.1	48.4	49.2	46.1	50.2	50.8	49.7	49.9	51.6	46.1	44.7	42.1	38.4	35.6	34.9	34.9	36.2	37.8
8	6.5	5.1	57.1	60.5	60.5	59.8	58.1	57.2	56.2	60.3	55.3	56.3	54.5	52.8	54.7	45.5	45.9	42.3	49.5	41.5	48.8	48	44.9	42.8	45.9	45.3	42.5	41.3	37.6	37.8	30	29.3	33	35.6
19.7	20.8	21.7	70.1	72.6	75.1	75.8	75.6	77.8	78.4	78.2	77.8	79.6	72.8	75.6	75	74	77.6	72.8	72.4	69.4	66.4	64.4	62.1	61.3	59	58.1	57.1	54.6	51.4	48.2	43.9	41	55.2	63
6.1	4.3	3.9	70.6	70.3	72.6	72.5	72	71.7	70.6	70	69	67.9	65.6	64	62.1	59.9	57.8	56	57.2	53.7	53.8	53.7	56.6	56	57	55.9	49.2	44.2	39.5	38	41.2	43.4	45.5	49.2
17.4	13.1	9.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19.8	20.7	21.6	67.7	66.9	62.4	62.7	56.5	60.1	57.2	58.6	54.1	57.9	57.8	57.2	56.2	56.2	55.5	50.7	50.6	49.4	48.6	48.3	44	43.2	42.2	36.6	33.7	30.3	27	24.2	24.2	26	55.1	63
5.1	4.1	3.7	70.3	70.6	70.3	70.6	71.1	68.9	67.3	66.6	64.8	63	61.2	57.6	55.5	52.6	50.1	49.1	48.5	45.5	48	49.2	46.1	47.5	48.8	43.5	41.3	37.7	34.3	32	31.2	34	36.5	38.5
5.9	4.3	4	63.9	65.7	63.8	65.3	62.8	61	59.6	64.1	61.2	56.8	57.1	56.9	53.2	51	50.5	50.4	53.1	48.3	54.9	54.6	49.2	50.6	54.3	50.6	45.7	42.7	40.8	35.5	34.2	35.6	38.2	42.4
19.8	20.7	21.5	69.8	64.2	62.3	58.6	52.8	48.7	48.5	48.2	47.1	45.3	42.5	40.2	40.1	39.5	39.5	39.2	43.1	39.7	41.7	37.1	37.2	36.1	34.1	29.3	24.6	22.8	21.9	23.8	24.5	24.5	55.2	63
4.4	3.8	5.8	49.8	48.3	48.4	46.9	49.6	47.5	47.1	48.1	46	43.6	41.6	40.1	39.5	40.4	42	42.7	45.6	45.6	46.6	46.9	47.4	50.7	51.9	49.7	45.3	39.6	34.4	34.5	37.7	39.4	41.5	44.9
6	4.4	6.8	41.5	45.5	44.1	41.9	48.5	44.3	45	44.5	45.5	43.1	42.3	34.7	42.9	42.9	45.3	43.7	45.3	45	48.3	48.4	48.7	48.7	57.3	52.6	46.3	41.5	35.7	37.7	41.3	41.8	45.3	49.9
19.9	20.5	21.7	65.2	60.2	55.2	54.2	56.2	60.7	55	55.9	55.5	54.8	52.2	51	47.8	52.8	47.8	45.7	47.4	43.9	43.8	47.5	46.8	52.2	47.4	37.6	39.3	31.9	29.6	25.2	24.6	26	55.2	63.2
4.2	3.6	3.7	47	46.5	47.7	46.9	48.9	48.3	48.9	49.2	46.8	43.3	41.3	39.4	39.8	40.3	40.7	41.5	43.1	40	43.5	46.6	41.5	42.3	43.2	39	37.2	32.7	31.8	30.7	27.9	29.7	30	32.2
4.8	3.9	6.6	40.4	51.6	48.8	48.4	46.9	44.9	48	53.2	46.5	46.1	42.7	38.1	39.8	40	39.1	41.6	40.5	38.1	44.5	43.1	45.9	52.1	41.4	41.7	43	37.6	31.6	27.6	26	28.3	30.8	33
19.7	20.6	21.7	53.8	52	43.3	44.3	49	44.7	47	50.1	46.5	43.5	47.9	48.3	50.4	52.2	45.3	49.2	46.8	48.1	49.1	47.2	46.7	47.6	48.4	49.2	49	38.8	32.7	34.7	31.7	33.9	55.4	63.4
4.3	4.1	8	45.2	45	45.2	43.6	47	47	45.6	48	43.7	41.1	38.7	38.4	38.8	41	41.6	41.4	42.2	41.7	43.8	41	40.9	45	43.6	41.4	37.4	30.4	26.3	27.3	31.1	32.5	33	34.6
5	5	11	39.4	46.2	34.6	46.2	31	47	48	40.8	37.4	36.9	31.2	38.8	42.9	45.4	40.2	37	42.4	41.6	41.4	36.4	32.4	32.8	32.8	26.4	23.8	24.9	18	20.3	20.6	20	18.4	18.9
19.8	20.7	21.6	57.4	42.1	47.1	41.7	43.1	47.9	47.9	46.3	48.3	45.1	42.2	40.3	39.9	41.6	39.9	38.9	39.6	37.5	40.9	39	35.6	36.5	37.8	34.4	29	31.5	27	24.6	22.5	25.3	55.4	63.4
4.3	3.7	4.3	50.1	50.5	49.5	48.4	49.5	48.5	49.1	48.2	46.3	43.4	41.4	41.3	41.9	42.4	40.7	41.4	42	39.9	43.9	42.3	38.6	40.9	41	37.9	33.8	31.7	29	28.3	25.7	26.4	31.2	30.1
5.5	4.5	5.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19.6	20.6	21.4	72.9	71.9	62.6	60.5	48.1	44.8	45.2	45	41.5	41.7	39.4	39.5	39.3	38.8	38.9	37.7	42.7	38.5	41.1	37.8	38.6	37.2	33.3	33	33.2	25.5	22	21.8	23	24.5	55.4	63.4
4.1	3.8	6.2	44.3	44.9	44.4	43.8	45.8	45.4	45.1	45.8	43.5	40.6	39	37.5	37.7	38.3	38.7	38.3	42.9	39.8	42.3	38.9	39.5	42	40.5	36.3	34.5	27.7	24.4	25.6	29.5	30.4	31.7	31.1
5.5	4.8	9.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19.8	20.7	21.4	73.3	70.7	67.5	57.7	49.5	41.5	47.3	47.6	45.6	44.1	43.2	41.8	42.5	40.6	40.3	40.1	41.7	39.7	40.8	36.4	35.1	36.7	36.6	38.1	33	29.6	25.9	25.5	23.5	26.1	55.4	63.4
4.2	3.8	4.8	50.2	48.3	48.6	47.4	48.1	46.8	46.2	46.2	43.6	40.9	39.2	38.9	39.9	39.3	39	39.2	40.9	38.2	41.7	38.7	36.7	39.7	36.2	34.9	31.3	28.8	26.5	25.6	25.3	25.1	28.7	27.2
4.9	4.7	5.4	44.8	38.3	45.4	48	43.6	46.8	45.4	54.2	50.8	42.6	41.6	45	41.4	40.2	38.6	41.4	38.4	38.8	45	40.5	34.1	35.9	36	33.1	32.2	26.5	26.7	24.8	25.2	26.7	27.8	30.8
19.8	20.6	21.4	75.6	65.4	64.1	55.6	47.2	49.3	44.1	45.2	43.1	38.6	39.3	40.4	41.1	41.9	43	56.5	58.3	54.5	54.5	51.2	50.3	53.5	52.1	49.8	43.9	39.5	34.2	31	35.5	36.4	55.6	63.4
4.2	3.8	4.3	45.1	44.5	44	43.1	44.6	44.7	42.7	43.5	41.2	38.7	38	37.1	38.1	38.5	40.1	41.2	44.7	47.1	46.3	43.6	43.1	44.9	43.7	42.9	38.5	34	31	30.7	33.1	35.4	34.9	36.8

																LfF,Perc6																
630 Hz	800 Hz	1.0 kHz	1.25 kHz	1.6 kHz	2.0 kHz	2.5 kHz	3.15 kHz	4.0 kHz	5.0 kHz	6.3 kHz	8.0 kHz	10.0 kHz	12.5 kHz	16.0 kHz	20.0 kHz	0.4 Hz	0.5 Hz	0.63 Hz	0.8 Hz	1.0 Hz	1.25 Hz	1.6 Hz	2.0 Hz	2.5 Hz	3.15 Hz	4.0 Hz	5.0 Hz	6.3 Hz	8.0 Hz	10 Hz	12.5 Hz	16 Hz
74.4	93.4	114.2	93.6	74.2	63.6	49.4	46	34.2	30.1	25.6	23.2	20.4	20.7	21.6	22.3	60.3	67.6	54.2	50.6	51.2	48.2	54.3	51.2	48.6	47	49.3	39.8	42.2	44.8	43.6	45.9	68.6
64.7	60.5	55.5	56	59.9	61.1	58.9	52.8	53.8	45.9	45.1	42.7	39.3	33.5	25.6	24.3	55.7	53.9	52.7	53.5	55.5	56.1	53.9	53.7	48.6	49.3	47.8	48.4	45.3	44.2	43.2	44.7	49.5
41.4	46.5	40.7	31.1	30.8	30.7	30.1	29.8	29	28.2	27.5	26.9	26.2	25.6	25.4	25.3	71.9	69.1	60.2	53.9	56.6	51.3	49	39.7	34.9	30.9	26.9	25.9	27.7	25.9	23.5	23.3	25.9
45.3	51.1	45.7	35.5	27.7	20.5	15.1	15.9	16.8	17	18.1	18.8	19.3	20.2	21.3	23.2	62.9	58.3	50.1	43.2	40.5	36.7	38.7	42.9	41.4	37.5	36.1	32.7	33.5	32.5	35	34.8	36.1
55.8	56	48.3	36.1	28.9	22.3	16.1	16.5	17.3	17.1	18	19	19.4	20.3	21.3	22.3	67.2	62.2	53.3	48.1	49.3	46.9	46.2	46.4	50.2	49.8	44.6	48.9	49	46.6	47.5	49.7	47.8
74.2	93.4	114.2	93.6	74.2	63.4	49.2	46	34.2	30	25.2	23.2	20.5	20.8	21.4	22.2	57	48.9	65.1	62.5	62.2	58.1	63.6	58.5	54.5	57.7	54.3	49.4	50.9	51.6	51.8	49.6	43.3
56.6	58.7	58.2	55.3	52.5	48.8	45.2	41.9	37.8	33.8	31.2	27.7	22	17.5	12.2	11.8	45.3	44.5	43.8	44	43	42.3	40.4	39.4	37.5	36.7	35.6	34.8	33.7	33.8	35	36.7	38.8
57	60.2	56.9	54.3	52	48.6	46	42.8	38.8	35.2	31.7	28.6	24.3	17.4	12.4	10	38.8	60.5	58.6	38.6	50.6	42.6	50.4	45.6	41.2	37.8	40.8	38	34.5	38.8	46	44.4	44.4
46.7	50.3	48.7	38.5	38.9	36.9	26.3	22.3	20.5	18	25	19.9	20.7	21.3	21.4	22.9	70.5	62.5	55.1	64	56.1	57.5	52.8	49.5	43.1	42.3	42.2	43.4	39.5	40.7	43.9	45	46.5
74.2	93.4	114	93.6	74.2	63.4	49.2	46.4	34.2	29.8	25.2	23.2	20.6	20.7	21.4	22.7	61.7	61.9	54.7	56.7	50.7	46.5	47.3	45.7	45.6	47.1	46	46.9	46.3	42.6	40.2	43.3	43.8
37.6	38.1	37.4	34.7	31.3	26.7	22.3	19.7	17.5	16	14.5	12.5	10.7	10	10	10	41.6	40.4	41.7	40.2	39.7	37.5	35.3	34.9	33.3	31.7	31.3	31.1	31.2	32.9	34.5	36.5	36.8
33.2	32	30.6	27.1	23.8	18	13.6	10	10	10	10	10	10	10	10	10	35.4	37.4	37.2	42.1	38.8	39	38.2	31.4	41.8	36	36.2	29.6	36.8	26.2	33.2	36.4	38.4
74.2	93.4	114	93.6	74.2	63.5	49.2	47.7	35.7	29.8	25.9	23.6	20.4	20.6	21.4	22.5	64.8	53.5	59.9	56.2	58.3	53.5	50.3	48.1	47.5	41.9	46.9	52.7	49.3	51.6	49.9	49.6	49.9
53.6	56.4	56.6	53.9	51.2	46.5	42.3	38.2	34	29.8	26.6	26.8	18.5	13.5	10	10	42.6	43.4	44.3	45.3	44	42.7	41.5	40.5	37.9	36.7	35.5	34.5	33.7	34.3	34.5	36.4	38.4
33.4	35.8	36.8	34.8	31.4	28.8	25.9	23	31.8	34	28	31.4	14.3	10	10	10	45.7	29.2	35	33.8	40.4	25.8	29.2	41.6	28.2	34.6	33.2	25.2	30.6	35.8	34	37.2	39.8
74.2	93.2	114	93.5	74.1	64.8	49.4	50	38	29.8	26.7	24.1	20.2	20.7	21.5	22.4	59.7	52	55.2	50.7	46.1	43.2	43.2	40.7	38.2	35.3	37	39.6	36.2	36.6	37.2	38.1	39.3
40	41.6	42	38.5	35	30.1	25.3	23.2	21.2	19.2	17.1	15.1	13.1	12.5	11.5	10	46.9	45.7	46.3	45.4	45.4	43.3	41.8	39.7	39.2	36.4	34	33.9	33.7	34.2	35.2	37.4	38.3
35.7	37.1	36.2	32.1	30.4	25.6	23.3	21.3	18	14.8	11.9	10.8	11.6	10.8	10	10	44.3	43.5	45.3	51.3	48.4	46.3	50.1	41.5	33.9	34.1	34.3	32.3	36.3	32.3	31.1	34.9	36.9
74.2	93.2	114	93.5	74.1	63.4	49.2	45.8	34	29.6	25.2	23.2	20	20.4	21.4	22.3	54.4	56	56.8	60.7	60.4	59.6	54	56.4	53.4	56.4	56.6	57.1	54.6	51.5	50.2	50.7	50.9
54.4	56.6	56.1	53.2	50.2	45.8	41.8	38.6	34.3	30.1	26.6	23.4	19.4	17.1	15	11.9	48.4	50.8	50.6	50.6	50.3	49.3	48.9	47.9	47.5	44.6	42.5	40.9	39.4	38	37.3	38.9	48.4
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
74.2	93.2	114	93.4	74	63.4	49.2	45.8	34	29.6	25.2	23.1	19.9	20.5	21.4	22.2	44.8	56.7	48	46.1	42	46.9	45	43.6	41.3	43.4	42.2	37.8	38.2	38.3	38.6	37.5	38.2
39.6	40.5	40	36.7	32.5	28.6	24.8	22.9	21.6	19.7	17.9	15.8	13.3	11.6	10.9	10	48.6	49.9	50	48.3	47.6	45.3	43.9	42.3	39.6	37.8	36.4	34.6	33.9	34.1	34.9	37.3	37.4
41	40.4	40	36.4	32.8	28.6	25	22	19.3	18.3	15.6	12.2	10	10	10	10	46.4	51.7	49.5	50	50.3	49.9	45.7	41.8	40.5	41.9	37.2	34.5	36.6	36.7	39.3	42.5	44
74.2	93.2	114	93.5	74.1	63.3	49.2	46.1	34.2	29.9	25.1	23	20.2	20.5	21.3	22.2	50.5	35.8	37	34	38.3	31.2	37.3	33.7	33	29.4	28.1	26	29.1	28.6	30.4	30.2	32.7
48.7	52.3	52.9	50.5	47	43.4	39.2	35.5	30.6	25.4	20.9	17.2	13.4	10.1	10	11.6	30.2	30.2	31.4	29.9	34.8	33.5	33	34.2	32.4	30.8	29	27.7	28	29.5	31.1	31.6	34.7
53.2	55	54.7	54.1	48.9	44.9	41.3	37.4	33.3	29.3	26.7	27.5	21.3	17.3	12.5	10.9	30.7	36.3	35.9	32.7	43.4	36.3	40.3	32.9	34.5	36.9	35	27.5	30.3	30.9	35.1	36.1	35.3
74.3	93.4	114.2	93.6	74.2	63.4	49.2	46.6	34.4	30.2	25.2	22.8	20.6	20.5	21.2	22.2	40	46.5	40.8	35	44.3	43.8	39.6	44.6	34	35.2	30.4	32.5	33	34.1	33.5	35	38.7
34.8	37.1	36.4	34	30.2	24.6	19.1	15.8	13.3	11	10	10	10	10	10	10	29.8	28.5	32.1	30.9	33.1	33.9	35.2	35.1	33.7	30.9	28.9	28	28.8	29.8	30.2	31	32.5
34.7	38.6	40.7	39.5	36.7	33	27.7	23	19.6	19.6	16.6	13.4	10.4	10	10	10	31	39.4	37.2	41.7	38.6	35.4	32.4	41.9	39.8	32	31.2	30.1	31	32	30.6	30.2	31
74.4	93.6	114.2	93.8	74.4	63.6	49.4	46.6	34.4	30.4	25.3	23	20.5	20.3	21.2	22.6	41.5	35.1	29.9	33.5	35.7	36.5	33.6	34.6	36.1	31.5	38.4	38.3	41.1	40.6	35.4	37.9	36
37.6	41.8	42.6	39.9	36.5	31.2	26.6	22.9	19.4	17.1	14.5	11.7	11.1	10	10	13.5	27	29.6	30.9	28.4	33	33.9	31.8	34.8	31.4	28.5	26.5	26.9	28	30	31.1	31.1	32.9
20.1	19.8	19.5	18.2	18	19	19.2	16.6	15.2	15.4	14.2	12.8	12.2	10.6	10	12.3	29.8	37.2	25	40.3	26.6	42.2	42.4	36	31.2	33.4	26	33.8	36.6	28.4	37.2	29	37
74.6	93.6	114.4	93.8	74.4	63.8	49.5	46.8	34.6	30.6	25.6	22.8	20.8	20.4	21.2	22.1	41.7	31	32.3	32.4	27.5	35.5	34.8	32.9	39.4	35.9	28.4	30.3	30.5	30.2	28.4	29.9	31.6
33.9	33.7	32.7	30	26.1	21.5	16.2	14	10.7	10	10	10	10	10	10	10	31.6	33.4	33.3	31.4	33.9	33.7	34.8	34.1	32.5	30.9	29.6	30.1	30.6	31.3	30.6	30.4	31.6
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	40	28.4	38.4	33.6	36.3	33.9	36	34	39.8	23.8	25	21	33.2	38	29.4	25.6	29.3
74.6	93.6	114.4	93.8	74.4	63.8	49.6	47	34.6	30.6	25.6	23	20.4	20.3	21.2	22	51.6	43.9	36.5	34	34.8	35.3	30.9	30.4	30.6	30.3	27.4	26.7	26.5	28.9	27.9	29.7	32.1
32	35.8	37.3	33.9	31.7	26.8	22.5	19.8	17.2	15.5	13.6	10.8	10	10	10	12.2	27.6	28.6	30	30.6	31.5	32	31.7	32	30.1	27.7	27.2	26.2	26.9	27.9	28.7	29.4	33.5
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
74.6	93.6	114.4	93.8	74.4	63.8	49.6	47.2	34.6	30.8	25.8	22.8	20.8	20.4	21.2	22.1	51.2	42.9	45	36.8	35.4	28.7	37.3	35.5	34.9	32.1	30.6	31.3	30.9	31.9	29.9	30.2	32.4
28.7	29.7	30	27.8	24.3	19.7	14.8	14.6	12	10.4	10	10	10	10	10	10	29.5	30.2	31	30.4	32.6	32.3	31.6	32.7	30.3	27.5	27.2	27.3	28.8	29	29.4	29.6	31
33.3	34.6	32.8	32.1	29.8	27	25	22.2	21.1	20.1	19.6	18.3	16.5	14.4	11	12.2	34	24.2	35	38.4	32.4	29.7	34.2	42	32	33.8	32.2	34.6	32.2	30	28	32.8	25.8
74.6	93.7	114.4	93.8	74.4	63.8	49.6	47.4	34.7	30.8	25.6	22.7	20.5	20.4	21.2	22	52.2	44	43.5	32.8	32.3	32.3	28.6	34.7	32.1	27.7	25.9	23.5	28.3	29.5	31	38.8	37.4
38.8	40.5	40.8	38.2	35.8	31.1	26.1	23.1	20	17.2	15.6	13.7	11.1	10	10	13.3	28.9	27.5	28.4	27.7	31.1	30.7	29.7	29.2	28	26.1	25.1	25.6	26.6	27.7	29.3	30.4	34.2

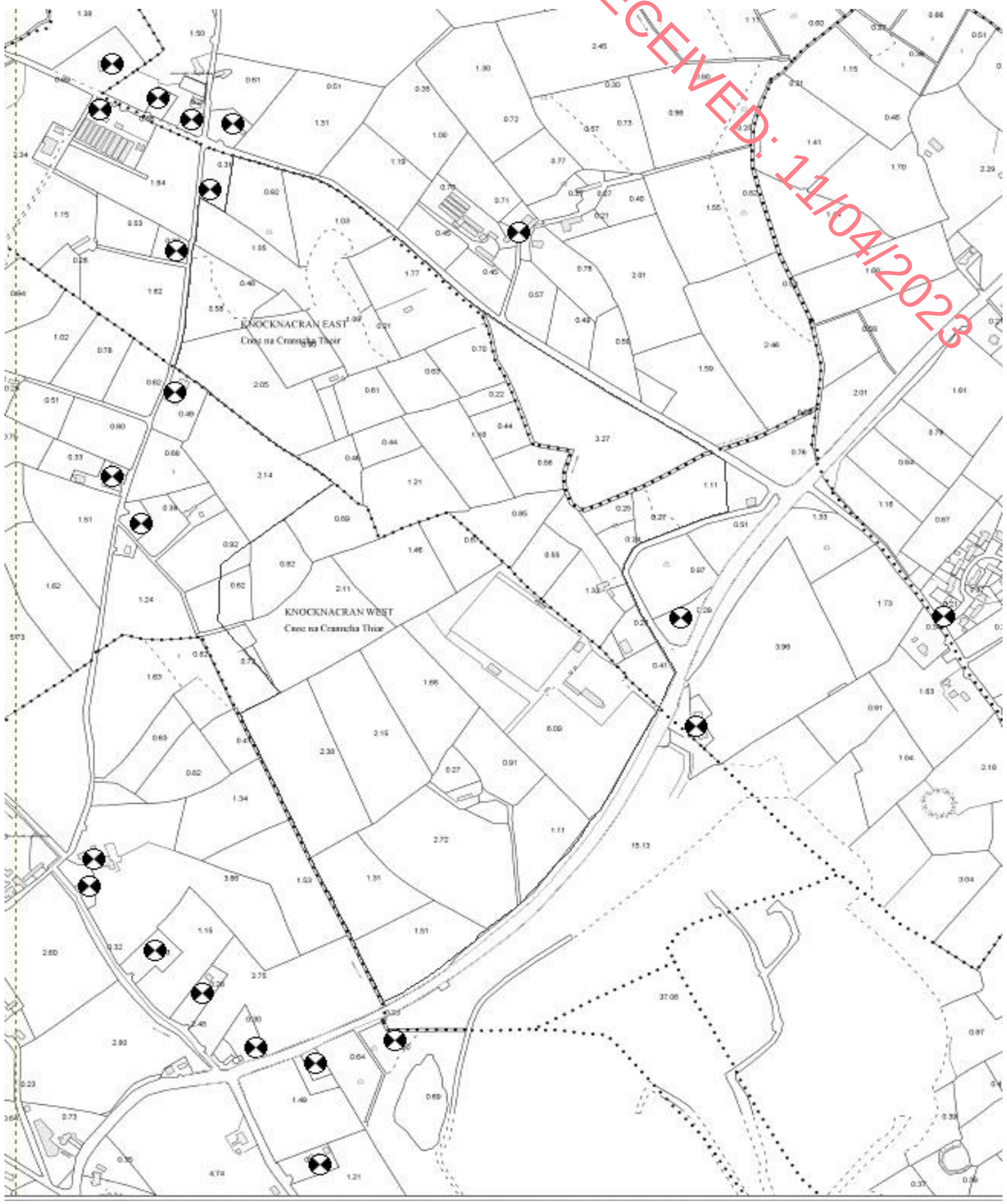
20 Hz	25 Hz	31.5 Hz	40 Hz	50 Hz	63 Hz	80 Hz	100 Hz	125 Hz	160 Hz	200 Hz	250 Hz	315 Hz	400 Hz	500 Hz	630 Hz	800 Hz	1.0 kHz	1.25 kHz	1.6 kHz	2.0 kHz	2.5 kHz	3.15 kHz	4.0 kHz	5.0 kHz	6.3 kHz	8.0 kHz	10.0 kHz	12.5 kHz	16.0 kHz	20.0 kHz
55	44	48.4	50.4	47.2	43.2	45.1	43.8	36.5	39.2	42	37	38.8	55.3	63.1	74.2	93.2	114	93.4	74	63.2	49.1	45.8	34	29.8	25	22.8	19.9	20.2	21.2	21.9
44.2	47.4	45.6	45.4	48.9	42.6	44.7	39.8	35.3	41.3	44.3	40.5	43.5	47.6	44.4	41.2	35.3	34.1	35.1	37.9	38.7	36.7	33.8	33.1	28.2	25.5	23	19.7	15.1	10	9.9
25.4	27	28.6	27.7	29.5	31.6	27.7	26.3	22.6	21.1	22.5	22.5	22.5	22	22.1	24.7	30.5	28.6	16.8	14.1	14.9	13.8	14.9	16.1	16.3	17.3	18.4	18.8	19.8	20.8	21.8
36.6	36.7	37.7	36.2	35.6	32.1	27.6	28.6	20.2	19.3	21.1	21.1	21.4	19.1	19	20.4	25.1	19.4	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.9	12.5
47.4	48.1	45.6	46.9	46.6	45.1	43.8	42.8	38.4	33	30.1	29.4	28.5	26.5	28.1	31	35.5	30.9	20.7	15.3	14.9	14	14.9	16.3	16.4	17.4	18.5	18.8	19.8	21	22
41.1	42.1	39.5	40.3	44.3	35.3	35.7	31.5	25.1	24.1	25.7	26	26.5	55.1	63	74	93.2	113.8	93.4	74	63.2	49	45.8	34	29.8	24.9	22.8	20	20.3	21	21.9
38	38.4	37.9	37.3	38.3	38.2	33.4	27.2	22	22.1	24.6	26.3	27.6	28.7	30.1	30.3	33.2	33.4	30.4	27.6	21.9	17.1	14.7	12.3	10	9.9	9.9	9.8	9.8	9.8	9.8
50.1	46	47.4	46.5	46	57.8	51.8	46.8	41.6	35.6	36.2	36.2	38.8	42.6	45.7	49	51.4	49.2	49	45.4	42.4	38.4	35.3	31.6	26.8	22.6	17.3	11.6	9.9	9.8	9.8
43.6	44	46.9	44	40.5	41.2	39.1	35.5	31.9	29.2	25.4	23.1	20.9	18.7	19.7	21.7	24.9	19.1	12.9	12.9	14.6	14	14.8	16.3	16.4	17.2	18.4	18.9	19.9	20.8	21.9
39.6	41.9	44	42.5	37.7	36.1	32.8	30	27.2	22.9	21.8	22.1	23.9	55	63	74	93.2	113.8	93.4	74	63.2	49	46.1	34	29.6	24.9	22.8	20.1	20.2	21	22.1
34.3	37.1	40	37.5	35.4	34.8	31.6	27.4	24.2	21.4	20.6	20.4	21.5	23	25.2	26.7	27.8	27.3	24.1	20.3	15.5	11.6	9.9	9.9	9.8	9.8	9.8	9.8	9.8	9.8	9.8
38.8	37.6	42.8	36.6	45.2	35.2	32.4	27.7	24.6	22.4	21.3	22.4	24.4	30.6	28	28.4	29	28.6	25.8	21.7	15.7	11.4	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8
47.8	48.2	45.9	43.5	43	39.8	37.2	31.8	27.7	25.8	24.1	24.3	24.1	54.9	62.8	74	93	113.8	93.2	73.8	63.2	49	45.6	34	29.4	24.9	22.8	19.7	20.1	21	22.1
38.1	39.9	38.6	38	38.3	36.7	33.9	27.7	22.1	21.2	23.4	25.4	26.7	28.1	28	28.1	31.9	32.3	29.3	26.7	20.9	16.6	14.5	12.6	10	9.9	9.9	9.8	9.8	9.8	9.8
42	41.6	39.4	44.3	44.9	44.7	35.2	28.7	26.2	22.7	25.5	29.1	32.8	32.8	29.2	30.4	32.7	33	30.7	29	23.4	19.6	15.8	18.8	14.2	13.4	14.8	9.8	9.8	9.8	9.8
35.4	41.1	38	35.6	36.2	36.8	32.3	32.4	27.7	24.7	20	19.9	21.9	54.8	62.8	73.8	93	113.7	93.2	73.8	63	49	45.6	33.8	29.3	24.9	22.8	19.6	20.1	21	21.8
35.9	40	40.5	38.6	38	38.1	33.2	30.8	29.4	25.9	25.3	24.5	26	27.3	29	31.1	32.1	32	29	25.5	21.5	17.6	15.2	12.6	10.5	9.9	9.9	9.8	9.8	9.8	9.8
33.7	40.7	42.1	38.3	39.1	38.9	40.3	37.3	35.2	33.2	30.6	27.9	26.1	28.1	29.7	30.5	33.8	33.3	29.9	27.2	23.3	20.7	19.1	16.5	13.4	10.6	9.9	10	9.8	9.8	9.8
49.4	47.3	48.5	46.4	44.3	42.4	39.5	37.8	30.9	27.2	28	27	27.5	54.9	62.8	74	93	113.8	93.2	73.8	63.1	48.9	45.6	33.8	29.3	24.9	22.8	19.5	20	21	21.9
41.6	42.8	40.6	40.7	42.2	38.5	35.4	32	25	22.3	23.8	26.6	28	29.2	29.6	29.8	31.6	32	29.4	26.4	21.8	18	16	13.8	12	10.8	10	9.9	9.8	9.8	9.8
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
37.5	39.5	40.4	35.9	34	33.1	29.6	27.6	25.2	22	20.2	21	22.5	54.8	62.8	73.9	93	113.8	93.2	73.8	63	48.9	45.5	33.8	29.3	24.8	22.8	19.4	20.1	20.9	21.8
34.9	37.6	39.3	35.1	35.7	35	31.8	30	27.5	24	23.1	23.3	24.9	26.6	27.3	28.6	28.9	28.6	26.3	23.4	20.3	18	16.4	14.5	12.3	10.2	9.9	9.8	9.8	9.8	9.8
40.6	45.2	45	42	40.8	44	35.8	33.4	31	28.1	26.5	27.9	30.1	33.4	35.2	35.7	36.4	35	32.2	28.5	24.4	20.7	18.3	16	13.1	10.6	9.8	9.8	9.8	9.8	9.8
32.9	33	31	30.5	30.8	29.3	24.7	19.9	19.3	18.3	20.5	21.6	22	54.8	62.8	74	93	113.8	93.2	73.8	63	48.9	45.8	33.9	29.6	24.8	22.6	19.8	20.1	20.9	21.8
34.2	35.5	33.6	32.7	33	32.2	27.1	21.9	21.9	21.1	23.5	24.6	23.7	22.2	19.7	21	20.7	21.6	18.3	14	10	9.9	9.9	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8
35.3	38.9	36.5	40.5	41.5	47.6	44.6	36.7	31.8	29.3	31.5	35.5	36	37.1	38.5	39.3	44.3	47.7	43.7	40.5	34.1	28.5	23.3	19.3	15.1	13.1	11	10	9.8	9.8	9.8
35.6	36.2	36.7	37.2	42.1	36.9	32.2	30.3	25	21.3	20.1	20.6	22.6	55	63	74	93.2	113.9	93.4	74	63.2	49	46.4	34.2	29.9	24.9	22.5	20.2	20	20.8	21.8
30.2	33.4	33.7	31.1	30.8	32.4	29.2	25.5	23.6	21.5	19.2	19.2	18.5	20	20.1	20.3	20.1	19.9	17.2	13.6	10	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8
31.3	36.6	36.2	39.8	36.3	36.1	34.9	34.3	27.8	22.8	21.1	21.2	24.5	26.5	28.8	31.9	35.4	36.9	36	31.7	23.4	17.5	12.4	9.9	9.8	9.8	9.8	9.8	9.8	9.8	9.8
34.2	36	34.1	32.8	33.1	33.3	28.8	22.3	17.9	17.3	18.2	19.7	22.2	55.2	63.2	74.2	93.4	114	93.6	74.2	63.4	49.2	46.3	34.2	30.2	25	22.7	20.1	19.9	20.8	22.2
32.8	34.9	31.4	30.7	30.7	28.8	23.5	18.5	16	15.1	17.5	18.4	17.9	15.4	14.6	15.6	16.1	14.7	11.2	9.9	9.9	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	11.3
35.8	35.4	31	29	30	26.6	22.2	19.6	23.3	15.2	19	17	17	15.6	14.2	13.4	13.6	12	11.8	10	9.9	9.9	9.9	9.9	9.9	9.9	9.8	9.9	9.8	9.8	11.1
30.4	34	32.4	30	31.2	30.4	29	25.1	26.4	22.5	19.9	19.8	23	55.2	63.2	74.2	93.4	114.1	93.6	74.2	63.5	49.2	46.6	34.4	30.4	25.2	22.5	20.4	20	20.8	21.8
30.3	34	32.3	30.1	32.5	32.3	30.7	26.7	24	22.1	18.4	17.7	19	21.6	21.6	23.5	17.7	17	14	10.3	9.9	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8
32.2	35.8	30.4	30.6	32.2	32	30.6	26.2	24.2	21.2	15.6	18.6	16.8	20	20.5	24	15	13.9	10.5	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8
31.7	33.2	31.6	32.5	31.4	28.6	27.8	29	21.4	18.4	18.1	20	22	55.2	63.2	74.4	93.4	114.2	93.6	74.2	63.6	49.4	46.8	34.4	30.4	25.2	22.6	20	19.8	20.8	21.6
31.8	34.2	31.5	31.5	30.5	28.4	26.1	21.5	18.6	17.5	18.8	20.4	20.1	18.5	16.4	16.5	16.4	14.8	11.3	10	9.9	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.9
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
29.9	32.9	30.4	28.9	30.4	30.5	30.9	27.3	25.8	22.8	20.3	20.2	23	55.2	63.2	74.3	93.4	114.2	93.6	74.2	63.5	49.3	47	34.4	30.4	25.4	22.4	20.3	20	20.8	21.7
28.9	33.4	30.8	29	30.5	29.2	28.7	24.9	22.6	21.7	19.1	19.7	18.3	18.7	17.2	16.6	14.6	13.8	11.1	9.9	9.9	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8
29.4	36.6	33.6	30.6	30	32.1	28.4	27.2	22.2	21.3	20.2	21	21.2	22.8	25.8	26.2	27.8	29.3	27	23.2	19.8	15.8	14.4	13	12.2	10.8	10	9.9	9.8	9.8	9.8
34.4	35.6	31.8	30.7	31.5	27.4	25.1	20.6	18.5	19.5	21.9	26.7	25.4	55.4	63.2	74.4	93.4	114.2	93.6	74.2	63.6	49.4	47	34.4	30.4	25.3	22.4	20.1	20	20.8	21.7
33.4	34.7	31.1	30.6	30.6	29	27.4	23.3	19.2	19	19.5	21.1	21.3	20.3	16.8	17.4	16.6	16.6	13.8	10	9.9	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8

APPENDIX 11.3
Modelling Results

Noise monitoring positions	Coordinates	
NMP ID	**X**	**Y**
NMP1	280942	300170
NMP2	280590	299731
NMP3	280761	300777
NMP4	280251	300982
NMP5	280225	300617
NSR1	280336	300873



Name	Limit. Value		Height above ground	Coordinates		
	Day	Night		X	Y	Z
	(dBA)	(dBA)	(m)	(m)	(m)	(m)
NSR1	55	50	4	280763	300808	64
NSR2	55	50	4	280369	300968	57
NSR3	55	50	4	280311	300973	54
NSR4	55	50	4	280266	301006	54
NSR5	55	50	4	280200	301057	47
NSR6	55	50	4	280185	300989	47
NSR7	55	50	4	280336	300872	56
NSR8	55	50	4	280290	300780	60
NSR9	55	50	4	280289	300569	55
NSR10	55	50	4	280201	300444	57
NSR11	55	50	4	280242	300375	60
NSR12	55	50	4	280175	299878	44
NSR13	55	50	4	280169	299837	44
NSR14	55	50	4	280260	299741	49
NSR15	55	50	4	280326	299678	52
NSR16	55	50	4	280400	299598	54
NSR17	55	50	4	280482	299575	51
NSR18	55	50	4	280593	299609	44
NSR19	55	50	4	280489	299425	55
NSR20	55	50	4	280517	299352	50
NSR21	55	50	4	280474	299279	60
NSR22	55	50	4	281010	300074	64
NSR23	55	50	4	280989	300236	62
NSR24	55	50	4	281352	300237	62



PHASE 1

Notes: Haul trucks modelled as moving point line sources around perimeter of void, to the tunnel and to the processing plant. Other mobile plant in void modelled as moving point area sources.

Pit Phasing Operational Noise

Point Sources

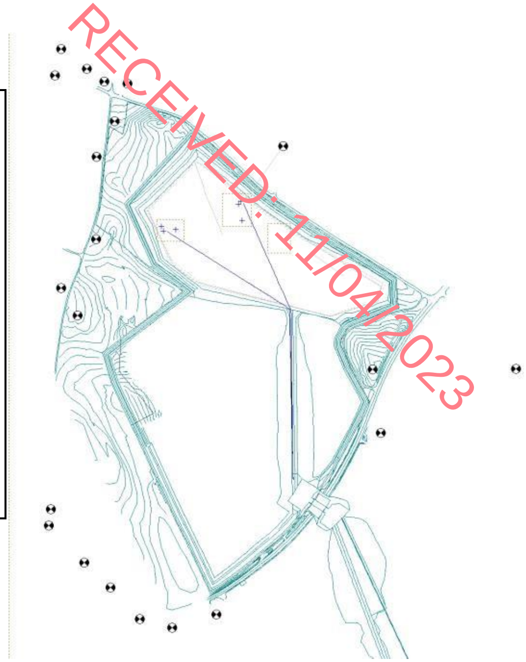
Name	Resultant Sound Power Level Day (dBA)	Lw/Li	BS5288 reference	Operating Time Day	Effective source height (m)	Coordinates X (m)	Y (m)	Z (m)
Excavator	106.1	Lw	BS_5228_2009_C8_11	480	2	280650	300659.8	42
Excavator	106.1	Lw	BS_5228_2009_C8_11	480	2	280656	300666.6	42
Dozer	102.2	Lw	BS_5228_2009_C8_9	240	2	280659	300617.6	42
Excavator	106.1	Lw	BS_5228_2009_C8_11	480	2	280460	300590.3	42
Excavator	106.1	Lw	BS_5228_2009_C8_11	480	2	280455	300602	42
Dozer	102.2	Lw	BS_5228_2009_C8_9	240	2	280491	300594.6	42

Line Sources

Name	ID	Result. PWL Day (dBA)	Result. PWL' Day (dBA)	Evening (dBA)	Night (dBA)	Lw / Li Type	Value	Operating Time Day (min)	Moving Pt. Src Number Day	Speed (km/h)
Haul Trucks	Haul trucks	106.7	80	-29.1	-29.1	PWL-Pt	BS_5228_2009_C6_18	480	8	20
Haul Trucks	Haul trucks	110.1	80	-29.1	-29.1	PWL-Pt	BS_5228_2009_C6_18	480	8	20

Area Sources

Name	ID	Result. PWL Day (dBA)	Result. PWL'' Day (dBA)	Lw / Li Type	Value	Operating Time Day (min)	Moving Pt. Src Number Day



PHASE 4

Notes: Haul trucks modelled as area sources within backfill area in southern void.

Pit Phasing Operational Noise

Point Sources

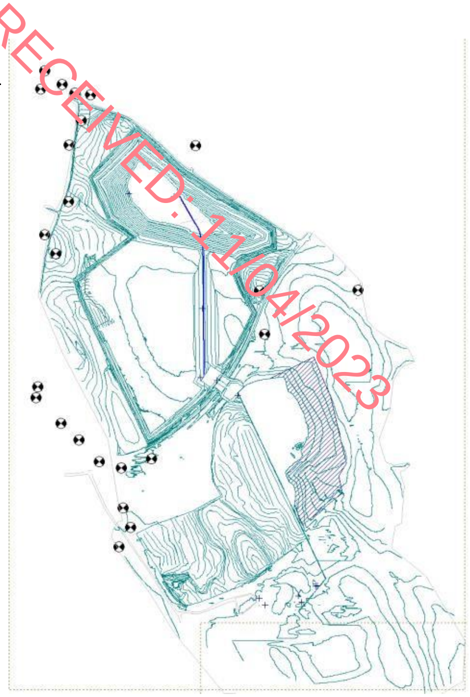
Name	Resultant Sound Power Level Day (dBA)	Lw/Li	BS5288 reference	Operating Time Day	Effective source height (m)	Coordinates X (m)	Y (m)	Z (m)
Semi Mobile Crusher	109.4	Lw	BS_5228_2009_C1_14	480	2	280775	299911	44.9
Drilling Rig	114.8	Lw	BS_5228_2009_C9_4	480	2	280510	300598	2.59
Drilling Rig	114.8	Lw	BS_5228_2009_C9_4	480	2	280510	300598	2.59
Tripping Conveyor	103.7	Lw	BS_5228_2009_C10_21	480	2	281204	299135	55.56
Overland Conveyor	103.7	Lw	BS_5228_2009_C10_21	480	2	280911	299845	45.8
Tunnel Conveyor	103.7	Lw	BS_5228_2009_C10_21	480	2	280835	299901	44.94
Ramp Conveyor	103.7	Lw	BS_5228_2009_C10_21	480	2	280781	300169	42.54
Tripping Conveyor	103.7	Lw	BS_5228_2009_C10_21	480	2	281197	299132	56.02
Tripping Conveyor	103.7	Lw	BS_5228_2009_C10_21	480	2	281133	299096	55.51
Reclaim stockpile conveyor	103.7	Lw	BS_5228_2009_C10_21	480	2	281146	299073	57.62
Reclaim stockpile conveyor	103.7	Lw	BS_5228_2009_C10_21	480	2	280989	299089	52.32
Reclaim stockpile conveyor	103.7	Lw	BS_5228_2009_C10_21	480	2	281011	299061	52.47
Haul Truck Loading	112	Lw	BS_5228_2009_C8_11	480	2	280676	300587	4.65
Haul Truck Loading	112	Lw	BS_5228_2009_C8_11	480	2	280676	300587	4.65

Line Sources

Name	Resultant sound power level Day (dBA)	Result. P VL' Day (dBA)	Lw / Li Type	BS5228 reference	Operating Time Day	Sound Reduction R	Moving Pt. Src Number Day	Speed (km/h)
Haul Trucks	106.5	PWL-Pt	PWL-Pt	BS_5228_2009_C6_18	480		8	20

Area Sources

Name	Resultant sound power level Day (dBA)	Result. PWL'' Day (dBA)	Lw / Li Type	BS5228 reference	Sound Reduction R	Area (m²)	Attenuation	Operating Time Day (min)	K0 (dB)	Freq. (Hz)	Direct.	Moving Pt. Src Number Day	Speed (km/h)	Note
Articulated Dump Truck	115		PWL-Pt	BS_5228_2009_C6_18				480				2	20	
50T Excavators x 3	110.8		PWL-Pt	BS_5228_2009_C8_11				480				3	10	
CAT D6 Dozer	106.5		PWL-Pt	BS_5228_2009_C2_13				240				1	10	
haultrucks	116.8		PWL-Pt	BS_5228_2009_C6_18				480				3	20	



PHASE 5
Pit Phasing Operational Noise

Point Sources

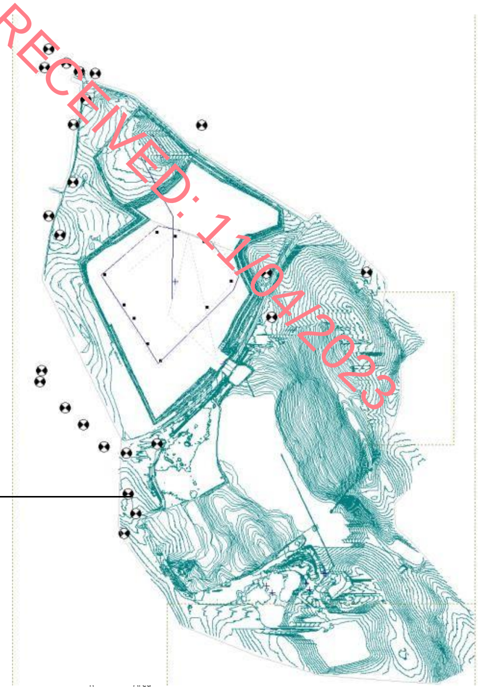
Name	Resultant Sound Power Level Day (dBA)	Lw/Li	BS5288 reference	Operating Time Day	Effective source height (m)	Coordinates X (m)	Y (m)	Z (m)
Semi Mobile Crusher	109.4	Lw	BS_5228_2009_C1_14	480	2	280658	300204	44.06
Tripping Conveyor	103.7	Lw	BS_5228_2009_C10_21	480	2	281204	299135	17.4
Tunnel Conveyor	103.7	Lw	BS_5228_2009_C10_21	480	2	280835	299901	17.4
Tripping Conveyor	103.7	Lw	BS_5228_2009_C10_21	480	2	281197	299132	59.03
Tripping Conveyor	103.7	Lw	BS_5228_2009_C10_21	480	2	281133	299096	39.45
Reclaim stockpile conveyor	103.7	Lw	BS_5228_2009_C10_21	480	2	281146	299073	45.28
Reclaim stockpile conveyor	103.7	Lw	BS_5228_2009_C10_21	480	2	280989	299089	39.4
Reclaim stockpile conveyor	103.7	Lw	BS_5228_2009_C10_21	480	2	281011	299061	49.02

Line Sources

Name	Resultant sound power level Day (dBA)	Result. P VL' Day (dBA)	Lw / Li Type	BS5228 reference	Operating Time Day	Sound Reduction R	Moving Pt. Src Number Day	Speed (km/h)
CAT Dozer	107.9	99.7	PWL-Pt	BS_5228_2009_C2_13	480		10	5
Haul Truck	103.4	102.8	PWL-Pt	BS_5228_2009_C6_18	480		8	20

Area Sources

Name	ID	Result. P VL Day (dBA)	Result. PWL'' Day (dBA)	Evening (dBA)	Night (dBA)	Lw / Li Type	Value	Moving Pt. Src Number	Speed (km/h)
Articulated Dump Truck	Articulated Dump Truck	115	63.1			PWL-Pt	BS_5228_2009_C6_18	2	
Excavators x3	Excavators	110.8	57.4			PWL-Pt	BS_5228_2009_C8_11	3	
CAT Dozer	CAT D6 Dozer	106.5	60.4			PWL-Pt	BS_5228_2009_C2_13	1	
haultrucks	Excavator	106.1	67			PWL-Pt	BS_5228_2009_C8_11	1	No. movements per hour halved and assumed speed increased to 20km/h



(m²)

PHASE 6
Pit Phasing Operational Noise

Point Sources

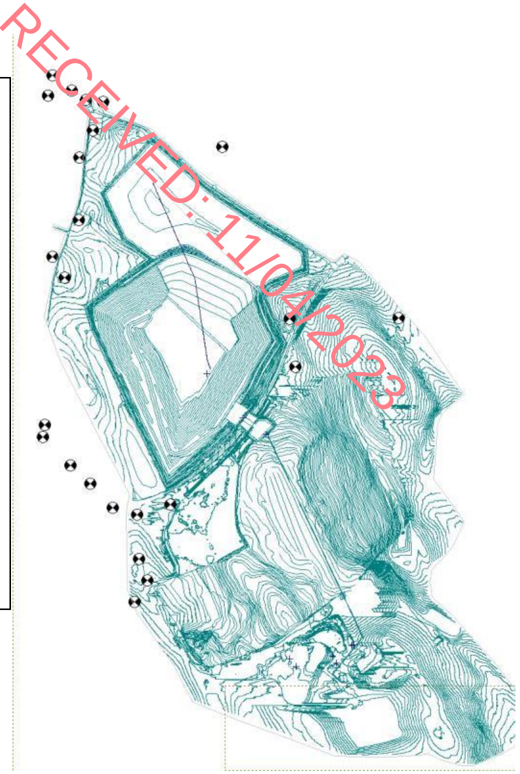
Name	Resultant Sound Power Level Day (dBA)	Lw/Li	BS5288 reference	Operating Time Day	Effective source height (m)	Coordinates X (m)	Y (m)	Z (m)
Semi Mobile Crusher	109.4	Lw	BS_5228_2009_C1_14	480	2	280714	300049	-33.31
Tripping Conveyor	103.7	Lw	BS_5228_2009_C10_21	480	2	281204	299135	54.9
Overland Conveyor	103.7	Lw	BS_5228_2009_C10_21	480	2	280911	299845	45.82
Tunnel Conveyor	103.7	Lw	BS_5228_2009_C10_21	480	2	280835	299901	44.94
Tripping Conveyor	103.7	Lw	BS_5228_2009_C10_21	480	2	281197	299132	55.34
Tripping Conveyor	103.7	Lw	BS_5228_2009_C10_21	480	2	281133	299096	55.7
Reclaim stockpile conveyor	103.7	Lw	BS_5228_2009_C10_21	480	2	281146	299073	57.14
Reclaim stockpile conveyor	103.7	Lw	BS_5228_2009_C10_21	480	2	280989	299089	52.52
Reclaim stockpile conveyor	103.7	Lw	BS_5228_2009_C10_21	480	2	281011	299061	53

Line Sources

Name	Resultant sound power level Day (dBA)	Result. P Day (dBA)	Type	BS5228 reference	Day	R	Number Day	Speed (km/h)
Haul Trucks	106.4	78	PWL-Pt	BS_5228_2009_C6_18	480		8	20

Area Sources

Name	ID	Result. P Day (dBA)	Day (dBA)	Type	Value	norm. dB(A)	Day (min)	Number Day
50T excavators x3	Excavators	110.8	58.2	PWL-Pt	BS_5228_2009_C8_11		480	3
CAT Dozer	CAT Dozer	106.5	53.9	PWL-Pt	BS_5228_2009_C2_13		480	1
Articulated Dump Trucks	Articulated Dump Trucks	115	63.1	PWL-Pt	BS_5228_2009_C6_18		240	2



PHASE 7
Pit Phasing Operational Noise

Point Sources

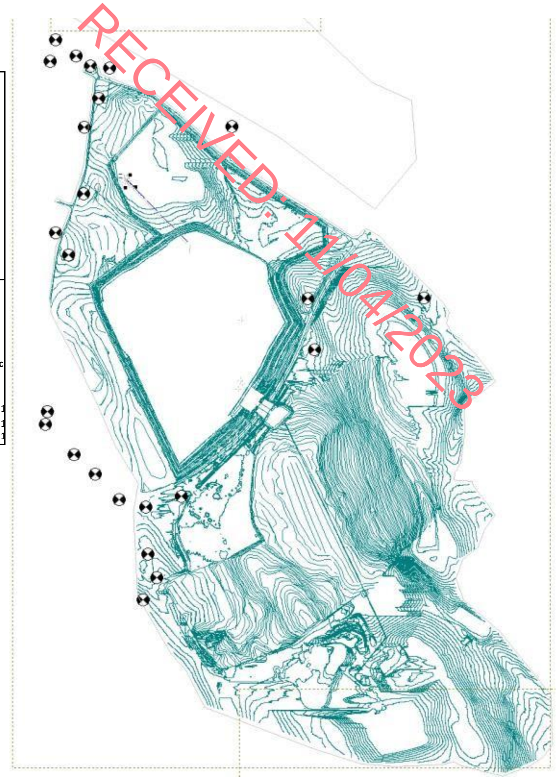
Name	Resultant Sound Power Level Day (dBA)	Lw/Li	BS5288 reference	Operating Time Day	Effective source height (m)	Coordinates X (m)	Y (m)	Z (m)
No point sources operating								

Line Sources

Name	Resultant sound power level Day (dBA)	Result. PWL' Day (dBA)	Lw / Li Type	BS5228 reference	Operating Time Day	Sound Reduction R	Moving Pt. Src Number Day	Speed (km/h)	Note
Haul trucks	98.2	73.8	PWL-Pt	BS_5228_2009_C6_18	continuous		3	20	No. movements per hour 3 and assumed speed increased to 20km/h

Area Sources

Name	Resultant sound power level Day (dBA)	Result. PWL'' Day (dBA)	Lw / Li Type	BS5228 reference	Sound Reduction R	Area (m²)	Attenuation	Operating Time Day (min)	K0 (dB)	Freq. (Hz)	Direct.	Moving Pt. Src Number Day
CAT Dozer	106.5	54.9	PWL-Pt	BS_5228_2009_C2_13				240				1
Roller	101.6	49.9	PWL-Pt	BS_5228_2009_C2_38				240				1
Excavator	97	69.1	PWL-Pt	BS_5228_2009_C8_10				480				1



PHASE 1 08:00 - 19:00 Haul Trucks with engines off while being loaded

Receiver Name	Limiting Value Day dB(A)	Predicted Level Day dB(A)	Exceedance Day
1	45	41.6	-3.4
2	45	29.1	-15.9
3	45	27.9	-17.1
4	45	25.9	-19.1
5	45	23.3	-21.7
6	45	23.8	-21.2
7	45	30.8	-14.2
8	45	32.5	-12.5
9	45	35.3	-9.7
10	45	33.5	-11.5
11	45	36.8	-8.2
12	55	27.3	-27.7
13	55	26.7	-28.3
14	55	20.7	-34.3
15	55	28.7	-26.3
16	55	28.6	-26.4
17	55	29	-26
18	55	29.5	-25.5
19	55	27.3	-27.7
20	55	26.7	-28.3
21	55	25.7	-29.3
22	55	28.6	-26.4
23	55	42.3	-12.7
24	55	30.1	-24.9

PHASE 1 19:00 - 20:00 Low noise NSRs - 5 Haul truck movements per hour, assumed 20km/h speed, 1 Excavator in operation, Haul Trucks with engines off while being loaded

Receiver Name	Limiting Value Evening dB(A)	Predicted Level Evening dB(A)	Exceedance Evening
1	40	39.5	-0.5
2	40	26.8	-13.2
3	40	25.7	-14.3
4	40	23.8	-16.2
5	40	21.2	-18.8
6	40	21.6	-18.4
7	40	28.6	-11.4
8	40	30.3	-9.7
9	40	33.1	-6.9
10	40	31.5	-8.5
11	40	34.7	-5.3
12	50	25.4	-24.6
13	50	24.7	-25.3
14	50	18.8	-31.2
15	50	26.5	-23.5
16	50	26.5	-23.5
17	50	26.9	-23.1
18	50	27.5	-22.5
19	50	25.2	-24.8
20	50	24.7	-25.3
21	50	23.6	-26.4
22	50	27.2	-22.8
23	50	41.3	-8.7
24	50	27.9	-22.1

NSR1 to NSR11 are Low Noise (45 dB Daytime, 40 dB Evening)
NSR12 to NSR24 (55 dB Daytime 50 dB Evening)
NSR11 - unhabited/derelict house - not now considered in assessment

PHASE 4

Receiver Name	Limiting Value Day dB(A)	Predicted Level Day dB(A)	Exceedance Day
1	45	40.1	-4.9
2	45	30.7	-14.3
3	45	31.1	-13.9
4	45	29	-16.0
5	45	27.2	-17.8
6	45	28	-17.0
7	45	31.8	-13.2
8	45	41.5	-3.5
9	45	39.4	-5.6
10	45	32.7	-12.3
11	45	43.9	-1.1
12	55	31.8	-23.2
13	55	31.8	-23.2
14	55	39.1	-15.9
15	55	39.6	-15.4
16	55	44.6	-10.4
17	55	42.9	-12.1
18	55	50.1	-4.9
19	55	47.8	-7.2
20	55	46.3	-8.7
21	55	45.8	-9.2
22	55	49.3	-5.7
23	55	42.7	-12.3
24	55	34.6	-20.4

PHASE 4 19:00 - 20:00
Low noise NSRs 5 Haul truck movements per hour, assumed 20km/h speed, Haul Trucks engines off while being loaded

Receiver Name	Limiting Value Evening dB(A)	Predicted Level Evening dB(A)	Exceedance Evening
1	40	39.7	-0.3
2	40	30.4	-9.6
3	40	30.9	-9.1
4	40	28.6	-11.4
5	40	26.7	-13.3
6	40	27.3	-12.7
7	40	31.6	-8.4
8	40	38.5	-1.5
9	40	38.2	-1.8
10	40	32.3	-7.7
11	40	41	1.0
12	50	30.4	-19.6
13	50	30.5	-19.5
14	50	37.2	-12.8
15	50	38	-12.0
16	50	44	-6.0
17	50	41.7	-8.3
18	50	45.7	-4.3
19	50	44.7	-5.3
20	50	43.4	-6.6
21	50	43.9	-6.1
22	50	47.2	-2.8
23	50	41.4	-8.6
24	50	34	-16.0

PHASE 5 - drill rigs OFF

Receiver Name	Limiting Value Day dB(A)	Predicted Level Day dB(A)	Exceedance Day
1	45	41.2	-3.8
2	45	38.4	-6.6
3	45	37.6	-7.4
4	45	35.4	-9.6
5	45	31.6	-13.4
6	45	29.6	-15.4
7	45	40.5	-4.5
8	45	44.5	-0.5
9	45	43.8	-1.2
10	45	43.8	-1.2
11	45	44.7	-0.3
12	55	31.5	-23.5
13	55	31.9	-23.1
14	55	37.7	-17.3
15	55	34.5	-20.5
16	55	35.3	-19.7
17	55	40.5	-14.5
18	55	42.3	-12.7
19	55	40.8	-14.2
20	55	40.3	-14.7
21	55	39.7	-15.3
22	55	42.9	-12.1
23	55	47.2	-7.8
24	55	36.1	-18.9

PHASE 5 - drill rigs OFF 19:00 - 20:00
~~Low noise NSRs 5 Haul truck movements per hour, assumed 20km/h speed, 1 Excav~~ator in operation, Haul Trucks engines off while being loaded

Receiver Name	Limiting Value Evening dB(A)	Predicted Level Evening dB(A)	Exceedance Evening
1	40	38.9	-1.1
2	40	27.3	-12.7
3	40	28.3	-11.7
4	40	28.5	-11.5
5	40	25.9	-14.1
6	40	24	-16.0
7	40	29.2	-10.8
8	40	32	-8.0
9	40	36.8	-3.2
10	40	40	0.0
11	40	42.3	2.3
12	50	31.4	-18.6
13	50	31.5	-18.5
14	50	37.5	-12.5
15	50	34.5	-15.5
16	50	34.7	-15.3
17	50	40.1	-9.9
18	50	41.9	-8.1
19	50	40.4	-9.6
20	50	40	-10.0
21	50	39.4	-10.6
22	50	41.3	-8.7
23	50	46.4	-3.6
24	50	31.1	-18.9

PHASE 6 - drill rigs OFF — **Low noise NSRs - Haul Trucks with engines off while being loaded**

Receiver Name	Limiting Value Day dB(A)	Predicted Level Day dB(A)	Exceedance Day
1	45	41.2	-3.8
2	45	34.4	-10.6
3	45	31.8	-13.2
4	45	31	-14.0
5	45	28.7	-16.3
6	45	27.2	-17.8
7	45	30.5	-14.5
8	45	32.3	-12.7
9	45	37.9	-7.1
10	45	42.9	-2.1
11	45	45.2	0.2
12	55	31.9	-23.1
13	55	32.2	-22.8
14	55	40.4	-14.6
15	55	37	-18.0
16	55	40.7	-14.3
17	55	42.9	-12.1
18	55	43.7	-11.3
19	55	42.4	-12.6
20	55	42.3	-12.7
21	55	42.2	-12.8
22	55	48.1	-6.9
23	55	50	-5.0
24	55	37.2	-17.8

5 Haul truck movements per hour, assumed 20km/h speed. Haul Trucks engines off while being loaded

Receiver Name	Limiting Value Evening dB(A)	Predicted Level Evening dB(A)	Exceedance Evening
1	40	39.6	-0.4
2	40	32.6	-7.4
3	40	29.7	-10.3
4	40	28.9	-11.1
5	40	26.6	-13.4
6	40	25.1	-14.9
7	40	28.5	-11.5
8	40	31	-9.0
9	40	36.8	-3.2
10	40	39.8	-0.2
11	40	41.6	1.6
12	50	30.6	-19.4
13	50	31.2	-18.8
14	50	36.1	-13.9
15	50	35.8	-14.2
16	50	38.2	-11.8
17	50	40.3	-9.7
18	50	42.3	-7.7
19	50	40.4	-9.6
20	50	40.6	-9.4
21	50	40.3	-9.7
22	50	44.3	-5.7
23	50	45.5	-4.5
24	50	33.9	-16.1

PHASE 7 — **Low noise NSRs - Haul Trucks with engines off while being loaded, 3 Haul Truck movements per hour, smaller excavator in operation**

Receiver Name	Limiting Value Day dB(A)	Predicted Level Day dB(A)	Exceedance Day
1	45	33.9	-11.1
2	45	32	-13.0
3	45	33.1	-11.9
4	45	33.1	-11.9
5	45	26.5	-18.5
6	45	23.5	-21.5
7	45	34.9	-10.1
8	45	40.8	-4.2
9	45	44	-1.0
10	45	39.9	-5.1
11	45	40.2	-4.8
12	55	21	-34.0
13	55	22.1	-32.9
14	55	28.4	-26.6
15	55	25.5	-29.5
16	55	29.6	-25.4
17	55	31.6	-23.4
18	55	32.8	-22.2
19	55	30.5	-24.5
20	55	29.8	-25.2
21	55	30.6	-24.4
22	55	36.7	-18.3
23	55	41.1	-13.9
24	55	29.7	-25.3

GAA Complex

Construction Noise - BS5288 ABC Method

Line sources

Name	Resultant sound power level Day (dBA)	Lw / Li Type	BS5228 reference	norm. dB(A)	Correction Day dB(A)	Area (m²)	Operating Time Day (min)	Moving Pt. Src Number Day	Speed (km/h)
10 to 20t excavator	96	PWL-Pt	BS_5228_2009_C2_24		0		660	3	10
Small Dozer	96.6	PWL-Pt	BS_5228_2009_C2_13		0		660	1	10
Medium Tractors	105.2	PWL-Pt	BS_5228_2009_C4_74		0		660	5	10
3 to 7t excavator	86	PWL-Pt	BS_5228_2009_C4_68		0		660	2	10
Medium Dozer	97	PWL-Pt	BS_5228_2009_C2_11		0		660	1	10
Haul Trucks	93.3	PWL-Pt	BS_5228_2009_C2_34		0		660	5	50

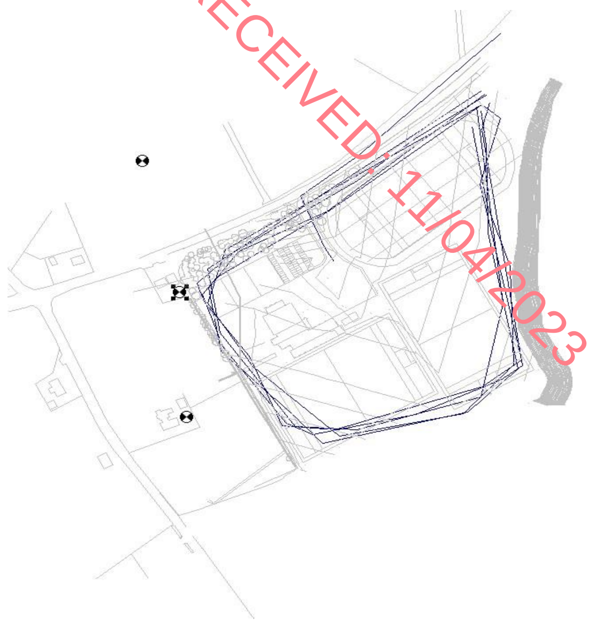
Line sources

Name	Resultant sound power level Day (dBA)	Lw / Li Type	BS5228 reference	norm. dB(A)	Correction Day dB(A)	Area (m²)	Operating Time Day (min)	Moving Pt. Src Number Day	Speed (km/h)
10 to 20t excavator	91.2	PWL-Pt	BS_5228_2009_C2_24		0	0	330	1	10
Small Dozer	96.6	PWL-Pt	BS_5228_2009_C2_13		0	0	660	1	10
Medium Tractors	98.2	PWL-Pt	BS_5228_2009_C4_74		0	0	330	1	10
3 to 7t excavator	86	PWL-Pt	BS_5228_2009_C4_68		0	0	330	2	10
Medium Dozer	97	PWL-Pt	BS_5228_2009_C2_11		0	0	330	1	10
Haul Trucks	89.3	PWL-Pt	BS_5228_2009_C2_34		0	0	330	2	50

Results - GAA construction

Receiver Name	Limiting Value - Category A (65dB) Day dB(A)	Predited level Day dB(A)	Exceedance Day dB(A)
NSR17	65	44.5	-20.5
NSR18	65	59.5	-5.5
NSR19	65	50.7	-14.3

Receiver Name	Limiting Value - Category A (65dB) Day dB(A)	Predited level Day dB(A)	Exceedance Day dB(A)
NSR17	55	40.2	-14.8
NSR18	55	54.5	-0.5
NSR19	55	45.1	-9.9



House Demolition

Construction Noise - BS5288 ABC Method

Point sources **Name**	**Resultant Sound Power Level** **Day** **(dBA)**	**Lw/Li**	**BS5288 reference**	**Operating** **Day**	**Effective source height** **(m)**	**Coordinates** **X** **(m)**	**Y** **(m)**	**Z** **(m)**
Excavator	106.1	Lw	BS_5228_2009_C8_11		2	280515	300577	58
Haul Truck loading	112	Lw	BS_5228_2009_C6_18		2	280530	300583	58
Excavator	106.1	Lw	BS_5228_2009_C8_11		2	280923	300173	54
Excavator	106.1	Lw	BS_5228_2009_C8_11		2	280902	300209	52
Excavator	106.1	Lw	BS_5228_2009_C8_11		2	280719	299780	45
Road Truck	106.9	Lw	BS_5228_2009_C11_16		2	280720	299766	45
Excavator	106.1	Lw	BS_5228_2009_C8_11		2	280710	299870	50
Haul Truck Loading	112	Lw	BS_5228_2009_C6_18		2	280709	299885	50
Road Truck	106.9	Lw	BS_5228_2009_C11_16		2	280728	300677	48

Line sources **Name**	**Resultant sound power level** **Day** **(dBA)**	**Lw / Li** **Type**	**BS5228 reference**	**norm.** **dB(A)**	**Correction** **Day** **dB(A)**	**Area** **(m²)**	**Operating Time** **Day** **(min)**	**Moving Pt. Src** **Number** **Day**	**Speed** **(km/h)**
Road truck 25 T	90.6	PWL-Pt	BS_5228_2009_C11_16		0	0		1	48
Road Truck 25T	87	PWL-Pt	BS_5228_2009_C11_16		0	0		1	48
Haul Truck	98.6	PWL-Pt	BS_5228_2009_C6_18		0	0		2	20
Road Truck 25T	79.2	PWL-Pt	BS_5228_2009_C11_16		0	0		1	48
Road Truck 25T	94.4	PWL-Pt	BS_5228_2009_C6_18		0	0		2	20

Results

Receiver **Name**	**Limiting Value - Category A (65dB)** **Day** **dB(A)**	**Predited level** **Day** **dB(A)**	**Exceedance** **Day** **dB(A)**
NSR22	65	55.8	-9.2
NSR23	65	59.9	-5.1

Screening Berms

Construction Noise - BS5288 ABC Method

Point sources

Name	Resultant Sound Power Level Day (dBA)	Lw/Li	BS5288 reference	Operating Day	Effective source height (m)	Coordinates X (m)	Y (m)	Z (m)
Excavator	106.1	Lw	BS_5228_2009_C8_11		2	280679.05	300704.9	49
Haul Truck loading	112	Lw	BS_5228_2009_C6_18		2	280665.89	300714.06	49
Haul Truck loading	112	Lw	BS_5228_2009_C6_18		2	280688.32	300692.9	48
Excavator	106.1	Lw	BS_5228_2009_C8_11		2	280541.17	299685.83	41
Excavator	106.1	Lw	BS_5228_2009_C8_11		2	280568.91	299690.64	41
Excavator	106.1	Lw	BS_5228_2009_C8_11		2	280594.51	299699.7	41

Line sources

Name	Resultant sound power level Day (dBA)	Lw / Li Type	BS5228 reference	norm. dB(A)	Correction Day dB(A)	Area (m²)	Operating Time Day (min)	Moving Pt. Src Number Day	Speed (km/h)
Road truck 25 T	90.6	PWL-Pt	BS_5228_2009_C11_16		0	0		1	48

Results

Receiver Name	Limiting Value - Category A (65dB) Day dB(A)	Predited level Day dB(A)	Exceedance Day dB(A)
NSR1	65	60.9	-4.1
NSR18	65	60	-5

Road Diversion

Construction Noise - BS5288 ABC Method

Point sources

Name	Resultant Sound Power Level Day (dBA)	Lw/Li	BS5288 reference	Operating Day	Effective source height (m)	Coordinates X (m)	Y (m)	Z (m)
Excavator	106.1	Lw	BS_5228_2009_C8_11		2	280905	300113	58
Haul Truck	112	Lw	BS_5228_2009_C6_18		2	280887	300103	58
Haul Truck	112	Lw	BS_5228_2009_C6_18		2	280888	300118	58
Haul Truck loading	112	Lw	BS_5228_2009_C6_18		2	280874	300106	58
Excavator	106.1	Lw	BS_5228_2009_C8_11		2	280753	299949	52
Dozer	106.1	Lw	BS_5228_2009_C8_11		2	280800	299991	55
Roller	107.6	Lw	BS_5228_2009_C5_19			280583	299734	41

Line sources

Name	Resultant sound power level Day (dBA)	Lw / Li Type	BS5228 reference	norm. dB(A)	Correction Day dB(A)	Area (m²)	Operating Time Day (min)	Moving Pt. Src Number Day	Speed (km/h)
Road truck 25 T	93.6	PWL-Pt	BS_5228_2009_C11_16		0	0		2	48

Results

Receiver Name	Limiting Value - Category A (65dB) Day dB(A)	Predited level Day dB(A)	Exceedance Day dB(A)
NSR22	65	63.9	-1.1
NSR23	65	61.5	-3.5

Contruction of Tunnel

Construction Noise - BS5288 ABC Method

Point sources

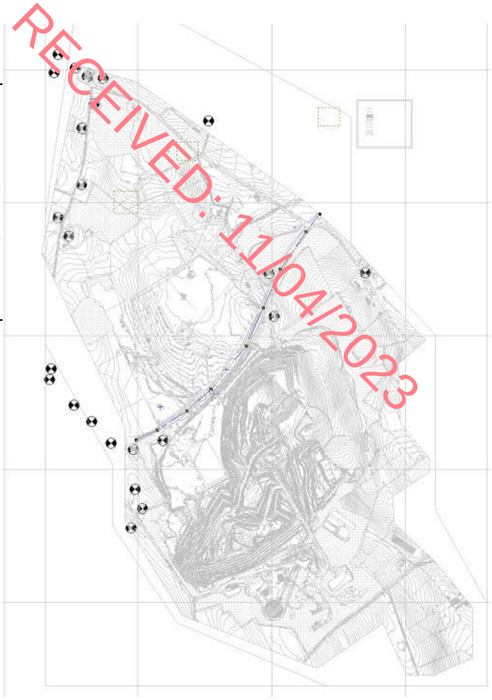
Name	Resultant Sound Power Level Day (dBA)	Lw/Li	BS5288 reference	Operating Day	Effective source height (m)	Coordinates X (m)	Y (m)	Z (m)
Excavator	106.1	Lw	BS_5228_2009_C8_11		2	280783	299783	49
Haul Truck	112	Lw	BS_5228_2009_C6_18		2	280799	299782	46
Haul Truck loading	112	Lw	BS_5228_2009_C6_18		2	280777	299766	47
Excavator	106.1	Lw	BS_5228_2009_C8_11		2	280769	299797	47
Dozer	106.1	Lw	BS_5228_2009_C8_11		2	280831	299872	50
Roller	107.6	Lw	BS_5228_2009_C5_19		2	280583	299734	41

Line sources

Name	Resultant sound power level Day (dBA)	Lw / Li Type	BS5228 reference	norm. dB(A)	Correction Day dB(A)	Area (m²)	Operating Time Day (min)	Moving Pt. Src Number Day	Speed (km/h)
Road truck 25 T	93.6	PWL-Pt	BS_5228_2009_C11_16		0	0		2	48

Results

Receiver Name	Limiting Value - Category A (65dB) Day dB(A)	Predited level Day dB(A)	Exceedance Day dB(A)
NSR17	65	54.2	-10.8
NSR18	65	58.2	-6.8



APPENDIX 11.4

Drumgoosat National School Technical Assessment

Saint-Gobain Mining (Ireland) Ltd.
2022-07-29

Dear Sir/Madam

ITPEnergised has been commissioned by SLR Consulting Ireland to provide a response to the Request for Information (RFI) produced by Monaghan County Council for the EIAR submitted for Knocknacran West Mine.

Item 21 of the RFI covers Noise and contains queries on the Noise EIAR Chapter completed by ITPEnergised and submitted in January 2022. This letter address the queries in Item 21 of the RFI document, which refers to Drumgoosat National School.

Item 21 – '*Drumgoosat National School is located to the north of the proposed development. Applicant should submit a detailed noise impact assessment that clearly demonstrates that the proposed activities (including the removal of overburden and interburden and during mineral extraction) will not result in a breach of indoor ambient noise levels (Table 1) recommended by the Department of Education and Skills SDG 02-0503 "Acoustic Performance in New Primary and Post Primary School Buildings" either directly or due to cumulative interactions with other sources*'

Table 1 in the 'Acoustic Performance in New Primary and Post Primary School Buildings' document is presented below.

Table 1 - Recommended Criteria for Indoor Ambient Noise Levels

Type of Room	Upper Limit for Indoor Ambient Noise Levels (IANL), $L_{Aeq,30min}$ (dB)
Primary School: general teaching areas: classrooms, Special Education Tuition rooms, Multi-Purpose room	35
Post-Primary School: general teaching areas: classrooms, inter-linked classrooms, pastoral offices, special tuition rooms, Multi-media rooms	35
Music	35
Libraries	35
Science Laboratories	35
Construction Studies/Engineering/Technology, Textiles, Home Economics, Design & Comm./Tech Graphics	40
Art/Craft Rooms	40
General Purpose Room1, Multi-Use/PE Hall1	35
Atria, circulation spaces	45
Kitchens	50
Offices / Staffroom	40
Toilets	50
Circulation Spaces	45

ITPEnergised has undertaken detailed noise modelling of each operational phase of the proposed Knocknacran West mine. It should be noted that all predictions at Noise Sensitive Receptors (NSRs) within the model are external, i.e. exclude any assumed attenuation across the building envelope.

Drumgoosat National School was included as NSR3 in the Noise EIAR Chapter. The highest predicted daytime level at NSR3 was **37 dB,** in the predictions for Phase 7 of mining operations (see Table 11.18 in the Noise EIAR chapter).

ITPEnergised also predicted noise levels at the school from the operation of the proposed Drumgoosat Community Centre. The highest predicted level at the school due to noise from the community centre was **19 dB**. The noise assessment completed for the proposed community centre is attached along with this letter.

Predicted external cumulative noise levels at the school from the mine and the community centre are therefore as follows:

Cumulative noise level = $\mathbf{10*\log(10^{(37/10)} + 10^{(19/10)}) = 37.1\ dB.}$[1]

To derive internal levels at Drumgoosat National School, a reduction to façade levels provided by open windows has been assumed. An open window is assumed to provide attenuation of approximately 15 dB to external levels, in accordance with BS8233:2014 – *Guidance on sound insulation and noise reduction for buildings*.

Predicted internal noise levels within the school due to noise from Knocknacran West and Drumgoosat Community Centre are therefore:

Cumulative noise level – open window attenuation = **37.1 dB – 15 dB = 22.1 dB**[2] on the most exposed façade(s).

Predicted internal noise levels at Drumgoosat National School therefore meet the target indoor ambient noise levels (Table 1) recommended by the Department of Education and Skills SDG 02-0503 "Acoustic performance in New Primary and Post Primary School Buildings".

Yours sincerely

Gregor Massie
Senior Noise Consultant
ITPEnergised
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[1] Decibels are logarithmic units and are therefore added logarithmically.
[2] This calculation is not done logarithmically, with open window attenuation providing a numeric reduction of approximately 15 dB, as stated in BS8233.

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12.0 VIBRATION

12.1 Introduction

This chapter considers potential vibration impacts associated with future operation of the Proposed Development. The assessment identifies appropriate evaluation criteria, considers potential sources of vibration and specifies mitigation measures to control vibration at sensitive receptors.

A potential impact of extraction operations is the noise and vibration associated with blasting for excavation of rock. Blasting results in ground borne vibrations and air-over pressure impacts. It is acknowledged that humans are particularly sensitive to vibration stimuli and that any perception of vibration may lead to concern. Gypsum is the only lithology that requires blasting, the overburden and interburden are removed by mechanical means (i.e. dug out by excavators) as these lithologies are soft.

12.2 Legislative and Policy Context

12.2.1 Relevant Legislation

There is no specific Irish legislation relating to environmental vibration. This assessment has therefore been undertaken in accordance with appropriate guidance as detailed below and in line with the existing EPA Licence limits under which the operations currently operate.

12.2.2 Relevant Guidance

This assessment has been made with guidance from the 'Guidelines on the information to be contained in environmental impact assessment reports', published in 'draft' by the EPA in August 2017. Guidance related specifically to vibration has been identified below.

British Standard BS 5228-1:2009+A1:2014 Code of Practice for Noise and Vibration Control on Construction and Open Sites, Part 2 - Vibration

BS5228 (BSI, 2014) provides a procedure for the estimation of construction noise and vibration levels and for the assessment of the significance of the predicted effects at the nearest sensitive receptors.

Part 2 of the Standard provides threshold levels at which vibration may be perceptible to people, through to becoming intolerable, and frequency-weighted thresholds at which vibration may cause cosmetic damage to structures.

The thresholds are dependent on frequency and the type of building, however, in the worst-case, residential or light commercial structures may see the onset of damage at 15 mm/s peak particle velocity (PPV) at 4 Hz, increasing to 20 mm/s PPV at 15 Hz and above.

BS6472-2:2008 Guide to evaluation of human exposure to vibration in buildings. Blast-induced vibration

BS 6472 provides 'satisfactory magnitudes' of vibration for the daytime and night-time period, expressed as PPV mm/s. The standard notes that the probability of 'adverse comment' (i.e. complaints) is low where the criteria are met.

Other Guidance

Other guidance reviewed as part of the assessment process include:

- The EPA's Environmental Management Guidelines: Environmental Management in the Extractive Industry (Non-Scheduled Minerals; April 2006);
- 'Guidelines on the information to be contained in environmental impact assessment reports', by the EPA in May 2022, and 'Advice notes for preparing Environmental Impact Statements', (Draft, 2015);
- BS 7385-1:1990 - Evaluation and measurement for vibrations in buildings;
- Environmental Code (2005) Irish Concrete Federation; and
- EPA guidelines in relation to blasting activities outlining the methodology and limits to be used for vibration measurement.

12.3 Assessment Methodology and Significance Criteria

12.3.1 Ground Vibration

Ground vibration is caused by the imperfect utilisation of the explosive energy released during blasting operations. The energy that is unused in the fragmentation of rock propagates as an elastic disturbance away from the shot area as seismic waves. These waves, which radiate in a complex manner, diminish in strength with distance from the source. The theory relative to this motion is based on an idealised (sinusoidal) vibratory motion. When these waves come into contact with a free face, physical motion results as the energy induces oscillation in the ground surface. Blasting vibration is a surface wave type, which incorporates components of both body and surface motion.

Ground vibration itself is inaudible, however air vibrations both audible and sub-audible usually accompany it. The resulting impacts of blasting vibration are often characterised as being impulsive and of short duration, usually less than 3 seconds. It is difficult for the average lay person to differentiate between the various types of vibrations (ground and air), humans commonly associate the level of vibration with the 'loudness' of a blast.

Ground Vibration Control

Ground vibration from blasting at any receptor is influenced mainly by:

- The characteristics of the rock mass;
- The maximum instantaneous charge of explosives;
- The medium between blast source and receptor point; and
- The distance between the receptor point and the blast source.

Ground Vibration Control is based on reducing the weight of explosives detonated per delay (reducing the maximum instantaneous charge). In any given situation, large amounts of explosives can be detonated using time delay intervals between each specific charge within the overall blast. The level of ground vibration is related to the maximum charge weight per delay and numerous studies have shown that peak particle velocity is closely related to the maximum charge weight per delay.

In terms of predicting ground vibration, each location is 'site specific'. Monitoring stations will be positioned at locations representative of sensitive residences nearest the area to be blasted in the open-cast mine or at alternative locations by agreement with the regulatory authorities.

12.3.2 Air Blast (Air Overpressure) Noise

An explosion causes a diverging shock-wave front that quickly reduces to the speed of sound, and an air blast is then propagated through the atmosphere as sound waves. 'Air blast' or 'air overpressure' is the term used to describe the low frequency, high energy air vibrations generated by blasting detonation. Air blasts are characterised by containing a larger proportion of its energy in the sub-audible spectrum, below 20Hz. Because the waves associated with air blasts are essentially outside the audible spectrum (below 20Hz), a separate unit of measure, pressure is reported.

The pressure is recorded using an air-blast transducer and the linear device must measure accurately in the structurally critical range, 2 to 20Hz. Air blast (sound waves) can be reported in two distinct units of measurements, pressure (psi) or decibels (dB).

Sound waves in the form of the sub-audible sound waves (air overpressure/air blast waves), and noise (the audible waves) are sometimes linked inextricable. It is difficult sometimes for humans to differentiate between the characteristics of air blasts and noise.

In general, the sub-audible waves are of greatest concern. The sub-audible sound waves, if high enough can excite structures to produce audible rattle inside structures and may in the extreme, break glass and crack wall coverings. There are no known cases of foundation cracks from air blasts at values anywhere near the glass breakage threshold of 140dB, (Siskind et al. 1993). The cracking of glass (the weakest component of a structure) is likely to be probabilistic in nature. In other words, not all windows will crack at above 140dB.

A wind speed of 9 m/sec produces a pressure equal to 133.7dB (0.014 psi). Although such wind is comparable in amplitude to a strong air blast, its effects are not as noticeable because of the relatively slow rate of wind change and the corresponding minor or non-existent rattling, compared with the rapid rise time (impulsive) of an air blast transient.

Air blast waves are attenuated over distance in much the same way as sound waves. However, there are some differences due to the lower frequency of the sub-audible air blast waves.

Control of Air Blasts (Air Overpressure)

The principal factors governing air blasts are as follows:

a) The type and quantity of explosives;

b) The degree of confinement (plaster shooting, overcharging and poor stemming);

c) The method of initiation (exposed detonating fuse etc.);

d) Local geology and topography;

e) Atmospheric conditions; and

f) Distance and condition of structures.

Factors a), b) and c) are variables within the control of the site operator whereas d), e) and f) are essentially uncontrollable at any particular site.

However, by varying the timing of a blast (avoiding early morning or late evening), the quantities of explosives, the degree of confinement and the method of initiation (non-use of detonating chord) the quarry operator, in effect, achieves partial control over the influence of atmospheric conditions and hence over the blast emissions.

12.3.3 Scope of Assessment

The scope of this assessment has included the following:

- Consultation with stakeholders;
- Analysis of historical blast vibration data;
- Review of applicable vibration criteria;
- Review of previously measured ground-borne vibration levels associated with above-ground blasting at representative locations;
- Evaluation of predicted blast vibration levels against agreed criteria; and
- Specification of appropriate mitigation, if required.

12.3.4 Overview of Vibration Sources

The most significant potential sources of ground borne vibrations that could be generated by the proposed operations at the mine is the extraction of gypsum by blasting.

To characterise potential vibration impacts at the closest receptors, monitoring undertaken at the adjacent Knocknacran Mine by the applicant has been considered in this assessment as the proposed Mine Development is not proposing a deviation from current open-cast mining methods and the gypsum is same between the two open-cast mines. Potential vibration and air overpressure levels have been assessed according to British Standard BS 7385: Evaluation and measurement for vibration in buildings, Part1 1990 Guide for measurement of vibrations and evaluation of their effects on buildings and Part 2 1993 Guide to damage levels arising from ground borne vibration and by comparison with the site's current vibration limits according to IE Licence P0519-04.

12.3.5 Vibration Measurement Parameters

Ground vibration at sensitive receptors is measured as Peak Particle Velocity (PPV) in mm/s. The PPV is the maximum instantaneous velocity of a particle at a point during a given time interval; and

Air blast (air overpressure) noise is measured in linear decibels dB(Lin). Air overpressure is energy transmitted from the blast site within the atmosphere in the form of pressure waves and is generally perceived as a loud bang.

12.3.6 EPA IE Licence Limits

The proposed mining area will be subject to conditions as set out in an EPA Licence, through a revision of the existing IE Licence (P0519-04). Applicable conditions and schedules from the existing IE Licence are summarised below. These limits will be sought for the proposed Mine Development.

4.6.1 Off-site noise, vibration & air overpressure.

(i) Noise from the installation shall not give rise to sound pressure levels (Leq, T) measured at noise sensitive locations of the installation which exceed the limit value(s).

(ii) Vibration levels measured at noise sensitive locations shall not exceed the specified limit values.

(iii) Air overpressure levels measured at noise sensitive locations shall not exceed the specified limit values.

5.7 No blast or combination of simultaneous blasts shall give rise to a vibration level at any noise sensitive location which exceeds a peak particle velocity of 7.5 mm/second, as measured in three mutually orthogonal directions about a fixed point.

5.8 No blast or combination of simultaneous blasts shall give rise to an air-overpressure level at any noise sensitive location which exceeds 125 dB (lin) max peak.

5.9 There shall be no clearly audible tonal component or impulsive component in the noise emission from the activity at any noise sensitive location other than when blasting occurs or when a siren is used to give blast warnings.

5.12 Vibration and air overpressure monitoring.

5.12.1 The licensee shall maintain air overpressure and vibration monitoring facilities at the currently agreed locations at the installation and at any additional location as may be required by the Agency.

5.12.2 Monitoring of air overpressure and vibration shall take place during each blast.

12.3.7 Study Area and Vibration Sensitive Receptors

The Site is located in the townlands of Knocknacran (East & West), Drumgoosat, Drummond, Derrynascobe, Enagh, and Derrynaglah Co. Monaghan, to the north and south of the R179, a regional road which runs between Carrickmacross and Kingscourt). The Site is accessed via a public road (L4816) which runs southeastwards from the R179. The town of Kingscourt is located ca. 7 km south of the Site along the R179, and the town of Carrickmacross is located ca. 7 km north of the Site also along the R179.

Blasting is proposed to be carried out on the Knocknacran West Mine site, to the north of the R179. The southern Knocknacran Mine will be actively restored using material from the Knocknacran West Mine site, and as such, the Knocknacran Mine would no longer carry out blasting activities. Consideration of vibration impacts is considered in the context of the Knocknacran West Mine, within the Mine Development.

The Knocknacran West Mine will comprise of two distinct areas over time. The initial area of open-cast mining (including a small active blast area) will be focussed on the north of the site, this will be worked during phases 1 to 4 and span ca. 15 years of development. Once the northern open-cast area has been exploited, and blasting is no longer required, development will move to the south of the site during phases 5 to 6 with overburden and interburden material extracted from the south to be used to restore the former northern open-cast. Development of the southern open-cast will take ca. 15 years.

Given the phased nature of the development and the two distinct open-casts areas over time, consideration has been given to the two study areas over time and the receptors which are within 250 m and 500 m of each open-cast area. The study areas include representative Vibration Sensitive Receptors (VSRs) identified to be potentially impacted by blast vibration from mining operations.

There are 10 existing VSRs and 1 potential VSR (proposed Community Centre) within 250 m of the northern open-cast area and 47 existing VSRs within 500 m of the northern open-cast area as shown on Figure 12.1.

The proposed Community Centre is considered here as a receptor as it is a reasonably foreseeable proposed development by SGMI in light of the 2018 subsidence which led to the removal of the former Community Centre and planning permission has recently granted for a new centre in the village. One existing residential dwelling will be removed to enable the development and provisions have been made to relocate the residents to a new residence in advance of the development.

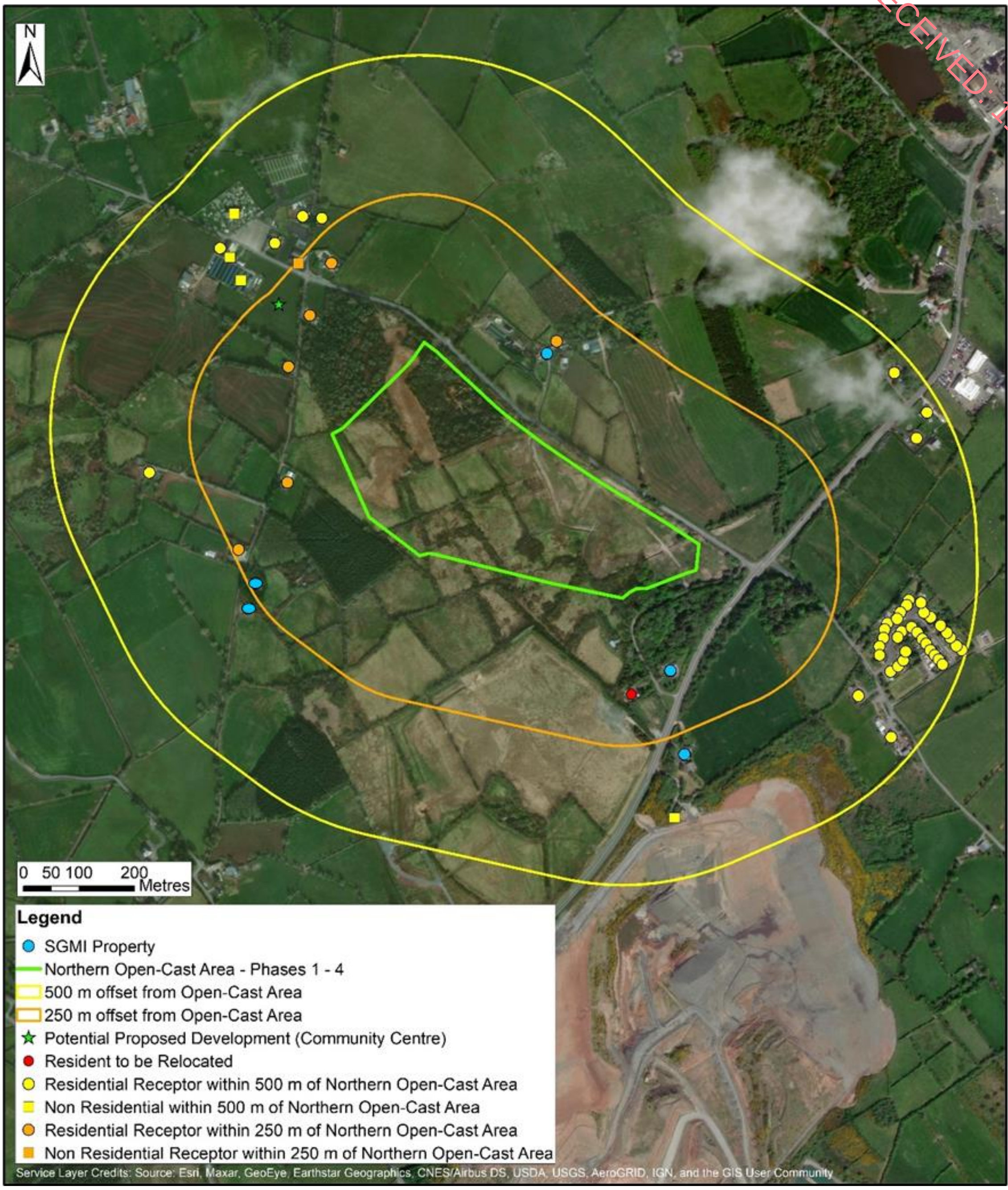

Figure 12.1: VSRs within 250 m and 500 m of the northern open-cast area during phases 1 - 4

There are 11 existing VSRs within 250 m of the southern open-cast area and 35 existing VSRs within 500 m of the northern open-cast area, Figure 12.2. There is one permitted residential dwelling within 500 m of the southern extraction area which has not yet been built at the time of writing of this EIAR but is considered to be a receptor. There is a second permitted residence which involves the restoration and extension of an existing (unoccupied) residence, this is also considered as a receptor. The same existing occupied residential dwelling that is within the study area for the northern open-cast is also within the study area for the southern open-cast area.

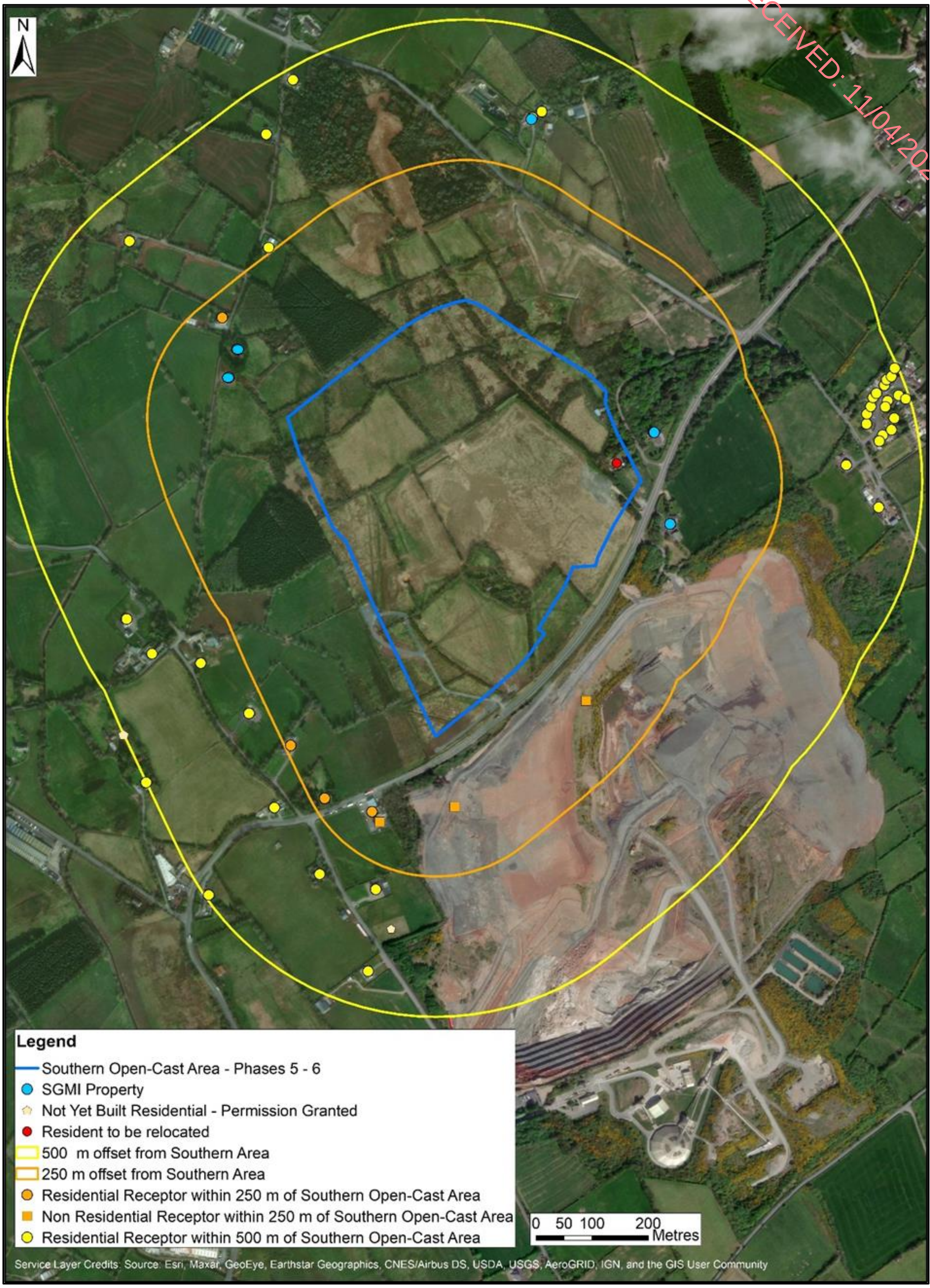

Figure 12.2: VSRs within 250 m and 500 m of the southern open-cast area during phases 5 - 6

12.3.8 Receptor Sensitivity

This assessment considers that human receptors, including residential dwellings, have a high sensitivity to vibration. Commercial and industrial receptors, comprising buildings and businesses, are considered to have a low sensitivity to vibration. It has been noted within the assessment that a national school is within 250 m of the proposed northern open-cast's area, and ca. 307 m from the Upper Gypsum blast area within the extraction area. This receptor is non-residential, but it is immediately adjacent to a high sensitivity residential receptor. Blasting is proposed to take place after 4 pm, after the normal school day has finished, apart from when exceptional circumstances may apply.

12.3.9 Evaluation Criteria

Table 1 in BS6472 (reproduced here as Table 12.1) provides magnitudes of vibration that are acceptable with respect to human response for up to three blast vibrations events per day.

Table 12.1: BS6472 Satisfactory Magnitude Criteria – Blast Vibration

Receptor Type	Time	Satisfactory Magnitude, PPV (mm/s)
Residential	Day – 07:00 to 18:00 Mon-Fri, 08:00 to 13:00 Saturdays Night – 23:00 to 07:00 Other times	6.0 to 10.0 2.0 4.5
Offices	Any time	14.0
Workshops	Any time	14.0

The table provides recommended magnitudes of vibration below which the probability of adverse comment is low. In the context of BS6472 satisfactory magnitude criteria, the mine's IEL vibration limit of 7.5 mm/s lies within the range at which the probability of adverse comment is low.

No such table is provided for air overpressure in BS6472; however, Section 7 provides information on satisfactory air overpressure magnitudes which have been considered in this assessment. BS6472 states that structural damage would not be expected at air overpressure levels below 180 dB but windows, which are generally the weakest parts of a structure, could crack at ca. 150 dB (when pre-stressed) or most windows may crack at ca. 170 dB.

This assessment adopts the limits provided in the IEL as evaluation criteria (Section 12.3.6).

Derived impact magnitude criteria drawing on the mine's IEL vibration limits and BS6472 criteria are provided in Table 12.2. Derived impact magnitude criteria for air overpressure are presented in Table 12.3.

Table 12.2: Derived Impact Magnitude Criteria for vibration

Measured vibration level, PPV mm/s	Impact Magnitude
Daytime period (08:00 to 22:00 Mon-Fri, 08:00 to 13:00 Saturdays)	
>10	High
>8, ≤10	Medium
>6, ≤8	Low
<6	Negligible

Night-time period (22:00 – 08:00)	
>4	High / Medium
>2, ≤4	Low
<2	Negligible

Table 12.3: Derived Impact Magnitude Criteria for air overpressure

Measured Air Overpressure (dB (lin))	Impact Magnitude
>180	High
>150 <180	Medium
>125 <150	Low
<125	Negligible

Drawing on the above impact magnitude criteria, a significance matrix is provided in Table 12.4, showing the significance of vibration and air overpressure effects for different magnitudes of impact, based on receptor sensitivity.

Table 12.4: Effect Significance as a Product of Impact Magnitude and Receptor Sensitivity

Impact Magnitude	Level of Significance, Relative of Receptor Sensitivity		
	Low Sensitivity	**Medium Sensitivity**	**High Sensitivity**
High	Moderate	Moderate/Large	Large
Medium	Slight	Moderate	Moderate
Low	Neutral	Slight	Slight
Negligible	Neutral	Neutral	Neutral

This assessment considers that effects with a significance of Moderate or Large are significant and effects with a significance of Slight or Neutral are not significant.

12.4 Baseline

The study areas comprise former amenity and agricultural lands over the former Drumgoosat underground workings. Since the subsidence events of 2018, the lands have remained disused. The lands surrounding the study area are used for agricultural and residential purposes. Industrial and commercial activities also occur within the surrounding area.

There is some sparse residential housing in the area, however this is primarily concentrated to linear ribbon settlement along local roads. Blasting is actively carried out in both the existing Knocknacran Open-Cast Mine and the Drummond Underground Mine to the south of Knocknacran West Mine. As such, current baseline conditions do comprise blast activities within the locality.

Human beings are extremely sensitive to vibration, the threshold of perception is typically in the PPV range of 0.14 mm/s to 0.3 mm/s. BS6472-2 sets out vibration levels from blasting activities at which minimal adverse comment is likely to be provoked (Table 12.2). If vibration levels from blasting exceed these values, then the chance of adverse comment increases significantly. Potential annoyance from blasting activities does not correlate to baseline vibration levels.

Vibration monitoring is currently carried out at each blasting event (for both the existing Drummond underground mine and the Knocknacran Open-Cast mine). All monitoring results are filed as part of the Site's Annual Environmental Reporting (AER). The vibration monitoring is undertaken in accordance with:

- Environmental Management in the Extractive Industry, EPA;
- The "Environmental Code" (ICF), EPA guidelines in relation to blasting activities outlining the methodology and limits to be used for vibration measurement;
- Mechanical vibration and shock - vibration of fixed structures - guidelines for the measurement of vibrations and evaluation of their effects on structures, BS ISO 4866:2010;
- Good Environmental Practice in the European Extractive Industry: a Reference Guide, (CTP) 2000;
- Vibration Monitoring undertaken by the Applicant as part of the Environmental Management System (EMS) in place at the Application Site;
- Department of the Environment, Heritage and Local Government – Quarries and Ancillary Activities: Guidelines for Planning Authorities, 2004;
- The Evaluation of Human Exposure to vibration in buildings, BS 6472-2:2008; and
- Evaluation and measurement for vibrations in buildings, BS 7385-1:1990.

Currently no blasting takes place on Sundays or Public Holidays. Blasts at Knocknacran usually takes place after 4 pm and occur generally less than once every two weeks, but these can vary due to exceptional circumstances.

12.4.1 Existing Blast Monitoring Locations

As per Condition 5.13 of the current IE Licence P0519-04 both Ground Vibration and Air Blast (Air Overpressure) are monitored for each blasting event at both the Drummond and Knocknacran mines. Licenced monitoring locations for Knocknacran Mine are shown on Figure 12.3, with a description of each monitoring location presented in Table 12.5 below. In addition to the three licenced locations, monitoring is also undertaken at various VSRs for each blast. These have varied from blast to blast and over time, e.g., during 2012 – 2014 monitoring of VSRs was undertaken as blasting occurred in the eastern open-cast area, while recent monitoring is undertaken at VSRs to the west, to reflect blasting in the west of the open-cast.

Figure 12.3: Location of licenced monitoring points (yellow) and monitored VSRs (purple) for the existing Knocknacran Mine. The green star is the former licenced monitoring location for MS2 up to August 2022

Table 12.5: Ground Vibration and Air Blast (Air Overpressure) Monitoring Location Details for Drummond and Knocknacran Mines

Location	Description
MS1	Located on the northern boundary corner of Knocknacran Mine - the nearest resident is ca. 50 m further north of this point.
MS2	Located at the western boundary corner of Knocknacran Mine - the nearest residence is located ca. 20 m west of this monitoring point. This location was moved south in August 2022 due to the Community Sports Complex.
MS3	Located at the southeastern boundary corner of Knocknacran Mine the nearest residence is located ca. 250 m to the east of this monitoring location.
VSR1	A residence to the east of Knocknacran Mine, was a monitoring point for blasts carried out on the east of the open-cast up to 2014, ca. 95 m east of Knocknacran Mine..
VSR2	A residence to the east of Knocknacran Mine, was used as a monitoring point for blasts carried out on the east of the open-cast up to 2014, ca. 270 m east of Knocknacran Mine.
VSR3	A residence to the southwest of Knocknacran Mine, used as a monitoring point for blasts carried out on the west of the open-cast since 2018, ca. 245 m southwest of Knocknacran Mine.
VSR4	A monitoring point adjacent to a residence to the west of Knocknacran Mine, this has been used as a monitoring point for blasts carried out on the west of the open-cast since 2018, ca. 115 m west of Knocknacran Mine.

VSR5	A residence to the west of Knocknacran Mine, this has been used as a monitoring point for blasts carried out on the west of the open-cast since 2018, ca. 235 m west of Knocknacran Mine.
VSR6	A residence to the west of Knocknacran Mine, this has been used as a monitoring point for blasts carried out on the west of the open-cast since 2019, ca. 400 m west of the Knocknacran Mine.

12.4.2 Results from Assessment Period 2012-2022: IEL Locations MS1, MS2 and MS3

Blasting during previous mining operations at the Knocknacran Open-Cast is considered as a good representation of future predicted blast events at the Knocknacran West Mine as the site setting (e.g. geology, ground conditions) remains the same and blasts will be designed in line with historical blasts.

Ground Vibration and Air Blast (Air Overpressure) monitoring results for blasting events, carried out between January 2012 and October 2022 are presented in Table 12.6 below for the three licenced locations MS1-MS3 for Knocknacran Mine. It is noted that there is a pause in the monitoring period as no blasting took place at the open-cast mine between August 2014 and March 2018. Blasting took place on the western side of the open cast from 11 April 2018 onwards, prior to this blasting was located on the eastern side of the open-cast for the monitoring period.

During the 84 blast events over this period there have been no exceedances in peak particle velocity recorded at MS1, MS2 or MS3. The maximum peak particle velocity recorded at MS1 was 5.1 mm/s (both longitudinal and transverse), 2.1 mm/s at MS2 (longitudinal) and 2.7 mm/s at MS3 (transverse). In total, 41 events at MS1, 34 events at MS2 and 32 events at MS3 failed to trigger the equipment. An additional two events, one at MS1 (26th September 2019) and one at MS2 (30th September 2022) were not recorded due to an equipment malfunction. During these two malfunction events, the other two licenced locations were monitored and results were either within limits or failed to trigger the equipment. The equipment trigger level used at the mine is 0.508 mm/s.

The impact magnitude of these is events is considered to be low – negligible while the sensitivity of the receptor is considered medium as MS1, MS2 and MS3 are proximal to residential receptors but lie within the mine site boundary. The effect significance therefore is considered to be Neutral at the existing mine.

Two exceedances (130 dB and 127.6 dB against a limit of 125 dB) in air overpressure were measured at MS1 during blast events on 30th July 2018 and 31st August 2018 at MS1, representing a 97.7% compliance over a ca. 6.5 year monitoring period for that station. The effect significance of these exceedances is considered to have been Slight for the two exceedances. There have been 46 subsequent blast events monitored at MS1 since the last exceedance, 35 of these events failed to trigger the monitoring equipment. During one event the equipment malfunctioned, and no reading was recorded, of the remaining 10 monitoring events the maximum air overpressure reading was 122 dB and the minimum was 110.9 dB.

No exceedances in air overpressure have been recorded at MS2 or MS3 during the 84 blast events. The effect significance of the majority of blasts events at Knocknacran Mine, omitting the 2 exceedances and malfunctioned equipment, are deemed to have been Neutral.

Table 12.6: Ground Vibration and Air Blast (Air Overpressure) Monitoring Results for Knocknacran Open-Cast Mine 2012 – 2022

Year Q	Date & Time	Explosives Quantity ANFO Kg	EMUGEL Kg	IEL Limits L mm/s	T mm/s	V mm/s	AOP dB	MS1 L mm/s	T mm/s	V mm/s	AOP dB	MS2 L mm/s	T mm/s	V mm/s	AOP dB	MS3 L mm/s	T mm/s	V mm/s	AOP dB
2012 Q1	06/01/2012 16:00	550	350	7.5	7.5	7.5	125	1.5	0.9	0.8	122	Failed to Trigger[1]				Failed to Trigger			
2012 Q1	30/01/2012 17:13	1750	2150	7.5	7.5	7.5	125	4.4	3.3	4.2	120	Failed to Trigger				Failed to Trigger			
2012 Q1	17/02/2012 16:00	1925	1075	7.5	7.5	7.5	125	2.6	1.6	2.1	118.8	0.5	0.4	0.1	117	Failed to Trigger			
2012 Q1	05/03/2012 16:00	950	450	7.5	7.5	7.5	125	0.3	0.3	0.1	125	Failed to Trigger				0.4	0.6	0.3	112
2012 Q2	20/04/2012 16:00	1375	500	7.5	7.5	7.5	125	0.8	0.6	0.4	114	Failed to Trigger				Failed to Trigger			
2012 Q2	16/05/2012 16:00	1600	825	7.5	7.5	7.5	125	4.9	5.1	3.8	114	0.4	0.6	0.1	116	Failed to Trigger			
2012 Q2	27/06/2012 16:00	825	375	7.5	7.5	7.5	125	1	0.8	0.6	117	Failed to Trigger				0.9	0.9	0.4	110
2012 Q3	19/07/2012 16:00	2300	1300	7.5	7.5	7.5	125	2.8	1.9	2.5	116	0.8	0.6	0.5	117	Failed to Trigger			
2012 Q3	06/09/2012 16:00	550	200	7.5	7.5	7.5	125	Failed to Trigger				Failed to Trigger				0.6	0.8	0.5	107
2012 Q4	05/10/2012 16:00	1000	650	7.5	7.5	7.5	125	1.8	1.5	1.3	121	Failed to Trigger				Failed to Trigger			
2012 Q4	19/10/2012 16:00	4350	1600	7.5	7.5	7.5	125	1	1.7	1.1	114	0.8	0.6	0.3	118	Failed to Trigger			
2012 Q4	20/11/2012 16:00	1300	775	7.5	7.5	7.5	125	1	1	0.6	118	Failed to Trigger				0.9	0.6	0.5	118
2012 Q4	12/12/2012 16:00	450	425	7.5	7.5	7.5	125	3.2	1.8	2.5	113	Failed to Trigger				Failed to Trigger			

[1] Note: "Failed to Trigger" indicates that the level of vibration was below the limit of detection of the equipment – it does not indicate any failure in the equipment.

Year Q	Date & Time	Explosives Quantity		IEL Limits				MS1				MS2				MS3			
		ANFO Kg	EMUGEL Kg	L mm/s	T mm/s	V mm/s	AOP dB	L mm/s	T mm/s	V mm/s	AOP dB	L mm/s	T mm/s	V mm/s	AOP dB	L mm/s	T mm/s	V mm/s	AOP dB
2013 Q1	09/01/2013 16:00	1275	1475	7.5	7.5	7.5	125	0.6	0.6	0.6	119	Failed to Trigger				0.8	0.6	0.8	106
2013 Q1	17/01/2013 16:00	375	500	7.5	7.5	7.5	125	Failed to Trigger				Failed to Trigger				0.6	0.8	0.4	106
2013 Q1	01/02/2013 16:00	200	1575	7.5	7.5	7.5	125	3	2.8	4	110	Failed to Trigger				Failed to Trigger			
2013 Q1	07/02/2013 16:00	1150	775	7.5	7.5	7.5	125	3.7	3.4	2.2	117	Failed to Trigger				Failed to Trigger			
2013 Q1	13/02/2013 16:00	75	1375	7.5	7.5	7.5	125	1.9	2.2	2.4	107	Failed to Trigger				Failed to Trigger			
2013 Q1	07/03/2013 16:00	3400	1475	7.5	7.5	7.5	125	5.1	4.4	3	117	0.6	0.6	0.3	118	1	0.7	0.6	104
2013 Q2	10/04/2013 16:00	3025	1050	7.5	7.5	7.5	125	0.7	1	0.6	115	Failed to Trigger				1	1	0.8	110
2013 Q2	30/04/2013 16:00	3500	2000	7.5	7.5	7.5	125	2	1.5	1.5	117	Failed to Trigger				1.1	1.3	1	110
2013 Q2	14/05/2013 16:00	1125	1631	7.5	7.5	7.5	125	Failed to Trigger				Failed to Trigger				1	0.9	1	106
2013 Q2	04/06/2013 16:00	950	550	7.5	7.5	7.5	125	0.5	0.6	0.4	111	Failed to Trigger				0.5	0.6	0.4	100
2013 Q2	24/06/2013 16:00	1500	1075	7.5	7.5	7.5	125	Failed to Trigger				Failed to Trigger				1.5	1.5	1.1	110
2013 Q3	22/07/2013 16:00	3750	1500	7.5	7.5	7.5	125	1.4	2	1.3	119	1	0.9	1	117	0.9	1	0.4	107
2013 Q3	28/08/2013 16:00	150	875	7.5	7.5	7.5	125	1.1	0.4	0.4	108	Failed to Trigger				Failed to Trigger			
2013 Q3	10/09/2013 16:00	625	1000	7.5	7.5	7.5	125	0.5	0.5	0.4	100	Failed to Trigger				0.6	0.6	0.4	98
2013 Q3	24/09/2013 16:00	3175	1825	7.5	7.5	7.5	125	0.6	0.4	0.4	118	0.5	0.8	0.3	119	2.4	2.7	1.4	107
2013 Q4	31/10/2013 16:00	500	75	7.5	7.5	7.5	125	2.4	1.9	2	120	Failed to Trigger				Failed to Trigger			

Year Q	Date & Time	Explosives Quantity		IEL Limits				MS1				MS2				MS3			
		ANFO	EMUGEL Kg	L	T	V	AOP	L	T	V	AOP	L	T	V	AOP	L	T	V	AOP
		Kg		mm/s	mm/s	mm/s	dB	mm/s	mm/s	mm/s	dB	mm/s	mm/s	mm/s	dB	mm/s	mm/s	mm/s	dB
2013 Q4	18/11/2013 16:00	50	350	7.5	7.5	7.5	125	Failed to Trigger				Failed to Trigger				Failed to Trigger			
2013 Q4	26/11/2013 16:00	100	500	7.5	7.5	7.5	125	0.5	0.4	0.4	110	Failed to Trigger				Failed to Trigger			
2013 Q4	03/12/2013 16:00	75	425	7.5	7.5	7.5	125	0.6	0.5	0.4	112	Failed to Trigger				Failed to Trigger			
2013 Q4	09/12/2013 16:00	600	50	7.5	7.5	7.5	125	1.8	2	1.9	110	Failed to Trigger				Failed to Trigger			
2014 Q1	24/01/2014 16:00	250	1800	7.5	7.5	7.5	125	2.2	3	2.9	112	Failed to Trigger				Failed to Trigger			
2014 Q1	05/02/2014 16:00	0	775	7.5	7.5	7.5	125	1.8	1.7	2	106	Failed to Trigger				Failed to Trigger			
2014 Q2	02/05/2014 16:00	200	625	7.5	7.5	7.5	125	1.8	2.2	1.3	118	Failed to Trigger				Failed to Trigger			
2014 Q3	07/07/2014 16:00	1850	475	7.5	7.5	7.5	125	3	2.9	1.9	122	Failed to Trigger				Failed to Trigger			
2018 Q2	11/04/2018 16:00	2000	145	7.5	7.5	7.5	125	Failed to Trigger				1.2	1	0.6	118	1.3	1.1	0.5	100
2018 Q2	22/06/2018 16:00	2250	550	7.5	7.5	7.5	125	0.2	0.1	0.1	122	1.016	1.524	0.635	121	1.3	1.1	0.8	114
2018 Q3	30/07/1018 16:00	1500	950	7.5	7.5	7.5	125	0.3	0.6	0.4	130	Failed to Trigger				1.7	1.5	1	114
2018 Q3	31/08/2018 16:00	2000	625	7.5	7.5	7.5	125	0.4	0.3	0.3	127.6	1.3	0.9	0.6	123.4	2.2	1.5	1	116
2018 Q3	12/09/2018 16:00	2000	625	7.5	7.5	7.5	125	Failed to Trigger				1.3	0.8	1	117	1.3	1.1	0.8	108.4
2018 Q3	21/09/2018 16:00	1875	900	7.5	7.5	7.5	125	0.4	0.7	0.3	121	1.5	1.3	1	112	1.3	1.4	0.8	116
2018 Q4	30/10/2018 16:00	1425	150	7.5	7.5	7.5	125	Failed to Trigger				0.5	0.5	0.3	122	1.7	1.7	0.8	110
2018 Q4	12/12/2018 16:00	2950	1023	7.5	7.5	7.5	125	0.3	0.1	0.3	120.8	1.3	1	0.8	117	1.3	1.3	1.5	117

Year Q	Date & Time	Explosives Quantity		IEL Limits				MS1				MS2				MS3			
		ANFO Kg	EMUGEL Kg	L mm/s	T mm/s	V mm/s	AOP dB	L mm/s	T mm/s	V mm/s	AOP dB	L mm/s	T mm/s	V mm/s	AOP dB	L mm/s	T mm/s	V mm/s	AOP dB
2019 Q1	24/01/2019 16:00	1375	573	7.5	7.5	7.5	125	Failed to Trigger				0.6	0.8	0.3	112	0.8	0.8	0.6	115
2019 Q1	14/02/2019 16:00	600	548	7.5	7.5	7.5	125	Failed to Trigger				Failed to Trigger				1	0.8	0.3	110
2019 Q1	28/02/2019 16:00	475	473	7.5	7.5	7.5	125	Failed to Trigger				Failed to Trigger				0.8	0.6	0.5	110
2019 Q1	14/03/2019 16:00	1125	1123	7.5	7.5	7.5	125	Failed to Trigger				1.3	1.5	0.8	110	2	1.1	1	104
2019 Q2	04/04/2019 16:00	3250	1125	7.5	7.5	7.5	125	Failed to Trigger				1.1	1.3	0.8	109.9	1.4	1.0	1.1	112
2019 Q2	09/05/2019 16:00	450	450	7.5	7.5	7.5	125	Failed to Trigger				0.8	0.5	0.5	114	0.6	0.4	0.3	106
2019 Q2	06/06/2019 16:00	225	1050	7.5	7.5	7.5	125	0.4	0.5	0.3	116	0.8	0.8	0.5	117	1.5	2.2	1.5	107.5
2019 Q2	27/06/2019 16:00	300	1050	7.5	7.5	7.5	125	Failed to Trigger				1	1	0.8	116	0.8	0.6	0.4	110
2019 Q3	11/07/2019 16:00	1650	850	7.5	7.5	7.5	125	Failed to Trigger				0.8	0.8	0.5	114	1.3	0.8	0.9	106
2019 Q3	25/07/2019 16:00	600	525	7.5	7.5	7.5	125	Failed to Trigger				0.6	0.5	0.3	110	Failed to Trigger			
2019 Q3	01/08/2019 16:00	1200	400	7.5	7.5	7.5	125	Failed to Trigger				0.7	0.6	0.4	107	Failed to Trigger			
2019 Q3	15/08/2019 16:00	2275	975	7.5	7.5	7.5	125	Failed to Trigger				1.1	0.8	0.7	111.8	Failed to Trigger			
2019 Q3	22/08/2019 16:00	1650	1025	7.5	7.5	7.5	125	Failed to Trigger				1	0.6	1.1	106	0.6	0.6	0.4	108
2019 Q3	05/09/2019 16:00	1250	800	7.5	7.5	7.5	125	Failed to Trigger				0.7	0.7	0.6	98	0.6	0.6	0.4	114.4
2019 Q3	12/09/2019 16:00	1725	825	7.5	7.5	7.5	125	Failed to Trigger				1.1	1	0.7	100	0.8	0.8	0.2	116.4
2019 Q3	19/09/2019 16:00	1850	875	7.5	7.5	7.5	125	Failed to Trigger				0.8	1	1.5	110	0.6	0.6	0.3	104.2

Year Q	Date & Time	Explosives Quantity		IEL Limits				MS1				MS2				MS3			
		ANFO	EMUGEL Kg	L	T	V	AOP	L	T	V	AOP	L	T	V	AOP	L	T	V	AOP
		Kg		mm/s	mm/s	mm/s	dB	mm/s	mm/s	mm/s	dB	mm/s	mm/s	mm/s	dB	mm/s	mm/s	mm/s	dB
2019 Q3	26/09/2019 16:00	950	800	7.5	7.5	7.5	125	Instrument Malfunction				1.2	0.6	1.2	110	Failed to Trigger			
2019 Q4	03/10/2019 16:00	975	750	7.5	7.5	7.5	125	0.6	0.5	0.7	113	Failed to Trigger				0.6	0.5	0.4	100
2019 Q4	10/10/2019 16:00	1025	625	7.5	7.5	7.5	125	Failed to Trigger				0.6	1.1	0.6	110	0.5	0.4	0.3	116
2019 Q4	17/10/2019 16:00	1850	900	7.5	7.5	7.5	125	Failed to Trigger				1.1	1.1	2.1	108	Failed to Trigger			
2019 Q4	24/10/2019 16:00	1075	750	7.5	7.5	7.5	125	Failed To Trigger				1	1	1.7	103	Failed To Trigger			
2019 Q4	07/11/2019 16:00	1250	950	7.5	7.5	7.5	125	Failed to Trigger				0.8	0.7	0.5	103.5	0.9	0.6	0.5	110.0
2019 Q4	14/11/2019 16:00	1100	800	7.5	7.5	7.5	125	Failed to Trigger				0.8	1.0	0.8	107	Failed to Trigger			
2019 Q4	28/11/2019 16:00	425	450	7.5	7.5	7.5	125	Failed to Trigger				0.8	0.8	1.3	100	Failed to Trigger			
2019 Q4	05/12/2019 16:00	1725	1250	7.5	7.5	7.5	125	Failed To Trigger				0.8	1	0.5	110	0.8	0.5	0.3	111.2
2020 Q1	05/03/2020 16:00:00	2100	800	7.5	7.5	7.5	125	0.2	0.1	0.1	122.1	0.9	0.9	0.8	117	1	0.8	0.7	118.2
2020 Q3	02/07/2020 16:00:00	800	1300	7.5	7.5	7.5	125	Failed To Trigger				1.1	0.9	0.9	116.0	0.9	0.4	0.3	116.7
2020 Q3	23/07/2020 16:00:00	2025	825	7.5	7.5	7.5	125	Failed To Trigger				1.5	1.5	1.0	111.0	0.7	0.7	0.6	119.2
2020 Q3	27/08/2020 16:00:00	525	825	7.5	7.5	7.5	125	Failed To Trigger				0.7	0.6	0.4	108.4	Failed To Trigger			
2020 Q4	08/10/2020 16:00:00	2250	1125	7.5	7.5	7.5	125	Failed To Trigger				1.9	1.0	1.7	112.0	0.6	0.6	0.6	119.7
2021 Q1	11/02/2021 16:00:00	2500	650	7.5	7.5	7.5	125	Failed To Trigger				1.0	1.4	0.8	112.0	0.8	0.8	0.7	109.5
2021 Q2	13/05/2021 16:00:00	1600	950	7.5	7.5	7.5	125	0.6	0.5	0.3	110.9	1.5	1.0	1.0	109.9	0.4	0.6	0.1	114.0

Year Q	Date & Time	Explosives Quantity		IEL Limits				MS1				MS2				MS3			
		ANFO Kg	EMUGEL Kg	L mm/s	T mm/s	V mm/s	AOP dB	L mm/s	T mm/s	V mm/s	AOP dB	L mm/s	T mm/s	V mm/s	AOP dB	L mm/s	T mm/s	V mm/s	AOP dB
2021 Q3	08/07/2021 16:00:00	2150	850	7.5	7.5	7.5	125	Failed To Trigger				1.3	1.0	0.8	110.0	0.8	0.5	0.4	110.6
2021 Q4	21/10/2021 16:00:00	1250	800	7.5	7.5	7.5	125	Failed To Trigger				1.1	0.9	1.1	106.0	Failed To Trigger			
2022 Q1	13/01/2021 16:00:00	1850	500	7.5	7.5	7.5	125	Failed To Trigger				1.8	1.1	0.6	114.0	1.1	1.2	0.8	91.5
2022 Q2	28/04/2022 16:00:00	1000	500	7.5	7.5	7.5	125	Failed To Trigger				0.9	1.1	1.3	100.0	0.8	0.6	0.6	98.8
2022 Q2	30/06/2022 16:00:00	1200	650	7.5	7.5	7.5	125	0.6	0.6	0.4	118.7	1.3	1.0	0.6	116.0	Equipment Malfunction			
2022 Q3	21/07/2022 16:00:00	800	275	7.5	7.5	7.5	125	Failed To Trigger				1.0	1.0	0.4	114.0	0.3	0.6	0.2	116.7
2022 Q4	27/10/2022 16:00:00	1992[2]		7.5	7.5	7.5	125	Failed To Trigger				2.1	1.1	0.8	120.3	1.0	0.8	0.6	108.0

[2] KEMEX

12.4.3 Results from Assessment Period 2012-2022: VSRs

As has been previously stated, monitoring is also undertaken by SGMI at residential dwellings (VSRs) located proximal to blast events.

Monitoring locations VSR1 and VSR2 are located to the east of the existing quarry, Figure 12.3. These locations represent monitoring of blasts which have occurred in the eastern part of the quarry during the period January 2012 and July 2014. In total, there were 37 blasts in the existing quarry during this period, all of these blasts were monitored at VSR1 and VSR2, Table 12.7.

During this period 5 blasts failed to trigger the equipment at VSR2, and 2 blasts failed to trigger the equipment at VSR1. The equipment trigger level was set at 0.508 mm/s. No exceedances in peak particle velocity or air overpressure were recorded at either location during the monitoring period. The maximum air overpressure recorded at VSR1 was 118 dB and 116 dB at VSR2. Peak particle velocity was recorded at a maximum of 5.8 mm/s (longitudinal) at VSR1 and 4.4 mm/s (transverse) at VSR2.

The sensitivity of these two VSRs is considered to have been high as they were monitoring points at residential locations. The magnitude of impact is considered to have been Negligible. For both air overpressure and vibration, the effect significance at the VSRs monitored is considered to have been Neutral.

Table 12.7: Ground Vibration and Air Blast (Air Overpressure) Monitoring Results for Knocknacran Mine January 2012 – March 2014 on the eastern side

Year Q	Date & Time	Explosives Quantity		IEL Limits				VSR2				VSR1			
		ANFO Kg	EMUGEL Kg	L mm/s	T mm/s	V mm/s	AOP dB	L mm/s	T mm/s	V mm/s	AOP dB	L mm/s	T mm/s	V mm/s	AOP dB
2012 Q1	06/01/2012 16:00	550	350	7.5	7.5	7.5	125	1.5	2.9	2.7	112	2.3	1.9	1.7	114
2012 Q1	30/01/2012 17:13	1750	2150	7.5	7.5	7.5	125	0.9	1	0.8	110	3.2	1.7	1.7	112
2012 Q1	17/02/2012 16:00	1925	1075	7.5	7.5	7.5	125	2.3	2	1.7	112	1	0.9	0.8	110
2012 Q1	05/03/2012 16:00	950	450	7.5	7.5	7.5	125	0.9	0.6	0.6	116	1	0.6	0.5	118
2012 Q2	20/04/2012 16:00	1375	500	7.5	7.5	7.5	125	1.5	1.3	1.3	112	1.3	1.4	1	110
2012 Q2	16/05/2012 16:00	1600	825	7.5	7.5	7.5	125	0.6	0.6	0.6	110	1.8	1.7	1.4	112
2012 Q2	27/06/2012 16:00	825	375	7.5	7.5	7.5	125	2	1.5	1.3	109	1.5	1.3	1.8	112
2012 Q3	19/07/2012 16:00	2300	1300	7.5	7.5	7.5	125	1.1	0.9	0.8	110	2.5	2	1.7	114
2012 Q3	06/09/2012 16:00	550	200	7.5	7.5	7.5	125	0.7	0.8	0.6	108	1	1	0.7	115
2012 Q4	05/10/2012 16:00	1000	650	7.5	7.5	7.5	125	Failed to Trigger[3]				2	2.2	2.1	114
2012 Q4	19/10/2012 16:00	4350	1600	7.5	7.5	7.5	125	2	4.4	2.7	110	3	2.3	1.5	110
2012 Q4	20/11/2012 16:00	1300	775	7.5	7.5	7.5	125	1.3	1.7	1.3	110	1.4	2.4	1.8	114
2012 Q4	12/12/2012 16:00	450	425	7.5	7.5	7.5	125	Failed to Trigger				0.8	0.6	0.6	106
2013 Q1	09/01/2013 16:00	1275	1475	7.5	7.5	7.5	125	2.2	2	2	109	2.3	1.4	1.1	112
2013 Q1	17/01/2013 16:00	375	500	7.5	7.5	7.5	125	1.1	1	1	104	0.8	0.5	0.6	110
2013 Q1	01/02/2013 16:00	200	1575	7.5	7.5	7.5	125	0.5	0.5	0.4	106	0.9	1.1	1	106
2013 Q1	07/02/2013 16:00	1150	775	7.5	7.5	7.5	125	0.6	0.6	0.5	112	1.1	1	0.9	114

[3] Note: "Failed to Trigger" indicates that the level of vibration was below the limit of detection of the equipment – it does not indicate any failure in the equipment.

		Explosives Quantity		IEL Limits				VSR2				VSR1			
Year Q	Date & Time	ANFO Kg	EMUGEL Kg	L mm/s	T mm/s	V mm/s	AOP dB	L mm/s	T mm/s	V mm/s	AOP dB	L mm/s	T mm/s	V mm/s	AOP dB
2013 Q1	13/02/2013 16:00	75	1375	7.5	7.5	7.5	125	0.5	0.5	0.4	106	1.1	0.8	0.6	112
2013 Q1	07/03/2013 16:00	3400	1475	7.5	7.5	7.5	125	2.4	2.3	1.5	110	5.8	3.8	3.7	106
2013 Q2	10/04/2013 16:00	3025	1050	7.5	7.5	7.5	125	2.8	2.4	1.5	110	2.2	1.9	1.5	112
2013 Q2	30/04/2013 16:00	3500	2000	7.5	7.5	7.5	125	3.3	3.4	2.2	112	2.8	3.4	3	112
2013 Q2	14/05/2013 16:00	1125	1631	7.5	7.5	7.5	125	2	2.1	1.3	111	0.6	1	0.6	112
2013 Q2	04/06/2013 16:00	950	550	7.5	7.5	7.5	125	0.9	1	0.8	107	0.9	0.9	0.8	106
2013 Q2	24/06/2013 16:00	1500	1075	7.5	7.5	7.5	125	2.3	2.1	1.9	112	0.9	1.3	0.9	112
2013 Q3	22/07/2013 16:00	3750	1500	7.5	7.5	7.5	125	1.5	1.7	1	110	2.9	5	3.4	110
2013 Q3	28/08/2013 16:00	150	875	7.5	7.5	7.5	125	0.5	0.8	0.4	106	Failed to Trigger			
2013 Q3	10/09/2013 16:00	625	1000	7.5	7.5	7.5	125	0.6	0.8	0.6	100	0.9	1.3	0.8	100
2013 Q3	24/09/2013 16:00	3175	1825	7.5	7.5	7.5	125	2.2	2	1.9	112	0.9	1.5	1.1	112
2013 Q4	31/10/2013 16:00	500	75	7.5	7.5	7.5	125	Failed to Trigger				0.9	0.8	0.6	116
2013 Q4	18/11/2013 16:00	50	350	7.5	7.5	7.5	125	0.5	0.3	0.3	106	Failed to Trigger			
2013 Q4	26/11/2013 16:00	100	500	7.5	7.5	7.5	125	Failed to Trigger				0.4	0.5	0.4	106
2013 Q4	03/12/2013 16:00	75	425	7.5	7.5	7.5	125	Failed to Trigger				0.5	0.4	0.4	106
2013 Q4	09/12/2013 16:00	600	50	7.5	7.5	7.5	125	0.5	0.9	0.6	100	1.7	2.5	1.4	106
2014 Q1	24/01/2014 16:00	250	1800	7.5	7.5	7.5	125	1.1	2.5	1.3	112	0.8	0.9	0.5	106
2014 Q1	05/02/2014 16:00	0	775	7.5	7.5	7.5	125	0.6	0.5	0.4	100	0.6	1.3	0.5	100
2014 Q2	02/05/2014 16:00	200	625	7.5	7.5	7.5	125	1	0.8	0.8	106	1.9	2.5	1.3	106
2014 Q3	07/07/2014 16:00	1850	475	7.5	7.5	7.5	125	0.9	1.4	0.8	106	2.4	2.3	2.4	112

Monitoring locations VSR3, VSR4, VSR5 and VSR6 are located to the west of the existing quarry, Figure 12.3. As such, these locations represent monitoring of blasts in the western part of the quarry between April 2018 and October 2022, details of which are presented in Table 12.8.

In total there were 47 blasts in the western side of the existing quarry during this monitoring period. Of these, 47 blasts were monitored at VSR3 and VSR4, 38 blasts were monitored at VSR5, and 35 blasts were monitored at VSR6. No exceedances were recorded for air overpressure or peak particle velocity at any of these locations. Failures to trigger were recorded at each monitoring location as follows: 2 at VSR3, 1 at VSR4, 3 at VSR5 and 19 at VSR6. The equipment trigger level was 0.508 mm/s. During one event, at VSR6, the equipment was faulty, and no data was recorded for the event (15th August 2019).

Maximum peak particle velocity recorded at VSR3 was 2.1 mm/s (transverse), 5.2 mm/s at VSR4 (longitudinal), 2.1 mm/s (vertical) at VSR5 and 0.8 mm/s at VSR6 (vertical and transverse). Maximum air overpressure recorded at VSR3 was 118 dB, 120 dB at VSR4, 115.6 dB at VSR5 and 110 dB at VSR6.

The sensitivity of the VSRs is considered to be high as they are monitoring points at residential locations. The magnitude of impact is considered to have been Negligible. For both air overpressure and vibration, the effect significance at the VSRs monitored is considered to have been Neutral.

In summary, no exceedances in either air overpressure or peak particle velocity have been recorded at residential dwellings during blast events between January 2012 and October 2022.

Table 12.8: Ground Vibration and Air Blast (Air Overpressure) Monitoring Results for Knocknacran Mine April 2018 – October 2022 on the western side

Year Q	Date & Time	Explosives Quantity		IEL Limits				VSR3				VSR4				VSR5				VSR6			
		ANFO	EMUGEL Kg	L	T	V	AOP	L	T	V	AOP	L	T	V	AOP	L	T	V	AOP	L	T	V	AOP
		Kg		mm/s	mm/s	mm/s	dB	mm/s	mm/s	mm/s	dB	mm/s	mm/s	mm/s	dB	mm/s	mm/s	mm/s	dB	mm/s	mm/s	mm/s	dB
2018 Q2	11/04/2018 16:00	2000	145	7.5	7.5	7.5	125	1.3	1.1	1	112	1.9	1	0.9	112								
2018 Q2	22/06/2018 16:00	2250	550	7.5	7.5	7.5	125	1.8	1.5	1.1	112	1.5	2.5	1.1	120								
2018 Q3	30/07/1018 16:00	1500	950	7.5	7.5	7.5	125	Failed to Trigger[4]				1.2	1	0.7	115								
2018 Q3	31/08/2018 16:00	2000	625	7.5	7.5	7.5	125	1.4	1.9	1.1	112	2	1.5	1.1	117	No monitored							
2018 Q3	12/09/2018 16:00	2000	625	7.5	7.5	7.5	125	1.5	1	1.1	111.2	1.9	2	1.7	118								
2018 Q3	21/09/2018 16:00	1875	900	7.5	7.5	7.5	125	1.7	1.5	1.7	112	2.7	1.7	2.3	116					Not monitored			
2018 Q4	30/10/2018 16:00	1425	150	7.5	7.5	7.5	125	1	1	0.6	108.8	Failed to Trigger											
2018 Q4	12/12/2018 16:00	2950	1023	7.5	7.5	7.5	125	2.1	0.8	0.8	114.2	1.8	1.1	1	116.3	1.1	0.9	1.2	115.2				
2019 Q1	24/01/2019 16:00	1375	573	7.5	7.5	7.5	125	1.3	0.8	0.8	112	1.4	0.9	1.0	112.0	0.889	0.953	0.762	110				
2019 Q1	14/02/2019 16:00	600	548	7.5	7.5	7.5	125	1.39	0.76	0.63	110	1.5	1	0.8	114	0.6	0.4	0.4	109				
2019 Q1	28/02/2019 16:00	475	473	7.5	7.5	7.5	125	1	0.5	0.5	106	1.3	0.8	0.5	112	0.7	0.3	0.3	108				

[4] Note: "Failed to Trigger" indicates that the level of vibration was below the limit of detection of the equipment – it does not indicate any failure in the equipment.

Year Q	Date & Time	Explosives Quantity		IEL Limits				VSR3				VSR4				VSR5				VSR6			
		ANFO	EMUGEL Kg	L	T	V	AOP	L	T	V	AOP	L	T	V	AOP	L	T	V	AOP	L	T	V	AOP
		Kg		mm/s	mm/s	mm/s	dB	mm/s	mm/s	mm/s	dB	mm/s	mm/s	mm/s	dB	mm/s	mm/s	mm/s	dB	mm/s	mm/s	mm/s	dB
2019 Q1	14/03/2019 16:00	1125	1123	7.5	7.5	7.5	125	1.4	1.3	0.9	112	2.5	1.1	1	110	1.6	0.6	0.7	109				
2019 Q2	04/04/2019 16:00	3250	1125	7.5	7.5	7.5	125	1.5	0.1	1	110	3	1.8	1.8	114					Failed to Trigger			
2019 Q2	09/05/2019 16:00	450	450	7.5	7.5	7.5	125	0.8	0.6	0.4	106	1.3	0.8	0.4	110	Failed to Trigger				Failed to Trigger			
2019 Q2	06/06/2019 16:00	225	1050	7.5	7.5	7.5	125	1.1	0.9	0.5	106	0.6	1.0	0.3	113.8	0.6	0.8	0.5	115.6	Failed to Trigger			
2019 Q2	27/06/2019 16:00	300	1050	7.5	7.5	7.5	125	0.9	0.9	0.5	112.6	1.1	0.9	0.7	109.9	0.6	0.8	0.8	104.9	Not monitored			
2019 Q3	11/07/2019 16:00	1650	850	7.5	7.5	7.5	125	1.1	0.9	0.9	106	1	0.8	0.4	112	0.8	0.8	1.1	109.2	Failed to Trigger			
2019 Q3	25/07/2019 16:00	600	525	7.5	7.5	7.5	125	1.4	2.1	0.8	107	1.2	1.2	0.7	112	0.4	0.6	0.3	106.5	Failed to Trigger			
2019 Q3	01/08/2019 16:00	1200	400	7.5	7.5	7.5	125	1.7	1.4	0.7	112.3	2	2.3	1.3	112	0.7	0.7	0.4	103.5	Failed to Trigger			
2019 Q3	15/08/2019 16:00	2275	975	7.5	7.5	7.5	125	1.3	1.7	0.6	114.2	3.6	2.7	1.7	110	0.8	0.8	0.5	106	Instrument damaged			
2019 Q3	22/08/2019 16:00	1650	1025	7.5	7.5	7.5	125	1.4	1.3	0.6	112	2.4	2	1.9	110	0.9	0.6	1	100	0.4	0.5	0.5	110
2019 Q3	05/09/2019 16:00	1250	800	7.5	7.5	7.5	125	1.3	1.9	0.5	114	1.8	2.2	1.3	106	0.6	0.8	0.5	100	Failed to Trigger			
2019 Q3	12/09/2019 16:00	1725	825	7.5	7.5	7.5	125	1	0.9	0.8	114	2	1.3	1.1	110	1	0.8	1.4	106	0.4	0.4	0.6	106
2019 Q3	19/09/2019 16:00	1850	875	7.5	7.5	7.5	125	0.6	0.6	0.5	112	2	2.5	1.8	112	0.6	0.9	0.9	108.8	0.3	0.4	0.6	106
2019 Q3	26/09/2019 16:00	950	800	7.5	7.5	7.5	125	Failed to Trigger				2.4	1.4	2.5	110	0.9	0.6	1.1	103.5	0.3	0.3	0.6	106

Year Q	Date & Time	Explosives Quantity		IEL Limits				VSR3				VSR4				VSR5				VSR6			
		ANFO Kg	EMUGEL Kg	L mm/s	T mm/s	V mm/s	AOP dB	L mm/s	T mm/s	V mm/s	AOP dB	L mm/s	T mm/s	V mm/s	AOP dB	L mm/s	T mm/s	V mm/s	AOP dB	L mm/s	T mm/s	V mm/s	AOP dB
2019 Q4	03/10/2019 16:00	975	750	7.5	7.5	7.5	125	0.9	1.0	0.5	106	2.3	1.9	1.5	112	Failed To Trigger				Failed To Trigger			
2019 Q4	10/10/2019 16:00	1025	625	7.5	7.5	7.5	125	0.9	1.1	0.5	110	2.8	3.2	2.7	110	0.8	1.3	0.6	106	0.4	0.5	0.8	109.2
2019 Q4	17/10/2019 16:00	1850	900	7.5	7.5	7.5	125	0.5	0.6	0.4	110	3.8	2.3	2.8	112	1.1	0.8	1.0	110.6	0.3	0.3	0.7	101
2019 Q4	24/10/2019 16:00	1075	750	7.5	7.5	7.5	125	0.8	0.6	0.4	114	2.7	3.2	2.5	110	0.9	0.7	1.2	103.5	0.3	0.4	0.6	101
2019 Q4	07/11/2019 16:00	1250	950	7.5	7.5	7.5	125	0.9	0.6	0.5	110	1.4	0.8	0.6	106	0.7	0.7	0.7	102.8	Failed to Trigger			
2019 Q4	14/11/2019 16:00	1100	800	7.5	7.5	7.5	125	0.6	0.8	0.6	118	5.2	3	3.7	114	1	1	1.7	106	0.4	0.4	0.8	103.5
2019 Q4	28/11/2019 16:00	425	450	7.5	7.5	7.5	125	0.5	0.4	0.3	112	3.4	2.9	2.5	110	0.6	0.7	1	101	0.3	0.4	0.8	95.9
2019 Q4	05/12/2019 16:00	1725	1250	7.5	7.5	7.5	125	1.1	1	0.6	100	1.8	1.1	1.5	106	0.9	1.4	1.1	107	Failed To Trigger			
2020 Q1	05/03/2020 16:00:00	2100	800	7.5	7.5	7.5	125	1.1	1	0.8	114	1.8	1	1.0	114	0.7	0.8	0.6	114.4	Failed To Trigger			
2020 Q3	02/07/2020 16:00:00	800	1300	7.5	7.5	7.5	125	1.0	1	0.6	112	1.9	1	1.4	116	1.0	1	1.0	112	0.3	1	0.4	109.2
2020 Q3	23/07/2020 16:00:00	2025	825	7.5	7.5	7.5	125	1.5	1	1.0	113.1	3.0	2	2.0	109.5	1.2	1	1.5	107	0.6	0	0.7	102.8
2020 Q3	27/08/2020 16:00:00	525	825	7.5	7.5	7.5	125	0.6	1	0.4	110	1.3	1	1.5	110	0.2	1	0.3	88	0.4	1	0.7	100
2020 Q4	08/10/2020 16:00:00	2250	1125	7.5	7.5	7.5	125	1.1	1	0.6	114.6	2.4	2	2.5	110	1.4	1	2.1	102.8	Failed To Trigger			
2021 Q1	11/02/2021 16:00:00	2500	650	7.5	7.5	7.5	125	1.3	1	0.8	112	1.8	2	2.3	112	1.0	1	1.8	114	0.5	1	0.6	95.9

Year Q	Date & Time	Explosives Quantity		IEL Limits				VSR3				VSR4				VSR5				VSR6			
		ANFO	EMUGEL Kg	L	T	V	AOP	L	T	V	AOP	L	T	V	AOP	L	T	V	AOP	L	T	V	AOP
		Kg		mm/s	mm/s	mm/s	dB	mm/s	mm/s	mm/s	dB	mm/s	mm/s	mm/s	dB	mm/s	mm/s	mm/s	dB	mm/s	mm/s	mm/s	dB
2021 Q2	13/05/2021 16:00:00	1600	950	7.5	7.5	7.5	125	0.9	1	0.5	110	1.4	1	1.5	110	1.0	1	1.0	108	Failed To Trigger			
2021 Q3	08/07/2021 16:00:00	2150	850	7.5	7.5	7.5	125	0.9	1	0.9	112	1.5	2	3.2	110	1.0	1	1.9	107	Failed To Trigger			
2021 Q4	21/10/2021 16:00:00	1250	800	7.5	7.5	7.5	125	0.5	0.3	0.4	106.0	1.3	1.8	0.8	116.0	0.8	0.5	1.1	104.2	Failed To Trigger			
2022 Q1	13/01/2021 16:00	1850	500	7.5	7.5	7.5	125	1.9	1.4	1.0	106.0	1.8	2.5	1.3	114.0	1.5	1.5	1.1	109.9	0.4	0.5	0.6	98.8
2022 Q2	28/04/2022 16:00	1000	500	7.5	7.5	7.5	125	0.8	0.9	0.8	106.0	1.1	0.9	0.9	106.0	0.5	0.6	0.9	103.5	Failed To Trigger			
2022 Q2	30/06/2022 16:00	1200	650	7.5	7.5	7.5	125	0.6	1.1	0.8	110.0	1.7	2.8	1.4	116.0	0.6	0.6	0.7	113.0	Failed To Trigger			
2022 Q3	21/07/2022 16:00	800	275	7.5	7.5	7.5	125	1.0	0.8	0.5	116.0	1.3	1.8	0.8	116.0	Failed To Trigger				Failed To Trigger			
2022 Q4	27/10/2022 16:00	1992[5]		7.5	7.5	7.5	125	1.3	1.2	0.6	109.2	1.1	1.3	0.6	117.9	Not Monitored				Failed To Trigger			

[5] KEMEX

12.4.4 EPA Blast Monitoring

In addition to the vibration monitoring carried out by SGMI, the EPA has undertaken vibration monitoring during 4 blasts in 2019 after receiving complaints from third parties. To date, complaints have been received for blasts on 15th August 2019, 22nd August 2019, 26th September 2019, 3rd October 2019, 24 October 2019, 14th November 2019, 28th November 2019 and 5th March 2020. These blasts have also been recorded by SGMI (refer to tables above) as part of routine monitoring and no exceedances were measured.

Following on from the submission of these third-party complaints, 4 blasts on 5th September 2019, 10th October 2019, 17th October 2019 and 31st October 2019 were monitored by the EPA at the two complainant's properties. A copy of the original complaints for the blasts submitted to the EPA is available upon request from the EPA, these have not been included in the EIAR as they include 3rd party information.

The EPA blast monitoring reports refer to two monitoring locations, Location A and Location B, both are listed as ca. 600 m from the blast events. Blasts on 5th September 2019, 10th October 2019 and 17th October 2019 were monitored at Location A while the fourth blast, on 14th November 2019, was monitored by the EPA at Location B. A fifth blast was scheduled to be monitored by the EPA on 31st October 2019, however, the blast was cancelled, and no monitoring was carried out.

Given that the 4 blasts monitored by the EPA have also been monitored by SGMI, it is possible to compare the two blast monitoring datasets. In half of the submissions no location was noted, in the other half receptor locations are noted and represent 2 receptors which are comparable to data from VSR6, and the other receptor is comparable to data from VSR4.

Complaints submitted to the EPA, which triggered the monitoring, relate to issues with blasts being 'very large' or 'very excessive' and that there is rattling of walls, roof tiles, windows and doors noted within the properties. One complainant (EPA ref. COM009689) perceives that blasting is 'getting worse' over time. Two complaints from one property to the west (EPA Location A/VSR6) note damage to roof tiles (two being broken with hairline cracks causing leaks, EPA ref. COM009490, blast dated 03/10/2019), broken shower glass and cracks in fresh paintwork on the house (EPA ref. COM009586, blast dated 24/10/2019).

Subsequent monitoring was undertaken at two locations by the EPA for 4 blast events, 3 at Location A and 1 at Location B. No exceedances in peak particle velocity or air overpressure were recorded by the EPA during these events at the locations. Corresponding blast monitoring carried out by SGMI monitoring data at VSR6 and VSR4 for the same events also did not show any exceedances in air overpressure or peak particle velocity. It is also considered likely that the other complaints relate to these two locations as the EPA did not propose monitoring of any other location to address complaints.

For the events on 5 September and 10th October 2019 (at Location A/VSR6) the EPA geo trigger level of 1.0mm/s was not reached and a result of 'no trigger' was recorded. Results were recorded by SGMI for the blast on 10th October 2019 (0.4 mm/s L, 0.5 mm/s T, 0.8 mm/s V and 109.2 dB AOB) as the geo trigger level is set lower (0.508 mm/s). A result of no trigger was also recorded by SGMI for the blast on 5 September 2019 at VSR6, despite a lower geo trigger level of 0.508 mm/s. This is not unexpected given that VSR6/Location A is one of the most distally located receptors to the existing Knocknacran Mine and has had a 48.1% rate of failure (13 failed events out of 27, in addition one event was not recorded due to damaged equipment) to trigger the monitoring equipment in the SGMI monitoring program at this location (April 2019 – July 2021).

EPA monitored blast events on 17th October 2019 and 31st October 2019 lowered the geo trigger level to 0.5 mm/s and results were recorded for both events, the former event recorded at Location A and the later at Location B, all records were within the licence limits.

The results of the EPA vibration and air overpressure monitoring are presented in Table 12.9 below and the SGMI monitoring record for these events is also included. In all cases of monitoring both by the EPA and by SGMI, the sensitivity of the receptor is considered to have been High, the magnitude of impact to have been Negligible and the effect significance is considered to have been Neutral for both air overpressure and vibration.

Table 12.9: Ground Vibration and Air Blast (Air Overpressure) Monitoring Results by the EPA during blast events at Knocknacran Mine 2019

Year Q	Location	Date & Time	Limits				EPA Report Number	Trigger Level				
			L	T	V	AOP		mm/s	L	T	V	AOP
			mm/s	mm/s	mm/s	dB			mm/s	mm/s	mm/s	dB
2019 Q3	Location A (EPA)	05/09/2019 Between 15:52 and 16:45	7.5	7.5	7.5	125	SV18341	1	Failed to Trigger			
2019 Q3	VSR6 (SGMI)	05/09/2019 16:00:00	7.5	7.5	7.5	125	N/A	0.508	Failed to Trigger			
2019 Q4	Location A (EPA)	10/10/2019 Between 15:49 and 16:02	7.5	7.5	7.5	125	SV18393	1	Failed to Trigger			
2019 Q4	VSR6 (SGMI)	10/10/2019 16:00:00	7.5	7.5	7.5	125	N/A	0.508	0.4	0.5	0.8	109.2
2019 Q4	Location A (EPA)	17/10/2019 Between 15:45 and 16:01	7.5	7.5	7.5	125	SV18405	0.5	0.381	0.381	0.889	106.5
2019 Q4	VSR6 (SGMI)	17/10/2019 16:00:00	7.5	7.5	7.5	125	N/A	0.508	0.3	0.3	0.7	101
2019 Q4	Location B (EPA)	14/11/2019 Between 15:45 and 16:01	7.5	7.5	7.5	125	SV18472	0.5	3.175	2.032	3.683	115
2019 Q4	VSR3(SGMI)	14/11/2019 16:00:00	7.5	7.5	7.5	125	N/A	0.508	5.2	3	3.7	114

12.5 Key Characteristics of the Proposed Development

12.5.1 Construction Phase: Community Sports Complex

During this phase, the existing Community Sports Complex will be further developed. The initial phase of this development has been constructed (Reg. Ref.: 20/365), and the next phase will involve extending the Community Sports Complex with the construction of two further playing pitches, one with a perimeter running track, an all-weather pitch, a new club building, including a sports hall, a handball alley, changing rooms & toilets, a viewing gallery, a part-covered grandstand, additional parking and associated siteworks.

12.5.2 Construction Phase: Mine Development

During this phase:

- Screening berms will be constructed;
- Planting (including bolstering and retention of the existing perimeter hedgerow which sits in front of/is separate to the proposed planted screening berms) will be carried out;
- Perimeter fencing will be installed;
- One residential house and three unoccupied houses and sheds on the Knocknacran West site will be demolished;

- A temporary diversion of the R179 will be constructed to maintain traffic flow while a Cut-and-Cover Tunnel is constructed; and
- A new vehicular entrance will be constructed to the existing mine site from the L4816.

12.5.3 Operational Phase: Community Sports Complex

During this phase, the Community Sports Complex will be in operation.

12.5.4 Operational Phase: Mine Development

The proposed phased extraction of gypsum by open-cast mining methods at Knocknacran West is to expose and recover the Upper and Lower gypsum seams/units remaining after the cessation of mining from the Drumgoosat underground mine in 1989. In parallel, the Knocknacran Mine will be backfilled and remediated to near original ground.

During this phase:

- Overburden and Interburden will be stripped by mechanical means (i.e. by digging out with an excavator) to expose the Gypsum Mineral at the new Knocknacran West Open cast mine. The overburden and interburden occur onsite as a soft, semi-consolidated material that does not require blasting;
- The gypsum remaining in the former Drumgoosat Underground Mine will be extracted by open-cast mining methods (i.e. by blasting);
- Blasting will occur in line with current operations, which can vary form every two weeks to every few months;
- The existing Knocknacran Mine will be restored to near original ground level;
- The existing processing plant on the existing Knocknacran Open-Cast Mine site will be refurbished;
- The existing plant site will process and despatch the extracted gypsum;
- The existing Drumgoosat dewatering pump, will be relocated to an existing borehole on the Knocknacran West site to continue to provide dewatering; and
- The depth of mining will be to a depth to which the base of the Lower gypsum bed extends in the open-cast area which is ca. - 53 m OD.

12.5.5 Restoration/Closure Phase: Community Sports Complex

There is no proposal to close the Community Sports Complex development, and this phase is therefore not applicable in this case.

12.5.6 Restoration/Closure Phase: Mine Development

During this phase:

- The new Knocknacran West site will be returned to grassland and a waterbody;

- The existing Knocknacran site will be returned to near original ground level;
- The existing Knocknacran Plant site will be partially dismantled whereby mine plant is removed; and
- In line with the current CRAMP it is presented that here that a suitable developer would be sought to utilise the general buildings existing on the existing site for a light industrial usage into the future. This would be subject to a future developer seeking the necessary permits for continuation of use and change of use from mining to a non-mining use.

12.6 Potential Effects

12.6.1 Potential Effects: Construction Phase: Community Sports Complex

No significant off-site vibration is anticipated associated with surface works during the construction phase. No blasting will take place and the plant and equipment used is that normally used in commercial construction projects.

A report in Appendix 7.14 assesses the potential for vibration impacts during the construction of the mine development and also considers general construction plant which is applicable to the construction phase of the Community Sports Complex.

In summary, the report considers that any vibration from construction plant would be imperceptible 10 m to 20 m away from construction equipment. It further considers that the plant generates vibration which lies below the residential damage threshold at a distance of 1 m away.

An extract from the report states:

"Vibration is normally measured as peak particle velocity (PPV) in mm/second. PPV reduces or attenuates as the distance from the source of vibration increases. Relationship between PPV and distance from source for a number of types of moving plant has been developed by Wiss (1981).

This relationship is shown in Figure 12.4, below.

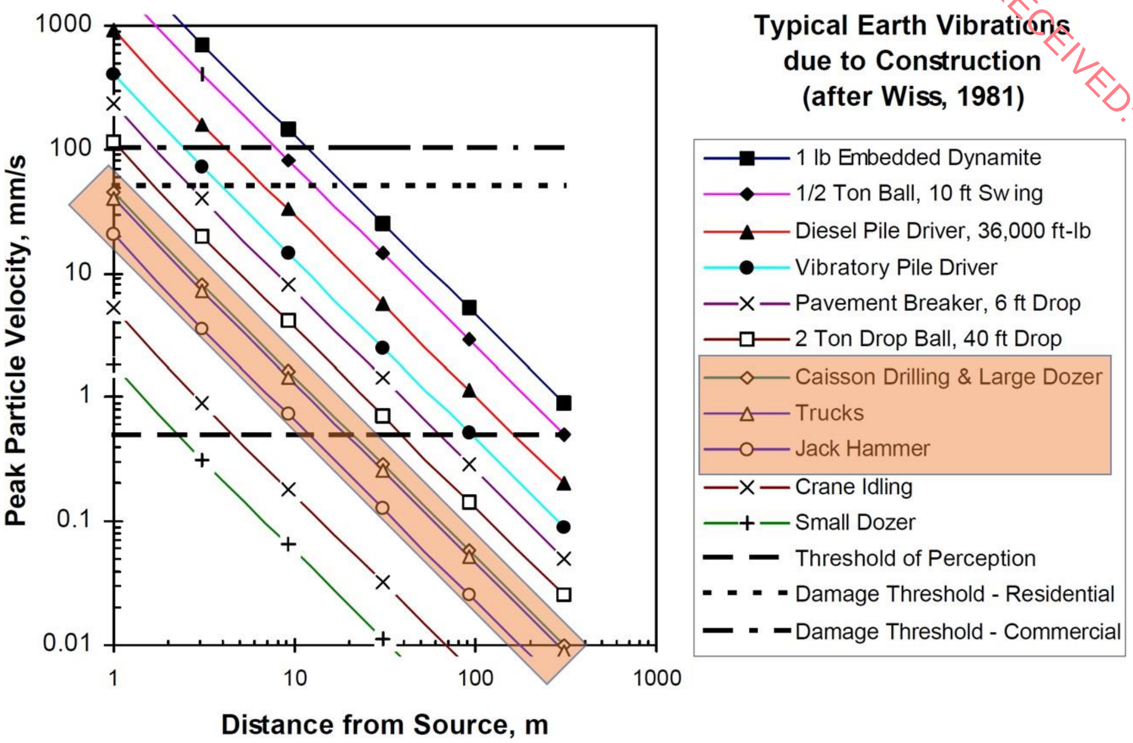

Figure 12.4: Vibration Attenuation Graph for Typical Construction Equipment

Highlighted in orange are the main types of equipment that would operate in an open-cast environment, large dozers, trucks and blasthole drills (jack hammers). Also included are various typical vibration thresholds – perception (0.5 mm/sec), damage to residential buildings (50 mm/sec) and damage to commercial buildings (100 mm/sec).

It can be seen that for the equipment that any vibration generated by them would become imperceptible from 10 m to 20 m away from the equipment. All equipment considered generates vibration which lies below the residential damage threshold at a distance of 1 m away."

No residential receptor is within 10 to 20 m of the construction phase on this site. Regardless, it is considered that the sensitivity of VSRs in the area is High. In turn, this considers that the magnitude of impact is Negligible and that the significance of effect is Neutral for nearby residences.

12.6.2 Potential Effects: Construction Phase: Mine Development

No significant off-site vibration is anticipated associated with surface works during the construction phase.

A report in Appendix 7.14 assesses the potential for vibration impacts during the construction from equipment and plant operating on the site.

In summary, the report considers that any vibration from construction plant would be imperceptible 10 m to 20 m away. It further considers that the plant generates vibration which lies below the residential damage threshold at a distance of 1 m away.

An extract from the report states:

"Vibration is normally measured as peak particle velocity (PPV) in mm/second. PPV reduces or attenuates as the distance from the source of vibration increases. Relationship between PPV and distance from source for a number of types of moving plant has been developed by Wiss (1981).

This relationship is shown in Figure 12.5, below.

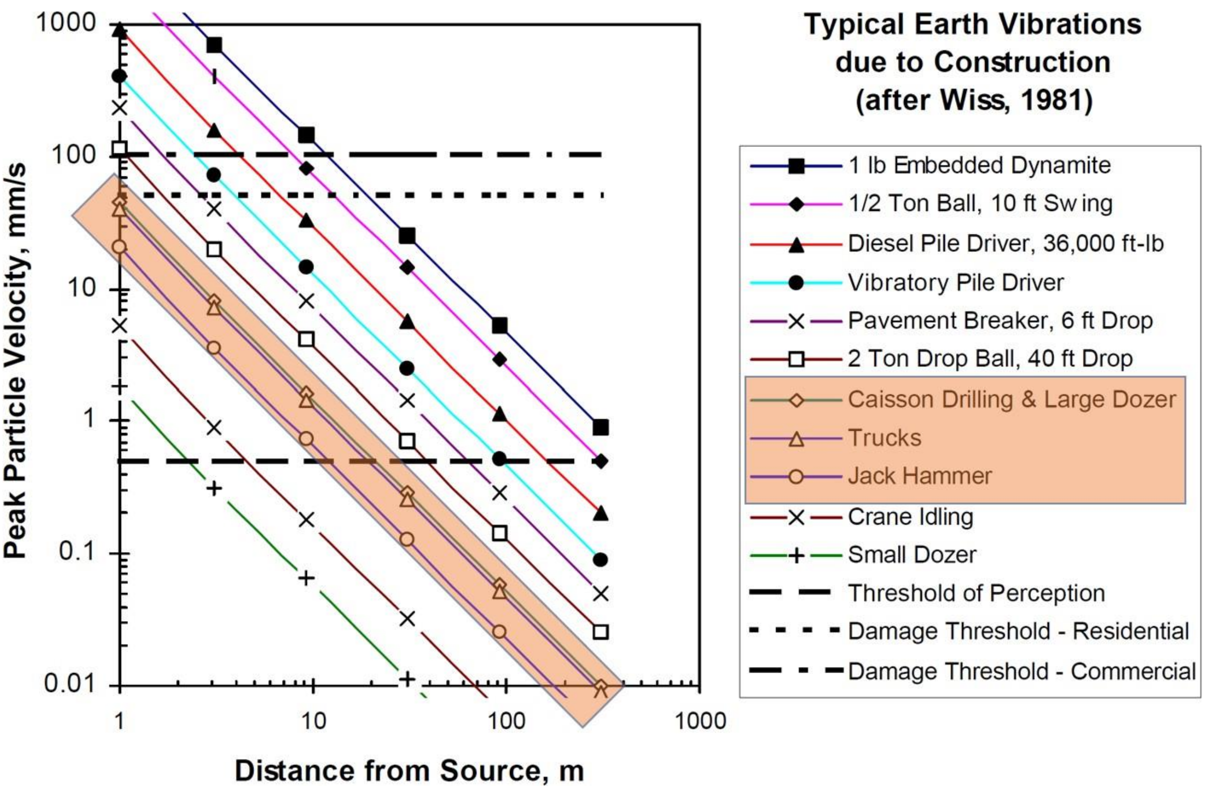

Figure 12.5: Vibration Attenuation Graph for Typical Construction Equipment

Highlighted in orange are the main types of equipment that would operate in an open-cast environment, large dozers, trucks and blasthole drills (jack hammers). Also included are various typical vibration thresholds – perception (0.5 mm/sec), damage to residential buildings (50 mm/sec) and damage to commercial buildings (100 mm/sec).

It can be seen that for the equipment that any vibration generated by them would become imperceptible from 10 m to 20 m away from the equipment. All equipment considered generates vibration which lies below the residential damage threshold at a distance of 1 m away."

The closest VSR is ca. 100 m from any potential source of vibration during the construction phase, the analysis indicates that the level of vibration necessary to cause damage to residential property will be contained to within 1 m of the operating plant.

The report also considers that the level of risk to stability of the mining tunnels from construction is very low. The risks and risk mitigation associated with vibration are well understood and will be addressed by method statements and standard operating procedures related to mining above and through underground workings based on the long-term experience of open-cast mining adjacent to and above such tunnels in the existing Knocknacran Open-Cast Mine.

It is considered that the sensitivity of VSRs in the area is High and sensitivity for the underground workings is Low. In turn, the magnitude of impact is Negligible and that the significance of effect is Neutral for both underground workings and VSRs.

12.6.3 Potential Effects: Operational Phase: Community Sports Complex

During the operational phase of the Community Sports Complex, the activities onsite will not give rise to vibration. This is scoped out for further consideration in this phase.

12.6.4 Potential Effects: Operational Phase: Mine Development

A quantitative assessment has been carried out of the potential impact upon nearby receptors using historical blast details at Knocknacran Mine as these are the same as proposed for Knocknacran West Mine. Lithologies between the two mines are the same and blasting will be carried out on the gypsum units only, as is practice within the existing mine.

In addition, consideration is given to the potential for vibration arising from the overburden and interburden equipment (i.e. truck movements causing vibration) and the potential for vibration impacting the underground workings.

Blasting Procedure

In the Proposed Development gypsum will continue to be extracted by blasting in compliance with the current IE Licence limits. It is not expected that a revision of the IE Licence to incorporate Knocknacran West would lead to a change in licence limits for the open-cast mine, however, it is expected that further monitoring points will be incorporated into the licence to monitor the proximal receptors to the blasts within Knocknacran West. Blasting will be carried out by trained personnel to ensure these limits are adhered to. All blasting on the Application Site will comply with Part 5 of the Guidelines to the Safety, Health and Welfare at Work (Quarries) Regulations 2008.

Blasting in the proposed new open-cast mine will be carefully monitored at sensitive receptors to ensure compliance with relevant EPA and DoEHLG guidelines. Residents in the area will be invited to register for a text messaging service and will be notified prior to the blast taking place. Prior to the firing of any blast, notice will be given of the intention to blast by the sounding of an audible siren for a minimum period of one minute. An 'all clear' signal shall be given by means of a siren when blasting has been completed. Mitigation measures presented below will be adhered to, to ensure that ground vibration and air overpressure are minimised and kept within the specified guideline limits.

Blasting operations will be planned for after 4pm, Monday to Saturday, but may vary due to exceptional circumstances. Blasting will take place as required to meet to demand, and will be comparable to existing blast occurrences at Knocknacran Mine which occur once every 2 to 4 weeks depending on markets demand. No blasting will be planned on Sundays or Public Holidays.

Blast Vibration – Effect at VSRs

It can be seen from the results provided for the existing Knocknacran Open Cast mine, above, the ground vibration and air blast (air overpressure) monitoring results for the period 2012 to 2022 were within the recommended threshold values for vibration. Only two exceedances of air overpressure were recorded during this period and these were only recorded at the mine's proximal onsite monitoring stations, not at the VSR locations. No exceedances in air overpressure have been recorded at the VSRs during this period. Independent monitoring by the EPA in 2019 also showed compliance with the thresholds. Efficient on-site practices and management have ensured that the existing site's operations have endeavoured to stay within the relevant limits.

In the proposed Mine Development, gypsum will continue to be extracted by blasting in compliance with current IE licence limits for the existing open-cast mine. Blasting will be carried out by trained personnel to ensure these limits are adhered to. All blasting on the Application Site will comply with Part 5 of the Guidelines to the Safety, Health and Welfare at Work (Quarries) Regulations 2008 (or any subsequent legislation).

The proposed Mine Development will create a new open-cast mine over the site of a former underground Drumgoosat Mine. The proposed Knocknacran West Mine will be broadly mined in two locations, and depending on market conditions, the initial 4 phases (ca. 15 years) will initially create an open-cast extraction in the northern half of the site. The subsequent 2 phases (ca. 15 years) will move the open-cast extraction area to the southern half of the site. It is proposed to extract the gypsum by means of blasting, in the same manner as currently takes place within Knocknacran.

The village of Drumgoosat is located to the northwest of the proposed mine site, operations during the excavation of the northern extraction area will be located proximally to the village. Within the village is a local shop, church, graveyard, national school, mushroom farm and several residential dwellings, however both ground conditions and receptor distances are similar to the existing Knocknacran Mine where the significance of effects have been deemed to have been Neutral at offsite VSRs and Slight to Neutral at onsite mine stations to date.

Figure 12.6 and Figure 12.7 provide a plan and cross-section details, showing the proximity of blast locations (i.e., the top of the gypsum seams/units) along a line of section from Drumgoosat National School to an SGMI owned property to the south.

At the northwest extent of the section line, Drumgoosat National School is shown ca. 306 m from the Upper Gypsum and ca. 20 -25 m below ground level. While at the southeast, the SGMI residence shown on the section is ca. 258 m from the Upper Gypsum and ca. 35 m below ground level.

It is considered that the VSRs surrounding the Knocknacran West site will be predominantly high sensitivity as they are residential receptors or sensitive receptors like a school. It is considered that the impact magnitude will be Negligible and that potential effects from the proposed Mine Development will be Neutral at VSRs.

It is proposed that blasting will continue to take place after 4 pm, this will be after the national school's normal opening hours and outside of the church's normal mass times to reduce the potential level of nuisance and disturbance in the area. The frequency of blasting will vary depending on market demand but will follow a similar frequency to the existing Knocknacran Mine of once every 2 weeks to less frequently.

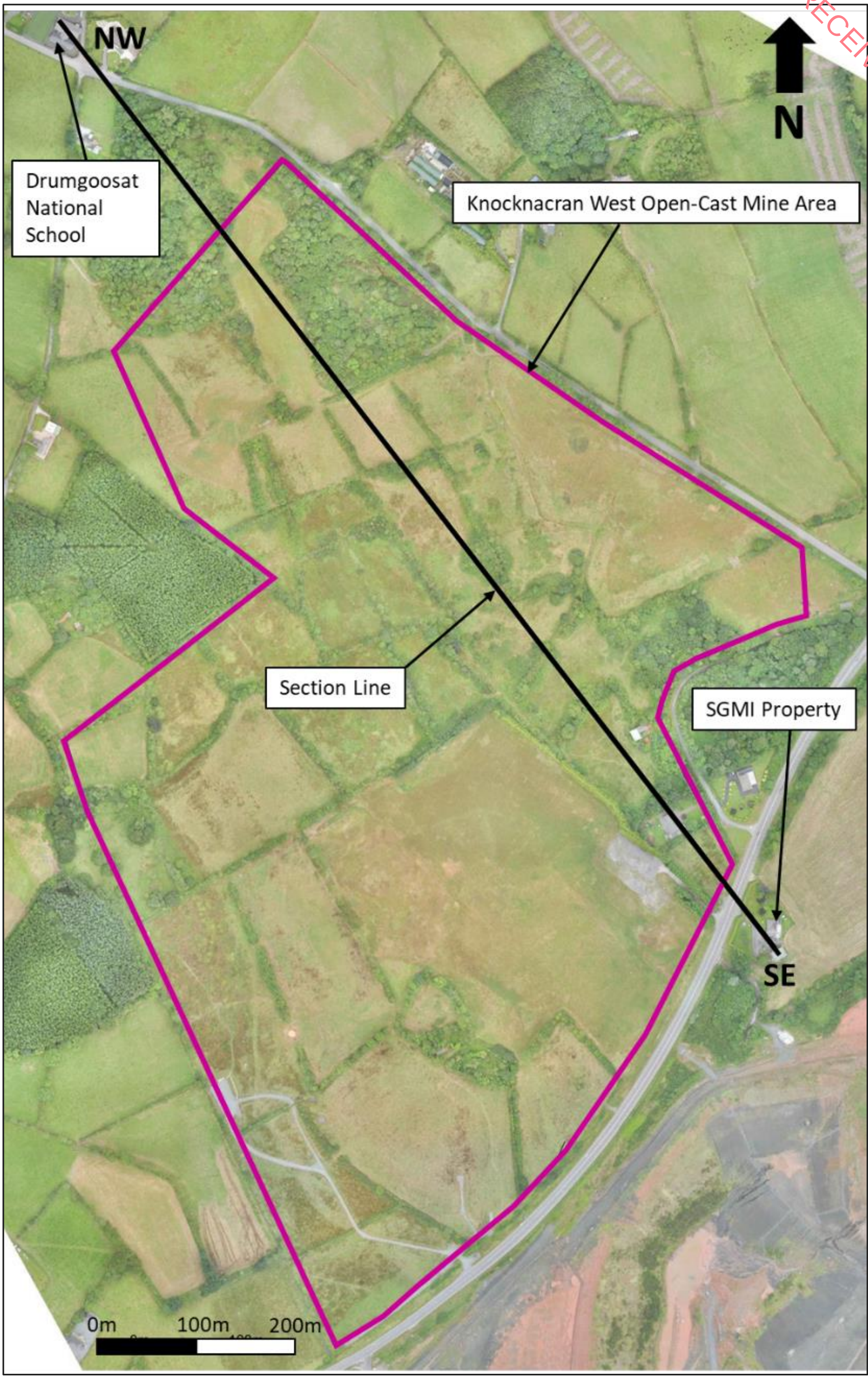

Figure 12.6: Cross-section location plan

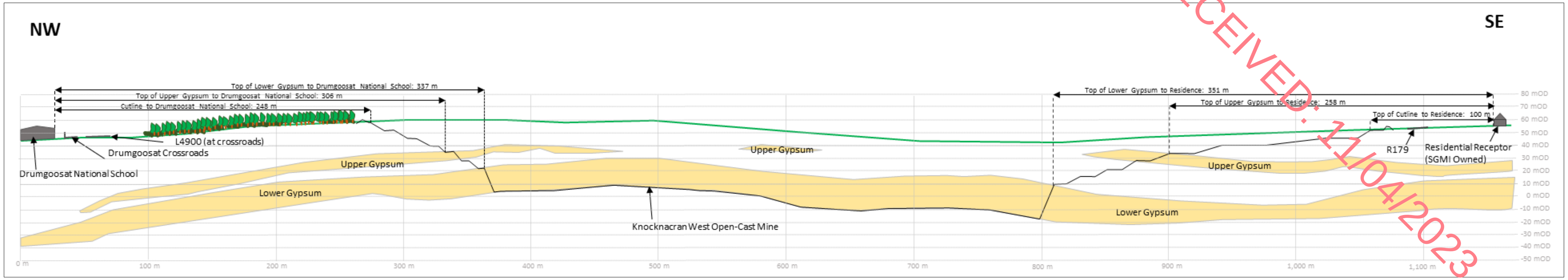

Figure 12.7: Cross-section between Drumgoosat National School, Knocknacran West Open-Cast Mine and a residence

Blast Vibration – Effect on Underground Workings

The impact of vibration on the stability of the mining tunnels has been assessed by SRK who have provided a technical memorandum titled "*Impact of Construction and Mining Vibration*". This memorandum is provided in Appendix 7.14.

The analysis indicates that the level of risk to stability of the mining tunnels from mining activity is very low.

Section 2.3 of the technical memorandum (Appendix 7.14) states that "*none of the typical quarry equipment will produce vibrations of sufficient intensity to reach the limiting PPV threshold…. On this basis vibrations from heavy equipment are highly unlikely to cause damage to the gypsum roof beams even if equipment is working directly on top of the gypsum."*

The risks and risk mitigation associated with vibration are well understood and will be addressed by method statements and standard operating procedures related to mining above and through underground workings based on the long-term experience of open-cast mining adjacent to and above such tunnels in the existing Knocknacran Open-Cast Mine. A proposed Standard Operating Procedure (SOP) for mining in the vicinity of suspected voids & unstable ground (underground mine workings) is provided in Appendix 7.14. This SOP is based on the current practices in place for the existing Knocknacran Open-Cast Mine for the safe removal of overburden / interburden and the mining of Gypsum.

It is considered that the sensitivity of the underground workings is Low. In turn, this considers that the magnitude of impact is Negligible and that the significance of effect is Neutral.

12.6.5 Potential Effects: Closure/Restoration Phase: Community Sports Complex

No closure phase is proposed for the Community Sports Complex, therefore the potential impact and effect from this phase is not considered further. It is scoped out for consideration in this phase.

12.6.6 Potential Effects: Closure/Restoration Phase: Mine Development

No blasting will occur during this phase and the majority of the workings will have been removed from the site. Potential vibration effects have been scoped out for further consideration during this phase.

12.7 Mitigation and Management

12.7.1 Mitigation and Management: Construction Phase: Community Sports Complex

Mitigation and management for vibration is not considered necessary for the construction phase of the Community Sports Complex.

12.7.2 Mitigation and Management: Construction Phase: Mine Development

Mitigation and management for vibration is not considered necessary for the construction phase of the Mine Development.

12.7.3 Mitigation and Management: Operational Phase: Community Sports Complex

Mitigation and management for vibration is not considered necessary for the operational phase of the Community Sports Complex.

12.7.4 Mitigation and Management: Operational Phase: Mine Development

12.7.4.1 Embedded Mitigation: Operational Phase: Mine Development

- The open-cast has been designed to include a 100 m offset to the nearest third party residence from the crest. This 100 m distance from the crest of the mine to third party residences, has been embedded as this is the established practice for the existing Knocknacran Open-Cast Mine. The distance from a receptor to an individual blast location will be greater as the gypsum to be blasted occurs down the open-cast pit slope further away from crest of the open-cast;

- A proposed Standard Operating Procedure (SOP) for mining in the vicinity of suspected voids & unstable ground (underground mine workings) is provided in Appendix 7.14. This SOP is based on the current practices in place for the existing Knocknacran Open-Cast Mine for the safe removal of overburden / interburden and the mining of Gypsum. This will be further development during the life of the Mine Development.

- The proposed screening berms to be located around the perimeter of the Knocknacran West site will be left intact for the life of the mine (and in perpetuity to continue to provide biodiversity to the Site and the local environment). They will also serve to mitigate against noise and potential dust emissions from the site, as well as offer reduced visibility of the site from the public road network and surrounding lands;

- All blasts will be initiated by electronic detonation system;

- The optimum blast ratio will be maintained and the maximum amount of explosive on any one delay and the maximum instantaneous charge is optimised so that the ground vibration levels are kept below those specified;

- Explosive charges are properly and adequately confined by using a sufficient quantity of stemming;

- Adequate confinement of all charges by means of accurate face survey and the subsequent judicious placement of explosives;

- No blasting will be carried out on Sundays or public holidays;

- No exposed detonating fuse will be used in blasting;

- An upland area which is densely populated by tree and scrubland separates the village from the mine site. As part of the mine design process, this vegetated upland area will largely be retained to buffer potential impacts from the proposed extraction activities;

- Notice of blasting times will continue to be given as currently practiced;

- Blasting is to be carried out by professionally trained blast engineers;

- All blasts will be measured (ground vibration & Air Overpressure) at each monitoring location to ensure compliance with the aforementioned limits and, so that information can be employed in any necessary modification of future blast designs; and

- All monitoring equipment will be calibrated regularly to ensure that peak particle velocity and air overpressure generated from each blast is accurately measured.

12.7.4.2 Additional Mitigation: Operational Phase: Mine Development

Details of mitigation measures that will be employed at the mine sites are summarised below:

- Works will be undertaken in line with any conditions set by the IE licence.

12.7.5 Mitigation and Management: Restoration/Closure Phase: Community Sports Complex

There is no proposed decommissioning of the Community Sports Complex and so this is not considered further.

12.7.6 Mitigation and Management: Restoration/Closure Phase: Mine Development

Mitigation and management for vibration is not considered necessary for the restoration phase of the Mine Development.

12.8 MONITORING

12.8.1 Monitoring: Construction Phase: Community Sports Complex

No vibration monitored is proposed for the construction phase of the Community Sports Complex.

12.8.2 Monitoring: Construction Phase: Mine Development

No vibration monitored is proposed for the construction phase of the Mine Development.

Monitoring of the extensometer network (for the underground workings) along the R179 and L4900 will continue during this phase.

12.8.3 Monitoring: Operational Phase: Community Sports Complex

No vibration monitored is proposed for the operational phase of the Community Sports Complex.

12.8.4 Monitoring: Operational Phase: Mine Development

It is proposed that the blasting of materials will meet the current maximum vibration limit of 7.5 mm/s ppv and air overpressure limit of 125 dB(Lin) as permitted in IE Licence P0519-04. Blasting will be carried out by trained personnel to ensure these limits are adhered to.

Blast monitoring locations (vibration and air overpressure) will be formally agreed with the EPA as part of a future IE Licence revision; however, it is currently proposed that monitoring locations will be set up at the northern, western, eastern and southern boundaries of the site (refer to Chapter 19.0 for monitoring locations). It is also proposed that monitoring at third-party residential dwellings and commercial/amenity facilities (dependent on their proximity to blasts) will be carried out as is currently undertaken for appropriate receptors.

Subject to later agreement with the EPA as part of a later licence review, it will be proposed that the existing blast monitoring locations (MS1-MS3) which are used to monitor blasting in Knocknacran Open-Cast Mine would no longer be used once Knocknacran West Open-Cast Mine is operational, as the former open-cast will be in restoration and no blasting will take place here. As mentioned previously, licenced blast monitoring will be proposed for Knocknacran West Open-Cast Mine at four alternative licence locations which are more proximally located to the blast area.

Mitigation measures presented above will be adhered to, to ensure that ground vibration and air overpressure noise are minimised and kept within the specified guideline limits.

As air overpressure is transmitted through the atmosphere, meteorological conditions such as wind speed and direction, temperature, cloud cover and humidity will all affect the intensity of the air overpressure experienced at a distance from the blast site. A predetermined date and time for each blast is arranged between Mine Management, Gardaí and the explosive supplier. It is difficult to arrange a date and time when favourable atmospheric conditions are present and as such blasting activities may often be carried out during times of prevailing meteorological conditions (i.e. low cloud, high wind, etc.).

12.8.5 Monitoring: Restoration/Closure Phase: Community Sports Complex

There is no proposed decommissioning of the Community Sports Complex and so this is not considered further here.

12.8.6 Monitoring: Restoration/Closure Phase: Mine Development

No vibration monitored is proposed for the restoration/closure phase of the Mine Development.

12.9 RESIDUAL EFFECTS

12.9.1 Community Sports Complex

Once the identified mitigation measures, appropriate design standards and operational infrastructure management plans are adhered to, it is considered that any effects surrounding the Community Sports Complex will be **Not Significant.**

12.9.2 Mine Development

The effects of the blasts will be a momentary increase in noise levels during the operational phase.

Once all mitigation measures, as highlighted in Sections Section 12.7.4 are adopted there should be only **Neutral** residual vibration effects in the area after blasting is completed. However, there may be some concerns from local residences about nuisance/damage to their properties.

In general, complaints concerning blast-induced vibration are not the result of actual structural damage, but rather due to adverse human responses and fears of structural damage, (Farnfield, 1998). SGMI will maintain a complaints register and be engaged to address any concerns that may arise due to the Mine Development.

12.10 CUMULATIVE EFFECTS

12.10.1 The Project – Community Sports Complex and Mine Development

As has been presented in the chapter, vibration effects from relevant phase of the Project are Not Significant. It is considered that there is no potential for a cumulative effect from vibration between the Community Sports Complex and Mine Developments.

12.10.2 The Project and Other Offsite Projects

Blasting at the Drummond underground mine will not take place at the same time as blasting from the proposed Knocknacran West open-cast mine, and as such there will be no cumulative effects as a result of blasting at the sites. Blasts in the existing Knocknacran Open-Cast Mine and Drummond Underground Mine are not scheduled together, this will continue for the Knocknacran West Mine and Drummond Mine.

Other vibration sources may include other local extractive industries: Limestone Industries Limited (Morkeeran Quarry), located ca. 4 km to the east, and Roadstone Ltd (Barley Hill) are located ca. 8 km to the southeast. However, due to their distance from the proposed open-cast mine, cumulative effects relating to vibration are not envisaged.

Losset ADN Materials Ltd. have a planning application under consideration (Reg. Ref. 22/254) and are located ca. 1 km to the north of the Project site. Based on a review of the current planning file data (to date 27th March 2023), this development there will be no significant sources of vibration that have the potential to have a cumulative effect with the Project.

No other existing developments in the area have potential vibration sources which could create a cumulative effect with the proposed development.

The cumulative effects are deemed **Not Significant** between the Project and other offsite Projects.

12.11 'Do-Nothing' Scenario

In the 'Do-Nothing' scenario no further mining will occur, and vibration levels will remain at current baseline levels until the closure of Knocknacran Mine and Drummond Mine.

12.12 Difficulties Encountered

No particular difficulties were encountered in this assessment.

12.13 REFERENCES

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