

BOLIDEN TARA MINES DAC

Environmental Impact Assessment Report

Proposed resumption of underground mining in the

Nevinstown orebody, Navan, Co. Meath



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1 INTRODUCTION

1.1 BACKGROUND

Boliden Tara Mines DAC (BTM) Europe's largest operating zinc and lead mine in Navan Co Meath, has been in operation for the past 40 years and is currently planning the continuing life of the mining operations.

BTM intends to apply to Meath County Council for planning permission to resume mining in the Nevinstown orebody. Planning permission was granted by An Bord Plenala, ref PL 17.204034, in January 2004 however this permission has expired.

This planning application is accompanied by this Environmental Impact Assessment Report (EIAR) which has been prepared under 2014 directive (2014/52/EU).¹

It is proposed to **resume mining in the 'Nevinstown' section of the orebody**. Nevinstown forms the most northerly section of the known 'Navan Orebody' which has been mined successfully over the past 40 years (Ref. Figure 1.1). The property has been operated as a grassland farm unit since 1972 and will remain as farmland used by grazing tenants.

The activity is regulated under the terms of an Industrial Emissions (IE) license (No. P0 516-03) issued and monitored by the Environmental Protection Agency (EPA). This licence limits and controls emissions from the extraction and processing of minerals and storage of related mineral waste. The resumption of mining in the Nevinstown orebody will be included in the existing IE license.

¹ Directive 2014/52/EU of the European Parliament and of the Council of 16 April 2014 amending Directive 2011/92/EU on the assessment of the effect of certain public and private projects on the environment.

1.2 THE PROPOSED DEVELOPMENT

The mine exploits the Zn-Pb deposit, which was discovered in 1970 by the Tara Exploration and Development Company Limited . Development of the orebody commenced in 1973 and production of concentrate commenced in 1977.

The original ore reserves (calculated in 1971) in the entire orebody amounted to 69.9 million tonnes grading 10.09% Zn, 2.63% Pb. Mining continues today at a rate of between 2.3 and 2.6 million tonnes of ore each year, resulting in 400,000 tonnes of zinc and lead concentrate.

On 1st January 2004, the ownership of Tara passed to Boliden.

Currently “proven and probable” mineral reserves are estimated at 17.0 million tonnes (2015 JORC data) at 7.2% Zn and 1.8% Pb. On-going exploration regularly modifies this estimate.

The approximate National Grid Reference of the Knockumber mine site is 284877E, 267985N : Ref Figure 1.1

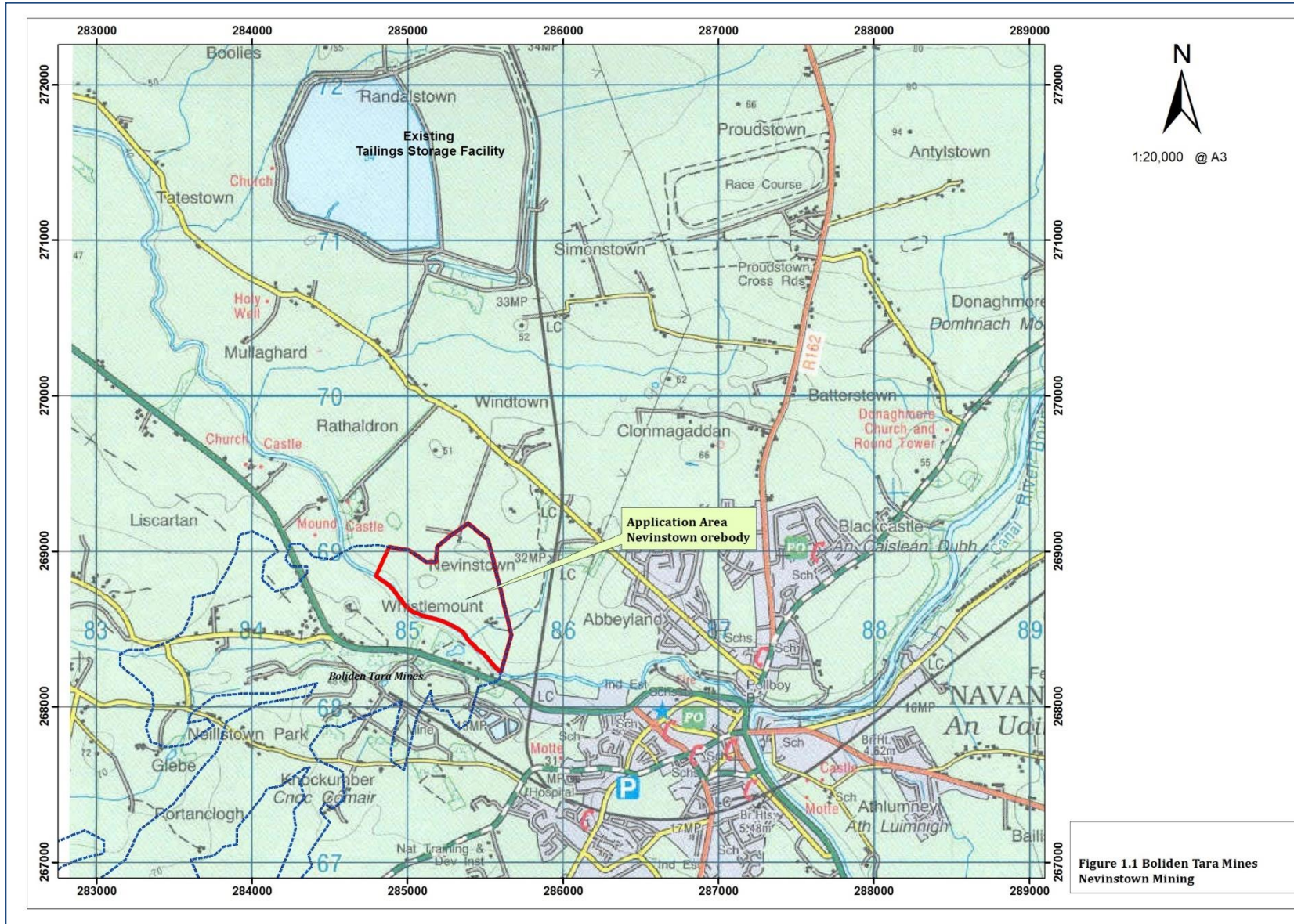
The facility is currently regulated under Industrial Emissions Licence P0516-03 and is operational 24-hours per day, 365 days per year.

1.2.1 CONTEXT OF THE DEVELOPMENT

The proposed development will not constitute an intensification of activity but rather will extend the life of mine plan.

It is estimated that 2 millions tonnes of lead and zinc ore in the Nevinstown orebody will be mined at an annual rate of c. 250,000 tonnes over an eight year period.

There will be no additional surface infrastructure associated with this development. The necessary infrastructure, both underground and on surface, for its operation is already in place; including administration, mining and processing facilities, tailings storage capacity, ventilation, effluent discharge facilities and road/rail links to Dublin Port.



1.3 SCREENING FOR ENVIRONMENTAL IMPACT ASSESSMENT (EIA)

The start of the EIA process involves deciding whether an EIA needs to be undertaken or not. An initial determination following the steps outlined in figure 1.2, establishes whether the proposed development constitutes a project as defined in the relevant legislation.

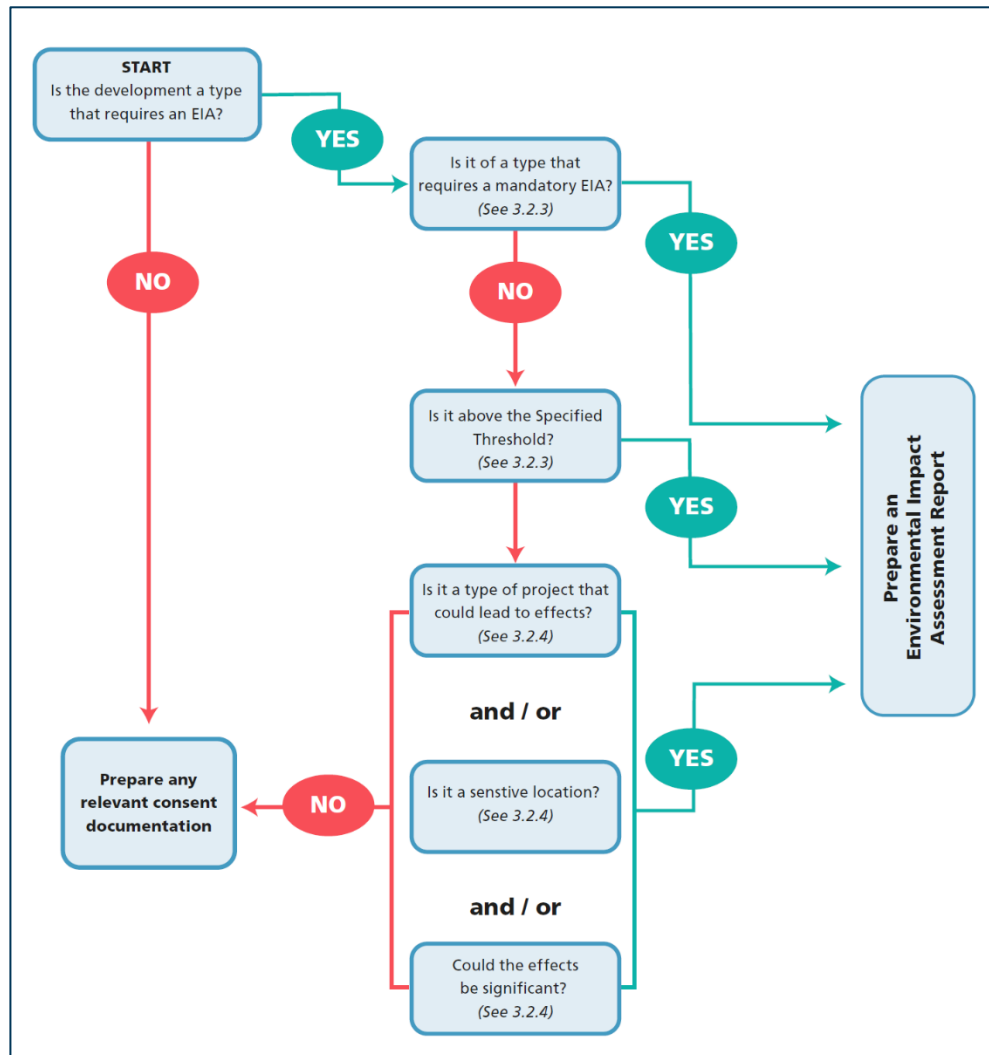


Figure 1.2 EIAR screening

1.3.1 LEGAL CONTEXT

1.3.1.1 ENVIRONMENTAL IMPACT ASSESSMENT LEGISLATION

1. The EIA Directive (85/337/EEC) is in force since 1985 and applies to a wide range of defined public and private projects, which are defined in Annexes I and II
2. The EIA Directive of 1985 has been amended three times, in 1997, in 2003 and in 2009:

3. The initial Directive of 1985 and its three amendments have been codified by DIRECTIVE 2011/92/EU of 13 December 2011. Directive 2011/92/EU has been amended in 2014 by DIRECTIVE 2014/52/EU
4. The newly amended Environmental Impact Assessment (EIA) Directive (2014/52/EU) entered into force on 15 May 2014. The revised version of the EIA directive (2014/52/EU) is to be transposed by member states into their own legislations by 16 May 2017.

Environmental impact assessment is provided for in Part X of the Planning and Development Act 2000 and in the Planning and Development Regulations 2001 for specified classes of development prescribed by regulations made under Section 176 of the Act.

The proposed development, 'mining operations in the Nevinstown orebody', constitutes a project as prescribed in Schedule 5 of the 2001 regulations.

SCHEDULE 5,(Development for the purposes of Part 10), Part 2,

2. Extractive Industry

(c) All extraction of minerals within the meaning of the Minerals Development Acts, 1940 to 1999.

It is therefore deemed that an Environmental Impact Assessment is mandatory.

1.4 ENVIRONMENTAL IMPACT ASSESSMENT REPORT

The Environmental Impact Assessment Report (EIA R) has been prepared by BTM, with specialist input from other consultants, on its behalf.

As noted in Department Circular PL 1/2017², the EIA Report follows the requirements of EIA Directive (2014/52/EU) and has had regard to original EIA Directive (85/337/EC), as amended by Council Directives 97/11/EC; 2003/4/EC; and 2009/31/EC – as codified in Directive 2011/92/EU).

² Circular Letter PL 1/2017. Implementation of Directive 2014/52/EU on the effects of certain public and private projects on the environment (EIA Directive): Advice on Administrative Provisions in Advance of Transposition. (Department of Housing, Planning, Community and Local Government, 2017)

The purpose of the EIA Directive is to ensure that projects likely to have significant effects on the environment are subject to a comprehensive assessment of environmental effects prior to development consent being given. The EIA Directive is transposed into the Irish land-use planning consent system by way of the Planning & Development Act 2000 (as amended) and the Planning & Development Regulations 2001 (as amended).

The EIA Report has been prepared with regard to requirements of EIA Directive (2014/52/EU) and the following principal EIA Guidance documents have been consulted in the preparation of this EIA Report. Other documentation reviewed in the preparation of this EIA Report are noted in the individual chapters, as appropriate.

- Directive 2014/52/EU of the European Parliament and of the Council of 16 April 2014 amending Directive 2011/92/EU on the assessment of the effect of certain public and private projects on the environment.
- Circular Letter PL 1/2017. Implementation of Directive 2014/52/EU on the effects of certain public and private projects on the environment (EIA Directive): Advice on Administrative Provisions in Advance of Transposition. (Department of Housing, Planning, Community and Local Government, 2017).
Transposition of 2014 EIA Directive (2014/52/EU) in the Land Use Planning and EPA Licencing Systems: Key Issues Consultation Paper. (Department of Housing, Planning, Community and Local Government, 2017).
- Advice Notes on Current Practice (in preparation of Environmental Impact Statements) (EPA 2003)
- Guidelines on the information to be contained in Environmental Impact Statements (EPA 2002)
- Revised (Consultation Draft) Advice Notes for preparing Environmental Impact Statements (EPA 2015).
- Draft Guidelines on the information to be contained in Environmental Impact Assessment Reports (EPA 2017)

1.5 REASON FOR THE PROPOSED DEVELOPMENT

The Nevinstown orebody is an uninterrupted northern continuation of the ‘main orebody’ currently being mined by BTM, see Figure 1.3 SIMPLIFIED GEOLOGICAL PLAN OF THE NAVAN OREBODY. The orebody is present at the surface level of the Nevinstown townland and dips steeply in a southwesterly direction, below the River Blackwater.

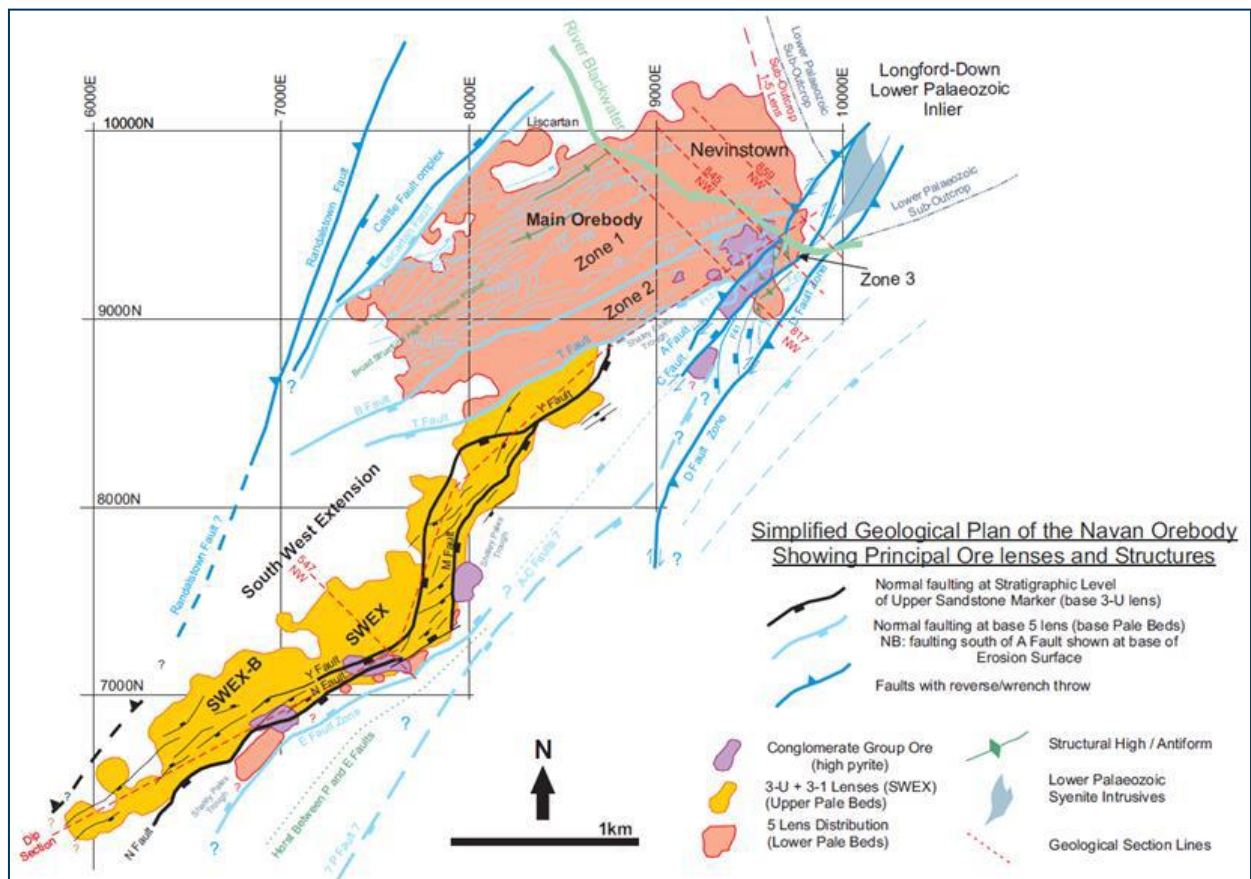


FIGURE 1.3 SIMPLIFIED GEOLOGICAL PLAN OF THE NAVAN OREBODY

Mining will follow the same cyclic pattern as currently persists resulting in the removal of ore underground followed by the filling of the voids using slag-cement and waste sand material that remains after the ore treatment process. The surface characteristics and features of the Nevinstown townland will be left unaltered during and after the mining in the area is completed.

Much of the ore in the Nevinstown orebody has already been mined, and the voids backfilled, however c. 2 million tonnes of ore remain and will be mined at an average rate of ~250k tonnes per annum as per the current Life of Mine plan.

1.6 ENVIRONMENTAL IMPACT ASSESSMENT (EIA)

Environmental Impact Assessment (EIA) is a procedure for systematic examination of the likely effects on the environment of a proposed development and is required for certain types and scales of development prescribed by Article 93 and Schedule 5 of the Planning and Development Regulations 2001-2006 and Article 23 of the European Communities (Environmental Impact Assessment Regulations) 1989-2006.

The European Communities (Environmental Impact Assessment) Regulations, 1989-2006 and the Planning and Development Regulations 2001-2006 bring EC Directive 85/337/EEC, as amended by Directives 97/11 and Article 3 of 2003/35/EC, (commonly known as the Environmental Impact Assessment Directive) into effect in Ireland.

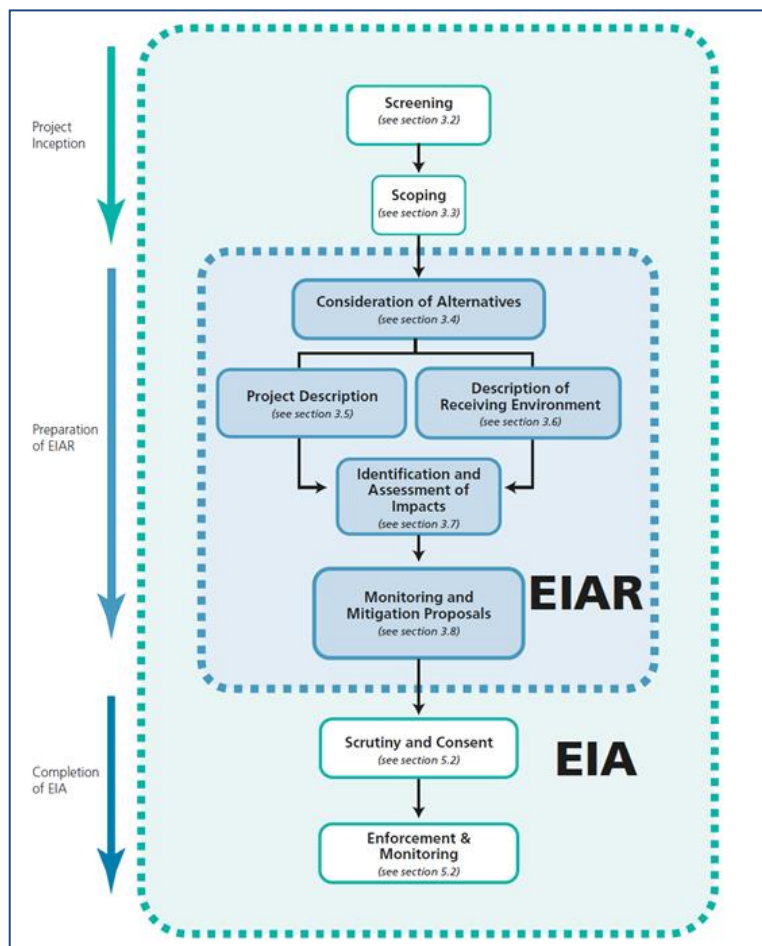


FIGURE 1.3 THE EIA PROCESS

1.6.1 ROLE OF GOVERNMENT AND STATUTORY BODIES

Responsibility for the protection of the environment and the regulation of planning issues lies primarily with The Department of Communications, Climate Action and Environment. Other Government departments, statutory bodies and special interest groups also exercise important control functions. This department has also assumed responsibility for further regulation in the natural resource sector, including mining. Also within this government department Natural Heritage Service, plays a major role in relation to the protection, conservation and management of the natural and built as well as the historic environment.

Of the statutory bodies, local authorities have a major role in relation to the enforcement of planning legislation especially at county and local level. The major environmental management responsibility for improving and protecting the environment lies with the Environmental Protection Agency (EPA). Another statutory body with important regulatory power is the Planning Appeals Board, An Bord Pleanála, which determines first and third party appeals *inter alia* against planning decisions. Other bodies with responsibilities in relation to mining development are the Health Service Executive and the Health and Safety Authority; however, the extent of their involvement varies with the circumstances of individual proposed developments.

Of the Special Interest Groups the most important is An Taisce, the National Trust for Ireland. It has prescribed body status under the planning acts and has the right of examination of planning applications.

1.7 SCOPING AND CONSULTATION

Scoping is the process of determining the content and extent of topics to be covered in the Environmental Impact Assessment and what methods should be used to gather and assess that information. It is defined in the EC guidance as:

'determining the content and extent of the matters which should be covered in the environmental information to be submitted in the EIAR'.

Scoping is best carried out by personnel having appropriate expertise and relevant prior experience of the factors involved. Knowledge of the characteristics of the project type and of the sensitivities likely to be present in the receiving environment are particularly valuable. Scoping is carried out on a case-by-case basis because the significant issues, for different projects are unlikely to ever be identical. However, there are standard issues that should be considered for each project to establish whether they apply in specific cases.

The potential for 'likely significant effects' throughout different phases of the proposed project, are considered at the scoping stage and include, site investigations, construction, commissioning and operation to decommissioning. Scoping also considers the range of alternatives to be considered.

Pre-application consultation was carried out for the preparation of this EIAR. Consultation involved:

- Both formal and informal consultation with the planning authority and statutory consultees (refer to Appendix 2.1) to identify relevant issues and agree appropriate methodologies.
- Public meeting with local communities and wider public to identify issues of potential concern.
- Due regard to information gained as a result of:
 - Consultations and meetings during the planning of previous mining operations in the Nevinstown orebody
 - Technical studies undertaken as part of previous EIA/EIS for mining operations in Nevinstown orebody
 - Monitoring records/results over the past 40 years
 - Comments and complaints received from local communities / public
 - Potential changes in the regulatory requirements and policy.
 - Developments in good practice.

1.7.1 KEY SCOPING CRITERIA

In keeping with guidance the EIAR is as tightly focussed as possible and efforts and resources have been placed on the key significant issues.

Scoping for this development was guided by the following criteria:

- Use of 'Likely' and 'Significant' as the principal criteria for determining what should be addressed. Any issues that do not pass this test should be omitted (scoped out) from further assessment.
- A description of the scoping process explaining why issues have been scoped out and not being considered further.
- Listing of all 'prescribed environmental factors' (EIAR section 2.5). Each environmental factor should be clearly covered by one or more specific section

headings in the EIAR.

- If scoping determines that no likely significant issues arise under any heading, then an explanatory is included.

1.8 ENVIRONMENTAL IMPACT ASSESSMENT REPORT (EIAR)

Directive 2011/92/EU as amended by Directive 2014/52/EU uses the term Environmental Impact Assessment Report for what was formerly referred to in Irish legislation as an Environmental Impact Statement.

An EIAR is defined in the EIA regulations as:

“A statement of the effects, if any, which proposed development, if carried out, would have on the environment”. The EIAR is prepared by the developer and is submitted as part of a consent process. The planning authority uses the information provided to assess the environmental effects of the project and, in the context of other considerations, to help determine if consent should be granted.

The information in the EIAR is also used by other parties to evaluate the acceptability of the project and its effects and to inform their submissions to the planning process.

The EIAR consists of a systematic analysis and assessment of the potential effects of a proposed project on the receiving environment. The amended EIA Directive prescribes a range of environmental factors which are used to organise descriptions of the environment and these factors must be addressed in the EIAR.

The Environmental Protection Agency (EPA) has produced guidelines on the production of an EIS in line with the Environmental Impact Assessment Regulations, and these guidelines have been followed in the production of this report. The EIS has been structure in what the EPA term a Grouped Format Structure, which examines each topic as a separate section referring to the existing environment, the proposed development, impacts and mitigation measures.

Boliden Tara Mine DAC has developed an extensive environmental monitoring programme around the existing mine facilities partly in response to conditions attached to previous planning conditions and in response to requirements of the Company's IE Licence No. P0516-03.

This information enables the environmental performance of the existing facility to be assessed over time and provides a sound basis to predict the magnitude and significance of potential / likely impacts from new development.

The preparation of the EIS has also afforded due regard to the following Environmental Protection Agency Guidance documents:

1. Draft guidelines on the information to be contained in Environmental Impact Assessment Reports, May 2017
2. Guidance on the Information to be Contained in Environmental Impact Statements (March 2002)
3. Advice Notes on Current Practice in the Preparation of Environmental Impact Statements (March 2003)

1.9 GLOSSARY OF TERMS

Alternatives

A description of other options that may have been considered during the conception of a project, these include alternative locations, alternative designs and alternative processes.

Baseline

The current state of environmental characteristics – including any evident trends in its status.

Baseline Survey

A survey to establish the current state of environmental characteristics.

Biodiversity

The variability among living organisms from all sources, including, inter alia, terrestrial, marine, and other aquatic ecosystems, and the ecological complexes of which they are part: this includes diversity within species, between species and of ecosystems”

Blast Ratio – The amount of work per unit of explosive measured in tonnes of rock per kilogram of explosives detonated

Boliden Tara Mines DAC – Abbreviated through as BTM . else referred to as The Company

Competent Authority (CA)

The term “competent authority” means the Minister or Public Authority to which an EIAR is required to be submitted, i.e. the authority charged with examining an EIAR with a view to issuing a consent to develop or operate.

dB – Decibel,

A unit of measure on a logarithmic scale used to quantify pressure fluctuations such as those associated with air overpressure

dB(A)

Decibel measured within an A weighted frequency curve that differentiates between sounds of different frequency in a similar way to the human ear

Decommissioning

The final closing down, and putting into a state of safety of a development, project or process when it has come to the end of its useful life.

Delay Interval (Explosives)

The time between successive detonations of detonators

Developer

A term used in the EIA Directive to describe persons or organisations proposing to carry out a project which is subject to the EIA Directive.

Development

A project involving new works [including alteration and/or demolition] or altered patterns of activity

“Do-nothing” Scenario

The situation or environment which would exist if a proposed, development, project or process were not carried out. This scenario needs to take account of the continuation or change of

current management regimes as well as the continuation or change of trends currently evident in the environment.

Ecology

The study of the relationships between living organisms and between organisms and their environment (especially animal and plant communities), their energy flows and their interactions with their surroundings.

Effect

A change resulting from the implementation of a project.

Effluent

Any liquid discharged from a source into the environment.

Environmental Impact Assessment – EIA

The process of examining the anticipated environmental effects of proposed project - from consideration of environmental aspects at design stage, through consultation and preparation of an Environmental Impact Assessment Report (EIAR), evaluation of the EIAR by a competent authority, the subsequent decision as to whether the project should be permitted to proceed, encompassing public response to that decision.

Environmental Impact Assessment Report – EIAR

A report or statement of the effects, if any, which the proposed project, if carried out, would have on the environment.

Environmental Factor

EIA legislation has defined a number of factors that are used to organise descriptions of the environment. The discussions of the characteristics of the environment in an EIAR are grouped under headings which correspond to these factors or closely related headings (ref. Section 3.3.6 Selection of Headings Under Which to Arrange Issues).

EPA

The Environmental Protection Agency.

Frequency (Hz)

The number of cycles per second of vibration usually expressed in Hertz (Hz)

Geology

The science of the earth, including the composition, structure and origin of its rocks.

Ground Water

The water which flows underground through naturally porous parts of the soil or rock.

Habitat

'A habitat is described as the area in which an organism or group of organisms lives, and is defined by the living (biotic) and non-living (abiotic) components of the environment. The latter includes physical, chemical and geographical factors, in addition to human impact or management.

Hydrology

The science concerned with the occurrence and circulation of water in all its phases and modes, and the relationship of these to man.

Impact

Change resulting from the implementation of project.

Impact Avoidance

The modification of project decisions (about site location or design for example) having regard to predictions about potentially significant environmental effects.

Industrial Emissions – IE Licence

Industrial Emissions Directive Activities are defined in Annex I of the Industrial Emissions Directive (Directive 2010/75/EU). These activities were incorporated into the First Schedule to the Environmental Protection Agency Act 1992 by the European Union (Industrial Emissions) Regulations 2013. Industrial Emissions Directive Activities are subject to an Industrial Emissions licensing system administered by the EPA. An IE licence is a single integrated licence which covers all emissions from the installation and its environmental management.

Infrastructure

The basic structure, framework or system which supports the operation of a project for example, installations such as roads and sewers which are necessary to support development projects.

Land-use

The human activities which take place within a given area of space.

Likely Effects (or Likely Impacts)

The effects that are specifically predicted to take place - based on an understanding of the interaction of the proposed project and the receiving environment. (See also Potential Effects and Residual Effects.)

Maximum Instantaneous Charge Weight (MIC)

The maximum amount of explosives detonated at any one precise time

Methodology

The specific approach or techniques used to analyse impacts or describe environments.

Mitigation Measures

Measures designed to avoid, reduce, remedy or offset impacts. These measures can mitigate impacts:

Monitoring

The observation, measurement and evaluation of environmental data to follow changes over a period of time, to assess the efficiency of control measures. This is typically a repetitive and continued process carried out during construction, operation or decommissioning of a project.

Nevinstown

The town land that lends its name to the orebody.

The Nevinstown orebody is an uninterrupted northern continuation of the 'main orebody' currently being mined by Boliden Tara Mines DAC. The orebody is present at the surface level of the Nevinstown townland and dips steeply below the River Blackwater.

Pathway

The route by which an effect is conveyed between a source and a receptor.

Peak Particle Velocity (PPV)

The maximum rate of change of particle displacement, measured in millimetres per second (mm/sec).

Pollution

Any release to the environment which has a subsequent adverse effect on the environment or man.

Potential Effect/ Impact

The effect / impact that would occur without mitigation.

Processes

The activities which take place within a project.

Project

For the purposes of the Guidelines, the term project is used to encompass the terms development, works and activity, as used in the relevant regulations

Reasonably Foreseen

A working assumption about the future that assumes that a project will be developed as planned and used within a receiving environment that will change in accordance with currently evident trends. It will include a consideration of the likelihood and consequences of abnormal occurrences - such as accidents.

Receiving Environment

The likely evolution of baseline environmental characteristics without implementation of the proposed project.

Receptor

Any element in the environment which is subject to impacts.

Residual Effect (or Residual Impact)

The effect / impact after mitigation.

Risk Assessment

An analytical study of the probabilities and magnitude of harm to human health and the environment associated with a biological, physical or chemical agent, activity or occurrence.

Scoping

The process of identifying the significant issues which should be addressed by a particular Impact Assessment as well as the means or methods of carrying out the assessment.

Screening

The process of assessing the requirement for a project to be subject to Impact Assessment based on project type and scale as well as the significance or environmental sensitivity of the receiving environment.

Sequential Detonation – The method of control of time intervals between explosions of individual charges

Services

The conduits, pipes and lines that carry water, phones, electricity, sewage etc. Sometimes referred to as built services.

Sensitivity

The potential of a receptor to be significantly affected.

Significance (of impact)

The importance of the outcome of the impact (or the consequence of change) for the receiving environment.

Source

The activity or place from which an effect originates.

Statutory Consultees

An organisation or authority stipulated by legislation to be notified by a CA or developer if an application is made which might give that organisation a cause for concern.

Surface Water

Natural water bodies such as streams, lakes and rivers and artificial features, such as canals and impoundments, that are visible on the surface of the earth.

Threshold

The magnitude of a project which, if exceeded, will trigger the requirement for an Environmental Impact Assessment to be carried out.

1.10 DESCRIPTION OF EFFECTS

<p>Quality of Effects</p> <p>It is important to inform the non-specialist reader whether an effect is positive, negative or neutral</p>	<p>Positive Effects</p> <p>A change which improves the quality of the environment (for example, by increasing species diversity; or the improving reproductive capacity of an ecosystem, or by removing nuisances or improving amenities).</p>
	<p>Neutral Effects</p> <p>No effects or effects that are imperceptible, within normal bounds of variation or within the margin of forecasting error.</p>
	<p>Negative/adverse Effects</p> <p>A change which reduces the quality of the environment (for example, lessening species diversity or diminishing the reproductive capacity of an ecosystem; or damaging health or property or by causing nuisance).</p>
<p>Describing the Significance of Effects</p> <p>“Significance’ is a concept that can have different meanings for different topics – in the absence of specific definitions for different topics the following definitions may be useful (also see <i>Determining Significance</i> below.).</p>	<p>Imperceptible</p> <p>An effect capable of measurement but without significant consequences.</p>
	<p>Not significant</p> <p>An effect which causes noticeable² changes in the character of the environment but without significant consequences.</p>
	<p>Slight Effects</p> <p>An effect which causes noticeable changes in the character of the environment without affecting its sensitivities.</p>
	<p>Moderate Effects</p> <p>An effect that alters the character of the environment in a manner that is consistent with existing and emerging baseline trends.</p>
	<p>Significant Effects</p> <p>An effect which, by its character, magnitude, duration or intensity alters a sensitive aspect of the environment.</p>
	<p>Very Significant</p> <p>An effect which, by its character, magnitude, duration or intensity significantly alters most of a sensitive aspect of the environment.</p>
	<p>Profound Effects</p> <p>An effect which obliterates sensitive characteristics</p>
<p>Describing the Extent and Context of Effects</p> <p>Context can affect the perception of significance. It is important to establish if the effect is unique or, perhaps, commonly or increasingly experienced.</p>	<p>Extent</p> <p>Describe the size of the area, the number of sites, and the proportion of a population affected by an effect.</p>
	<p>Context</p> <p>Describe whether the extent, duration, or frequency will conform or contrast with established (baseline) conditions (is it the biggest, longest effect ever?)</p>

<p>Describing the Probability of Effects</p> <p>Descriptions of effects should establish how likely it is that the predicted effects will occur – so that the CA can take a view of the balance of risk over advantage when making a decision.</p>	<p>Likely Effects</p> <p>The effects that can reasonably be expected to occur because of the planned project if all mitigation measures are properly implemented.</p> <p>Unlikely Effects</p> <p>The effects that can reasonably be expected not to occur because of the planned project if all mitigation measures are properly implemented.</p>
<p>Describing the Duration and Frequency of Effects</p> <p>‘Duration’ is a concept that can have different meanings for different topics – in the absence of specific definitions for different topics the following definitions may be useful.</p>	<p>Momentary Effects</p> <p>Effects lasting from seconds to minutes</p> <p>Brief Effects</p> <p>Effects lasting less than a day</p> <p>Temporary Effects</p> <p>Effects lasting less than a year</p> <p>Short-term Effects</p> <p>Effects lasting one to seven years.</p> <p>Medium-term Effects</p> <p>Effects lasting seven to fifteen years.</p> <p>Long-term Effects</p> <p>Effects lasting fifteen to sixty years.</p> <p>Permanent Effects</p> <p>Effects lasting over sixty years</p> <p>Reversible Effects</p> <p>Effects that can be undone, for example through remediation or restoration</p> <p>Frequency of Effects</p> <p>Describe how often the effect will occur. ((once, rarely, occasionally, frequently, constantly – or hourly, daily, weekly, monthly, annually))</p>

Describing the Types of Effects	Indirect Effects (a.k.a. Secondary Effects) Impacts on the environment, which are not a direct result of the project, often produced away from the project site or because of a complex pathway.
	Cumulative Effects The addition of many minor or significant effects, including effects of other projects, to create larger, more significant effects.
	'Do-Nothing Effects' The environment as it would be in the future should the subject project not be carried out.
	'Worst case' Effects The effects arising from a project in the case where mitigation measures substantially fail.
	Indeterminable Effects When the full consequences of a change in the environment cannot be described.
	Irreversible Effects When the character, distinctiveness, diversity or reproductive capacity of an environment is permanently lost.
	Residual Effects The degree of environmental change that will occur after the proposed mitigation measures have taken effect.
	Synergistic Effects Where the resultant effect is of greater significance than the sum of its constituents, (e.g. combination of SO _x and NO _x to produce smog).

1.11 LIST OF ACRONYMS

BTM	Boliden Tara Mines
BR	Bedrock
COPC	Chemicals of Potential Concern
EC	European Commission
EIA	Environmental Impact Assessment
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency
EU	European Union
ERBD	Eastern River Basin District
EPA	Environmental Protection Agency
GSI	Geological Survey of Ireland
GTV	Groundwater Threshold Value
IGV	Interim Guideline Values
maMD	Metres Above Mine Datum
MRV	Minimum Reporting Values
NBL	Natural Background Level
NPWS	National Parks and Wildlife Service
OB	Overburden
PMP	Probable Maximum Precipitation
PTS	Passive Treatment System
TIA	Traffic Impact Assessment
TBC	To Be Considered
TMF	Tailings Management Facility
TSF	Tailings Storage Facility
WFD	Water Framework Directive

2 SCOPING & CONSULTATION

2.1 THE SCOPING PROCESS

'Scoping' is a process of deciding what information should be contained in an EIAR and what methods should be used to gather and assess that information. It is defined in the EC guidance³ as:

'determining the content and extent of the matters which should be covered in the environmental information to be submitted in the EIAR'

Scoping is best carried out by personnel having appropriate expertise and relevant prior experience of the factors involved. Knowledge of the characteristics of the project type and of the sensitivities likely to be present in the receiving environment are particularly valuable. Scoping is carried out on a case-by-case basis because the significant issues, for different projects are unlikely to ever be identical. However, there are standard issues that should be considered for each project to establish whether they apply in specific cases.

The potential for 'likely significant effects' throughout different phases of the proposed project, are considered at the scoping stage and include, site investigations, construction, commissioning and operation to decommissioning. Scoping also considers the range of alternatives to be considered.

2.2 KEY SCOPING CRITERIA

The EIAR should be as tightly focussed as possible and efforts and resources placed on the key significant issues.

Scoping for this development was guided by the following criteria:

- Use of 'Likely' and 'Significant' as the principal criteria for determining what should be addressed. Any issues that do not pass this test should be omitted (*scoped out*) from further assessment (refer to Table 2.4).
- A description of the scoping process explaining why issues have been scoped out and not being considered further.

³ Guidance of EIA scoping, EC 2001

- Listing of all 'prescribed environmental factors' (section 2.5). Each environmental factor should be clearly covered by one or more specific section headings in the EIAR.
- If scoping determines that no likely significant issues arise under any heading, then an explanatory is included.

2.3 CRITERIA FOR DETERMINING ITEMS TO BE ADDRESSED:

2.3.1 'LIKELY' AND 'SIGNIFICANT' ENVIRONMENTAL EFFECTS

The method used to identify what should be addressed in the EIAR and the criteria for assessing the significance of effects is presented below.

2.3.1.1 THE LIKELIHOOD OF EFFECTS

It is necessary to focus on those effects that are probable or likely to occur. Likely or probable effects can be described as those which are planned to take place (e.g. the projected emissions, the proposed earthmoving etc.) and those which can be reasonably foreseen to be inevitable consequences of the normal construction and operation of the project.

The basis for 'Likelihood of Effects' used is outlined in Table 2.1.

A description of each effect is given and ranked by the likelihood of occurrence.

TABLE 2.1 LIKELIHOOD OF EFFECTS

Rating	Category	Description	Likelihood of Occurrence
1	Unlikely Likely	Very low chance occurring	Never/ once in the lifetime of a project
2	Likely	Guaranteed to occur	Frequently as a matter of routine

2.3.1.2 THE SIGNIFICANCE OF EFFECTS

The 'Significance of effects' is understood to mean the importance of the outcome of the effects (the consequences of the change). Significance is determined by a combination of (objective) scientific and subjective (social) concerns.

A definition, description and ranking for each category of 'Significance of Effects' is given in Table 2.2.

TABLE 2.2 SIGNIFICANCE OF EFFECTS

Rating	Category	Description
1	Imperceptible/ Not significant	Capable of measurement but without significant consequences/ Causes noticeable changes in the character of the environment but without significant consequences.
2	Slight Effects	An effect which causes noticeable changes in the character of the environment without affecting its sensitivities.
3	Moderate Effects	An effect that alters the character of the environment in a manner that is consistent with existing and emerging baseline trends.
4	Significant Effects	An effect which, by its character, magnitude, duration or intensity alters a sensitive aspect of the environment.
5	Very Significant/ Profound Effects	An effect which, by its character, magnitude, duration or intensity significantly alters most of a sensitive aspect of the environment/Obliterates sensitive characteristics

To determine what should be addressed in the EIAR a rating is allocated to each prescribed environmental factor (refer to Table 2.3). These ratings are displayed on a matrix (Table 2.4).

TABLE 2.3 DETERMINATION OF WHAT SHOULD BE ADDRESSED

Category	Score ⁴
Effects that have the potential to cause lasting profound environmental impacts and are therefore the highest priority.	8 to 10
Effects deemed through their significance or frequency of occurrence to be Medium-priority.	6 to 7
Effects with low significance or low levels of occurrence are deemed low Priority.	3 to 5
Effects deemed unlikely of insignificant that can be scoped out	1 to 2

2.3.2 QUALITY OF EFFECTS

It is important to note whether an effect is positive, negative or neutral.

Positive Effects

A change which improves the quality of the environment (for example, by increasing species diversity; or the improving reproductive capacity of an ecosystem, or by removing nuisances or improving amenities).

Neutral Effects

No effects or effects that are imperceptible, within normal bounds of variation or within the margin of forecasting error.

Negative/adverse Effects

A change which reduces the quality of the environment (for example, lessening species diversity or diminishing the reproductive capacity of an ecosystem; or damaging health or property or by causing nuisance).

⁴ The Product of the Likelihood rating multiplied by the significance rating

2.4 PRESCRIBED ENVIRONMENTAL FACTORS

2.4.1 POPULATION AND HUMAN HEALTH

- Employment
- Human Health (considered with reference to other headings such as water and air)
- Amenity (e.g. effects on amenity uses of a site or of other areas in the vicinity – may be addressed under the factor of Landscape)

2.4.2 BIODIVERSITY⁵

- Habitats
- Breeding/Feeding/Roosting Areas
- Routes and landscape features
- Mammals/Birds/Fish/Invertebrates/Reptiles
- Vascular plants/bryophytes/lichens/fungi
- Population Stability
- Population Management
- Critical Resources
- Terrestrial/Aquatic/Marine
- Seasonality
- Existing Management
- Ecosystem Services
- Legal protection

2.4.3 LAND & SOILS

- Land (for example land take)
- Soil (for example organic matter, erosion, compaction, sealing)
- Agricultural capability

⁵ The amended Directive replaces the environmental factor of 'Flora & Fauna' with 'Biodiversity'

- Geology

2.4.4 WATER/HYDROGEOLOGY

- Ground/Surface/Estuarine/Marine
- Hydro-morphological changes, quantity and quality
- Physical characteristics
- Chemical characteristics
- Q value
- Beneficial uses

2.4.5 AIR

- Air Quality
- Odour
- Noise & Vibration
- Radiation

2.4.6 CLIMATE

The amended Directive also requires the vulnerability of a project to climate change to be addressed, particularly ‘the risk of major accidents and/or disasters which are relevant to the project concerned, including those caused by climate change, in accordance with scientific knowledge.

- CFCs
- Acid Rain
- Thermal Pollution
- Climate change trends (macro and micro)

2.4.7 MATERIAL ASSETS

Material assets can now be taken to mean built services and infrastructure. Traffic is included because in effect traffic consumes roads infrastructure. Sealing of agricultural land and effects on mining or quarrying potential come under the factors of land and soils.

- Built Services
- Roads and Traffic

- Waste Management

2.4.8 CULTURAL HERITAGE

- Archaeology
- Known archaeological monuments & Areas of archaeological potential
- Underwater archaeology
- Architectural heritage
- Designated architectural heritage
- Designations or sensitivities

2.4.9 THE LANDSCAPE

- Landscape Appearance and Character
- Landscape Context
- Views & Prospects
- Historical Landscapes

2.5 INTERACTIONS BETWEEN FACTORS

The interactions between impacts on different environmental factors should be addressed throughout the EIAR.

A matrix showing where interactions between effects on different factors have been considered and addressed is presented in Table 2.5

TABLE 2.4 RATING PRESCRIBED ENVIRONMENTAL FACTORS

Prescribed environmental factors		Likelihood of environmental impact	Significance of environmental impact	Rating	Relevant EIAR Section
Population and Human Health	Employment	2	5	10	Section 10
	Human Health (considered with reference to other headings such as water and air)	1	1	1	Section 12
	Amenity (e.g. effects on amenity uses of a site or of other areas in the vicinity – may be addressed under the factor of Landscape)	1	1	1	Scoped out
Biodiversity	Habitats: Terrestrial/Aquatic/Marine Breeding/Feeding/Roosting Areas Routes and landscape features Mammals/Birds/Fish/Invertebrates/Reptiles Vascular plants/bryophytes/lichens/fungi	1	5	5	Section 4
	Population Stability Population Management Critical Resources	1	5	5	

Prescribed environmental factors		Likelihood of environmental impact	Significance of environmental impact	Rating	Relevant EIAR Section
	Seasonality Existing Management Ecosystem Services	1	5	5	
	Legal protection	1	5	5	
Land & Soil	Land take Soil impacts Agricultural capability	1	4	4	Section 9
	Geology/Geotechnical	2	5	10	Section 11
Water/Hydrology	Ground/Surface/Estuarine/Marine	2	2	4	Section 6 & Section 7
	Hydro-morphological changes, quantity and quality	1	1	1	
	Physical characteristics Chemical characteristics Q value	2	4	8	
	Beneficial uses	2	1	2	
	Flooding	1	4	4	
Air	Air Quality	1	4	4	Section 5

Prescribed environmental factors		Likelihood of environmental impact	Significance of environmental impact	Rating	Relevant EIAR Section
	Odour	1	1	1	Scoped out
	Noise & Vibration	2	3	6	Section 9 & 10
	Radiation	1	1	1	Scoped out
Climate	CFCs Acid Rain Thermal Pollution Climate change trends (macro and micro)	1	1	1	Scoped out
Material Assets	Built Services Roads and Traffic	1	1	1	Scoped out
	Waste Management	2	2	4	Section 11

Prescribed environmental factors		Likelihood of environmental impact	Significance of environmental impact	Rating	Relevant EIAR Section
Cultural Heritage	Archaeology Known archaeological monuments Areas of archaeological potential (including unknown archaeology) Underwater archaeology Architectural heritage Designated architectural heritage Other significant architectural heritage Folklore and history Designations or sensitivities	2	2	4	Section 8
Landscape	Landscape Appearance and Character Landscape Context Views & Prospects Historical Landscapes	1	1	1	Scoped out

**Interactions between these factors

TABLE 2.5 MATRIX TO SHOW INTERACTIONS BETWEEN FACTORS

Interaction	Population & Human Health		Biodiversity		Land, Soils & Geology		Hydrology & Hydrogeology		Noise & Vibration		Material Assets		Waste Management		Archaeology		Architectural Heritage		Scoped out See section X						
	Con.	Op.	Con.	Op.	Con.	Op.	Con.	Op.	Con.	Op.	Con.	Op.	Con.	Op.	Con.	Op.	Con.	Op.	Landscape		Air Quality & Climate		Roads, Traffic & Transportation		
																				Con.	Op.	Con.	Op.	Con.	Op.
Population & Human Health				✓		✓		✓		✓		✓		✓		X		X							
Biodiversity						✓		✓		X		✓		✓		X		X							
Land, Soils & Geology								✓		X		✓		✓		X		X							
Hydrology & Hydrogeology										X		X		✓		X		X							
Noise & Vibration												X		X		X		X							
Material Assets														X		X		X							
Waste Management																X		X							
Archaeology																		X							
Architectural Heritage																									
Landscape																									
Air Quality & Climate																									
Roads, Traffic & Transportation																									

Con.	Construction Phase
Op.	Operational Phase

✓	Interaction
X	No Interaction

Scoped out

2.6 EXAMINATION OF ALTERNATIVES

The presentation and consideration of the various reasonable alternatives investigated by the developer is an important requirement of the EIA process.

The EIA Directive requires an EIAR to contain:

“A description of the reasonable alternatives (for example in terms of project design, technology, location, size and scale) studied by the developer, which are relevant to the proposed project and its specific characteristics, and an indication of the main reasons for selecting the chosen option, including a comparison of the environmental effects.”

The objective is for the developer to present a representative range of the practicable alternatives considered. The alternatives should be described with ‘an indication of the main reasons for selecting the chosen option’. It is generally sufficient to provide a broad description of each main alternative and the key issues associated with each, showing how environmental considerations were taken into account in deciding on the selected option. A detailed assessment (or ‘mini-EIA’) of each alternative is not required.

2.6.1 ‘DO-NOTHING’ ALTERNATIVE

The do-nothing alternative is a general description of the evolution of the key environmental factors of the site and environs if the proposed project did not proceed.

The do-nothing alternative should describe consequences that are reasonably likely to occur. It ought not be used to exaggerate environmental consequences that may occur without the proposed project.

TABLE 2.6 EXAMINATION OF ALTERNATIVES

Category	Description	Comment
ALTERNATIVE LOCATIONS	Some locations have more inherent environmental sensitivities than others. Depending on the type of project and the range of alternatives which the developer can realistically consider, it may be possible to avoid such sites in favour of sites which have fewer constraints and more capacity to sustainably assimilate the project.	Due to the nature of the mineral extraction industry the minerals can only be mined where they are found in nature. Processing and waste management facilities are normally associated development in close proximity to the orebody
ALTERNATIVE LAYOUTS	Alternative layouts can often be devised to consider how different elements of a proposal can be arranged on a site, typically with different environmental, as well as design implications	The proposal is for a resumption of underground mining. There are no alternative layouts available.
ALTERNATIVE DESIGNS	Many environmental issues can be resolved by design solutions that vary key aspects such as the shape of buildings or the location of facilities.	The design will follow the best available techniques to maximize the recovery of the natural resource to the benefit of the Company and the state through the payment of royalties and taxes
ALTERNATIVE PROCESSES	Within each design solution there can be several different options as to how the processes or activities of the project can be carried out	The only alternative option for extracting the ore from the orebody would be opencast mining. In terms of environmental impact this option would have greater potential impacts of the majority of the Prescribed environmental factors. It is proposed to resume mining in the 'Nevinstown' section of the orebody. <i>Nevinstown</i> forms the most northerly section of the known 'Navan Orebody' which has been mined successfully over the past 40 years.

Category	Description	Comment
		<p>There will be no additional surface infrastructure associated with this development. The necessary infrastructure, both underground and on surface, for its operation is already in place; including administration, mining and processing facilities, tailings storage capacity, ventilation, effluent discharge facilities and road/rail links to Dublin Port. The property has been operated as a grassland farm unit since 1972 and will remain as farmland used by grazing tenants.</p>
ALTERNATIVE MITIGATION MEASURES	<p>It may be possible to mitigate effects in a few different ways. In these circumstances the EIAR can describe the various options and provide an indication of the main reasons for selecting the chosen option, including a comparison of the environmental effects.</p>	<p>Where deemed necessary mitigation measures are outlined in the EIAR. The operation will be controlled by the conditions detailed in its IE Licence.</p> <p>The licence sets out in detail the conditions under which the will operate and manage this installation.</p>

2.7 CONSULTATION

Consultation is a key element of each stage of the EIA process (illustrated in Figure 2.1). Pre-application consultation was carried out for the preparation of this EIAR. Consultation involved: Both formal and informal consultation with the planning authority and statutory consultees (refer to Appendix 2.1) to identify relevant issues and agree appropriate methodologies.

Public meeting with local communities and wider public to identify issues of potential concern.

Due regard to information gained as a result of

- Consultations and meetings during the planning of previous mining operations in the Nevinstown orebody
- Technical studies undertaken as part of previous EIA/EIS for mining operations in Nevinstown orebody
- Monitoring records/results over the past 40 years
- Comments and complaints received from local communities / public
- Potential changes in the regulatory requirements and policy.
- Developments in good practice.

2.7.1 KEY ISSUES RAISED THROUGH THE CONSULTATION PROCESS

- Ground subsidence
- Ground vibration
- Waste tailings
- Ground water
- Employment

Tara Mines has been in operation for over 40 years and is an integral component of the social and geogaphhic fabric of the town of Navan. Residents living in the environs of the mine are intimately aware of the operations and the impacts. The Nevinstown orebody was successfully mined between 2004 and 2015 with minimal environmental impacts. The environmental department at Tara Mines liaiase on a continuous basis with memebers of the public and their representatives. The company operate and 'open door policy' with regard to environmental information and the Envoronmental Department is strategically located, outside the mine complex, along the Kells rtoad, to faciliate public access.

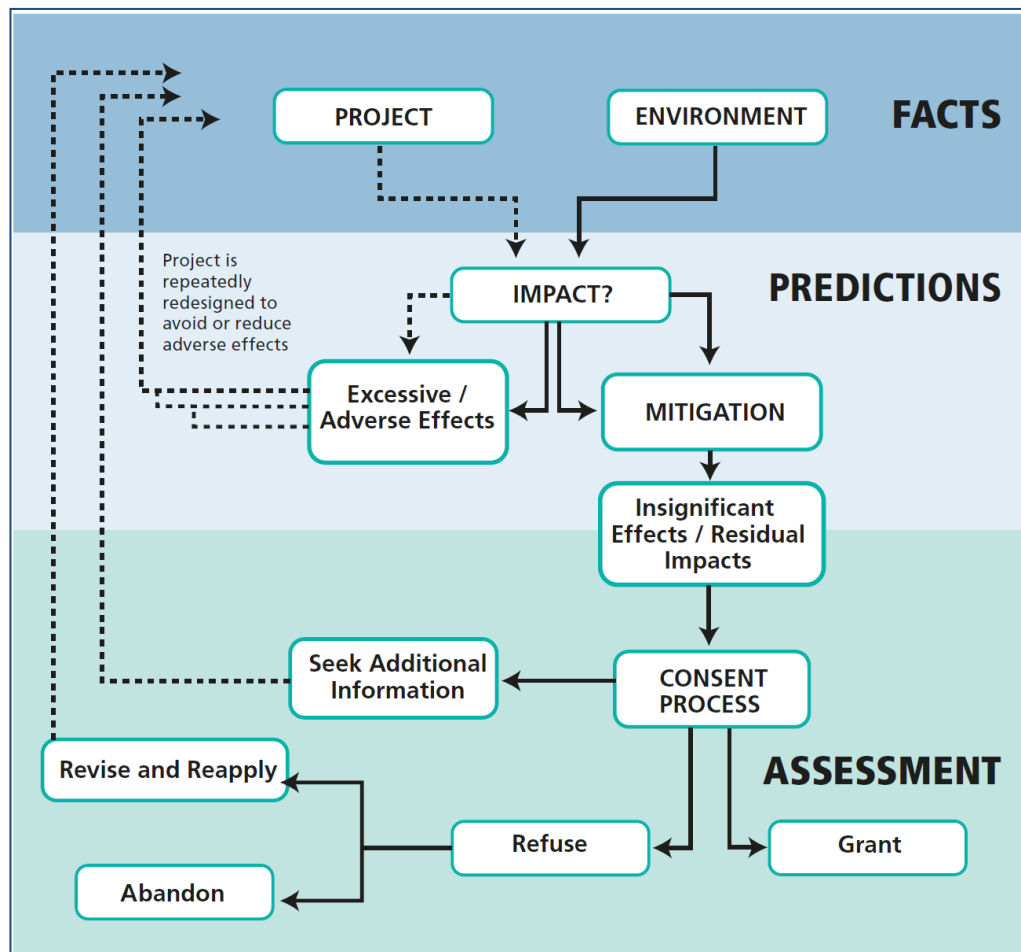


FIGURE 2.1 KEY STAGES IN THE PREPARATION OF AN EIAR AND THE EIA PROCESS

2.8 CONTENT OF THE EIAR

In accordance with the current published guidelines the EIAR should include:

- A description of the project comprising information on the site, design, size and other relevant features of the project;
- A description of the likely significant effects of the project on the environment;
- a description of the features of the project and/or measures envisaged in order to avoid, prevent or reduce and, if possible, offset likely significant adverse effects on the environment;
- A description of the reasonable alternatives studied by the developer, which are relevant to the project and its specific characteristics, and an indication of the main reasons for the option chosen, taking into account the effects of the project on the environment;
- A non-technical summary;
- Any additional information specified in Annex IV relevant to the specific characteristics of a particular project or type of project and to the environmental features likely to be

The EIA / EIAR should address the issues identified above within the context of:

- Both positive and negative impacts.
- Direct impacts arising from the construction, operation and eventual closure of the facility.
- Alternatives within the framework of preferred option (i.e. alternative access routes, sources of material, timing of construction activity etc.).
- Indirect impacts, including those arising as a consequence of planned mitigation measures.
- Cumulative impacts (additional to impacts arising from the existing facility).
- Short term and temporary impacts experienced during construction or during particular phases of operation.
- Long-term and permanent impacts.

2.9 PROJECT TEAM

BTD Environmental Department staff has prepared this EIAR with assistance of the following specialists

Project Design/Description, Scoping

Oliver Fitzsimons, MSc. Snr Environmental Engineer. BTM

Paschal Walsh BSc. Environmental Manager

Ailish Mc Cabe BSc Snr Environmental Engineer. BTM

Land and soils

Oliver Fitzsimons, MSc. Snr Environmental Engineer. BTM

Water/Hydrogeology

Geoff Beale. *Piteau Associates UK LTD*

Air

Dr Brian Sheridan, *Odour Monitoring Ireland*

Biodiversity

Dr. Patrick Moran, *Forest, Environmental Research Services Limited*

Noise & Vibration

Brendan O'Reilly MSc. Noise & Vibration Consultants

Oliver Fitzsimons, MSc. Snr Environmental Engineer. BTM

Human Health

PM Group,

Ailish Mc Cabe, Snr Environmental Engineer. BTML

Archaeology- Heritage and Cultural

David Sweetman

2.10 APPENDICES

Appendix 2.1 Statutory Consultees Consulted

Name	Statutory BODY
Mr. Pat Gallagher, Senior Planner	Meath County Council (MCC)
Ms. Loreto Guinan, Heritage Officer	Meath County Council
Mr. Kevin Stewart, Director of Services	MCC, Planning Enterprise & Environment
Mr. Nicholas Whyatt, Senior Transport Engineer	Meath County Council
Mr. Ian Iumley, Built Environment & Heritage Officer	An Taisce
Mr. Muiris O'Conchuir, Divisional Manager	Developments Applications Unit, Heritage Division, Department of Arts, Heritage & the Gaelteacht
Dr. Eibhlín Doyle, Principal Geologist	Department of Communications, Climate Action & Environment: Exploration and Mining Division
Mr. Brian Breslin, Assistant Principal Officer	Department of Communications, Climate Action & Environment: Exploration and Mining Division
Ms. Josephine Beckett, Higher Executive Officer	Department of Agriculture & the Marine, District Veterinary Office
Mr. Dominic Mullaney, Principal Advisor	Department of Transport, Tourism & Roads, Roads Division
Regional Manager	National Roads Authority, Department of Transportation
Mr. Frank Clinton	Office of Climate & Resource Use Licensing, Environmental Protection Agency
Ms. Carol O'Sullivan, Regional Inspectorate	Environmental Protection Agency
Ms. Caitriona Collins, Regional Inspectorate	Environmental Protection Agency
Mr. Noel Mc Gloin, Senior Fisheries Environmental Officer	Inland Fisheries Ireland
Mr. Brian Beckett, Chief Director	Inland Fisheries Ireland
Mr. Willie Roche	Inland Fisheries Ireland
Ms. Annette Lynch,	National Park & Wildlife services
Mr. Pat Griffin, Senior Inspector	Health & Safety Authority
Ms. Monica Lee,	The Geological Survey of Ireland

Name	Statutory BODY
Mr. Pat Doyle, Executive Officer	Department of Agriculture & the Marine
Mr. Larry O'Loughlin, Regional Manager	Teagasc
Mr. Anthony Clinton, Regional Development Officer	Irish Farmers Association
Mr. John Murphy, Regional Engineer	Office of Public Works
M. Elish O'Reilly, Principle Environmental Health Officer	Health Service Executive
Mr. Alan Rogers, Area Administrator	Navan Municipal District
Ms. Donna Farrell, President	Navan Chamber of Commerce
Mr. Peter Killeen, Manager	Navan Racecourse
Ms. Amy Harding, Operations Manager	Navan Racecourse
Mr. Pat Kinsella, Senior Executive Engineer	Meath County Council, Environmental & Water Services
Mr. Larry Whelan, Senior Executive Officer	Meath County Council, Environmental & Water Services
Mr. Pdraig O'Longaigh, Chief Fire Officer	Meath County Fire & Rescue Services
Sergeant Pat Dowd	Dunshaughlin Garda Station
Ms. Fiona Beers	Meath County Council, Transport
Mr. David Caffrey, Planner	Meath County Council, Planning Department
Ms. Wendy Bagnall	Meath County Council
Mr. Michael O'Toole, MEPS, Emergency Management officer	HSA Dublin North East
Mr. Michael Fitzsimons, Civil Defence Officer	Civil Defense Services
Mr. Tadgh McDonnell, Director of Services	Meath County Council, Environment, Water Fire & Emergency

3 PROJECT DESCRIPTION

3.1 BOLIDEN TARA MINES DAC

Boliden Tara Mines is located close to the town of Navan, Co. Meath. The mine site is approximately 50km from both Dublin City and airport.

In 1969, exploration began for mineral deposits near Navan. In 1970, a shallow soil geochemical survey showed very high concentrations of zinc and lead. An extensive diamond-drilling programme indicated an ore-body of almost 70 million tonnes at a grade of 10.1% zinc and 2.6% lead. It soon became apparent that the company had discovered the largest zinc and lead deposit in Europe. Development of the mine began in 1973 and consisted of driving tunnels into the ore-body, construction of the Development and Production Shafts and construction of surface facilities. Production of ore from underground commenced in June 1977.

The Navan ore-body lies between 20 (Nevinstown) and 1,000 (SWEX) metres below surface. At the extreme eastern section it dips steeply to the southwest. Moving southward the dip is less steep and is generally at a 15-degree inclination for the remainder of the currently known orebody. The thickness of mineable ore ranges from 15m to 80m, with the thicker ore predominant in the eastern section.

3.2 THE PROPOSED DEVELOPMENT

The mine exploits the Zn-Pb deposit, which was discovered in 1970 by the Tara Exploration and Development Company Limited. Development of the orebody commenced in 1973 and production of concentrate commenced in 1977.

The original ore reserves (calculated in 1971) in the entire orebody amounted to 69.9 million tonnes grading 10.09% Zn, 2.63% Pb. Mining continues today at a rate of between 2.3 and 2.6 million tonnes of ore each year, resulting in 400,000 tonnes of zinc and lead concentrate.

On 1st January 2004, the ownership of Tara passed to Boliden.

Boliden Tara Mines Limited (BTML) currently has “proven and probable” mineral reserves of 17.0 million tonnes (JORC data) at 7.2% Zn and 1.8% Pb. On-going exploration regularly modifies this estimate. At current rates of production, the known reserves extend the operating life of BTML well beyond 2020.

It is proposed to resume mining in the ‘Nevinstown’ section of the orebody. Nevinstown forms the most northerly section of the known ‘Navan Orebody’ which has been mined successfully over the past 40 years.

The Nevinstown orebody is an uninterrupted northern continuation of the ‘main orebody’ currently being mined by Boliden Tara Mines DAC. The orebody is present at the surface level of the Nevinstown townland and dips steeply below the River Blackwater into the property of Tara Mines DAC.

Mining will follow the same cyclic pattern as currently persists resulting in the removal of ore underground followed by the filling of the voids using slag-cement and waste sand material that remains after the ore treatment process. The surface characteristics and features of the Nevinstown townland will be left unaltered after the mining in the area is completed. Much of the ore in the Nevinstown orebody is already extracted and the void backfilled however due to cost reduction and technical advance some parts of the Nevinstown Orebody that previously were classed as not minable are now part of the Life of Mine plan. Approximately 2 M tonnes remaining in the Nevinstown orebody and will be mined at an average rate of c.250k tonnes per annum. The proposed development will include the mining of the area know as the “Crown Pillar”.

The Crown Pillar or mining blocks N8 and N9 are situated in the north-eastern part of the Nevinstown orebody where the orebody outcrops on the surface just north of the river Blackwater.

The “Crown Pillar” resource is some 735k tonnes with typically 9% zinc and 2% lead. The proposed stope size is 10m wide, up to 30m long and approximately 22m high leaving a pillar to surface of 8m. The remaining “crown pillar” will be supported by cablebolts from the development drifts above the stopes.

The stopes will be filled immediately after the ore is extracted with slag-cement stabilised backfilling using continuous pour backfilling minimising the risk of water from the river entering the mine.

There will be no additional surface infrastructure associated with this development. The necessary infrastructure, both underground and on surface, for its operation is already in place; including administration, mining and processing facilities, tailings storage capacity, ventilation, effluent discharge facilities and road/rail links to Dublin Port.

3.2.1 DEVELOPMENT PLANNING HISTORY

Table 3.1 presents details of pertinent significant planning applications that have altered the mine and ancillary facilities over its history.

Key developments

- 1970. Exploration. Shallow soil geochemical survey near Navan Meath showed very high concentrations of both zinc and lead.
- An extensive drilling program indicated an orebody of almost 70 million tonnes at a grade of 10.1% zinc and 2.6% lead.
- 1973 Development of the orebody began
- 1977 Production commenced
- 1975 Tailings Facility original development (Stages 1 and 2)
- 1984 Extension to tailings facility (Stage 3)
- 1998 Further tailings facility extension (Stage 4)
- 2004 Original Nevinstown mine development
- 2004 South West Extension of the underground mine (SWEX)
- 2008 Mill Upgrade
- 2010 Tailings facility extension (Stage 5)

- 2011 Mine extension into the Liasartan/Rathaldron orebody
- 2018 Tailings facility Extension (Stage 6)

By 2017 (after 40 years of production), over 90 million tonnes had been mined and processed including ~ 9.6 million derived from the Nevinstown orebody.

TABLE 3.1 KEY PLANNING APPLICATIONS

Planning Application No.	Date Granted	Works undertaken
P 71/1047	30/11/1971	Original Exploratory Shaft at Knockumber
P 71/1046	28/09/1972	Original Exploratory Gallery at Knockember
P 72/1525	02/03/1974	Original Declines at Knockumber
P 73/125	12/03/1974	Development consisting of the Construction of facilities for mining and concentrating zinc/lead ore
P 74/732	12/08/1974	Construction of dykes for the disposal of mine tailings at Randalstown & Simonstown
P 83/464	23/07/1984	Modification & extension to the mine tailings proposal at Randalstown (Stage 3 - including Randalstown Road)
P 84/1022	26/07/1985	Construction of a Mine Ventilation Facility at Whistlement (RAR 3)
P 91/62	15/03/1991	Development of new belt conveyor & gallery between transfer house & concentrator building
P 91/1351	28/01/1992	Development of Zinc Refloat Installation at Knockumber
P96/702	09/08/1996	Extend existing mill building at Knockumber
P 96/919	26/06/1998	Vertically extend its existing tailings facility (Stage 4) & operate two Borrow Pit areas (52 & 35 hectares) . EIA Undertaken
PL 17.204034	15/01/2004	Extension of the existing underground mining operations into Nevinstown. EIA Undertaken
NA /40005	23/07/2004	South West Extension (SWEX B) of Existing Mining Operations & Construction of 2 Air Raises
NA /40383	28/10/2004	Extend existng mill building to house an upgrade to the Mine Backfill Plant
NA 801280	12/06/2008	New electricity sunStation
NA 801570	10/07/2008	Mill Upgrade – Autogenous Grind Mill
NA 901452	12/05/2010	TMF Extension Stage 5. EIA Undertaken
NA/101054	29/06/2011	Liscartan and Rathaldron Mine Development
NA 111149	09/02/2012	Ventilation Shaft - RAR 5 NORTH
NA 120917	04/12/2012	Ventilation Shaft - FAR 5
NA 151405	22/12/2013	Erection of a 1.5 megawatt electricity generating wind turbine
PI 17247707	21/07/2017	TMF Extension Stage 6. EIA Undertaken

3.2.2 NEVINSTOWN MINING HISTORY

Planning permission was granted by An Bord Pleanála, ref PL 17.204034, in January 2004.

Production began in 2004 and ceased in 2015 during which time 9,682,857 tonnes of ore were produced (Table 3.2)

Table 3.2 Historic operations in Nevinstown

Mine Area	Tunnels	Production Ore			Devt Ore		Total Ore	Dev Waste
	km	Tonnes	Zn%	Pb%	Tonnes	Zn+Pb	Tonnes	Tonnes
Nevinstown	37	8,362,572	8.59	1.80	1,320,285	5.72	9,682,857	839,038

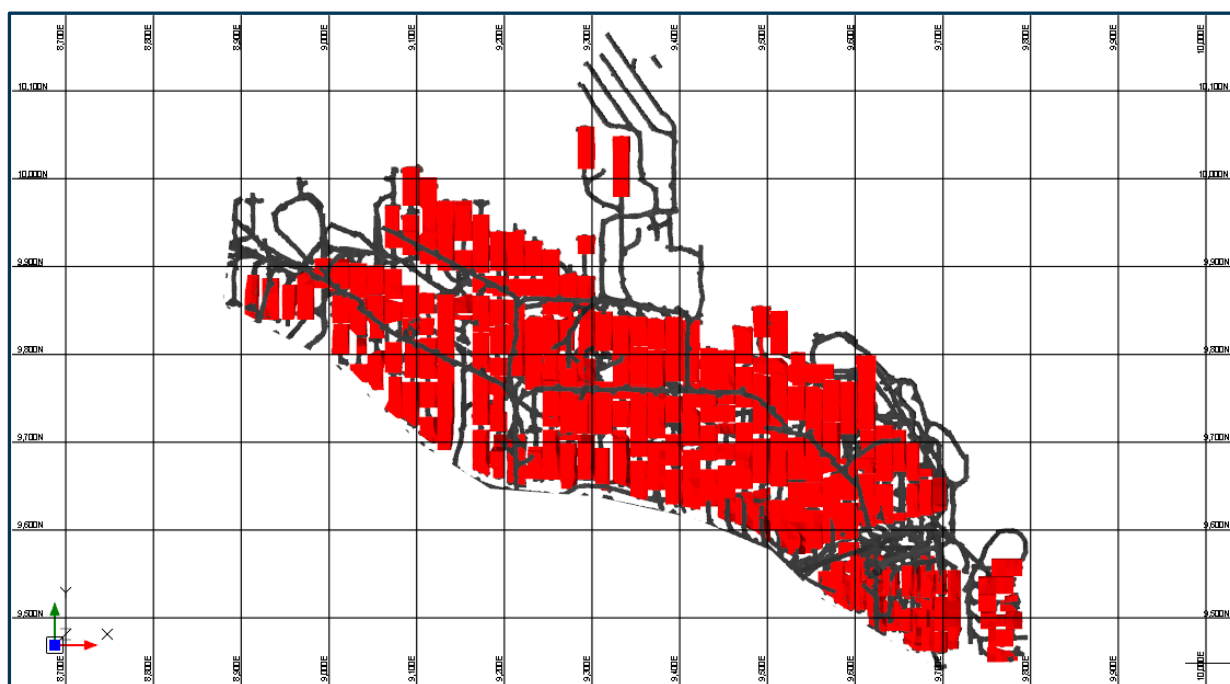


Figure 3.1 Existing mining within Nevinstown (tunnels in gray, stopes in red)



FIGURE 3.2: NEVINSTOWN BLOCKS TO BE MINED (ORANGE) AND ALREADY MINED (CYAN).

3.3 “THE NAVAN OREBODY”

The Navan orebody was initially mined in the Main zone, but subsequently extended into four major mining areas — *Nevinstown*, *Rathaldron*, *Liscartan* and *SWEX* (South West Extension), ref Figure 3.3. The orebody is striking NE-SW and dipping gently towards south-west. The thickness of the mineralization ranges from 15 to 80 m, with the thicker areas generally in the eastern portion.

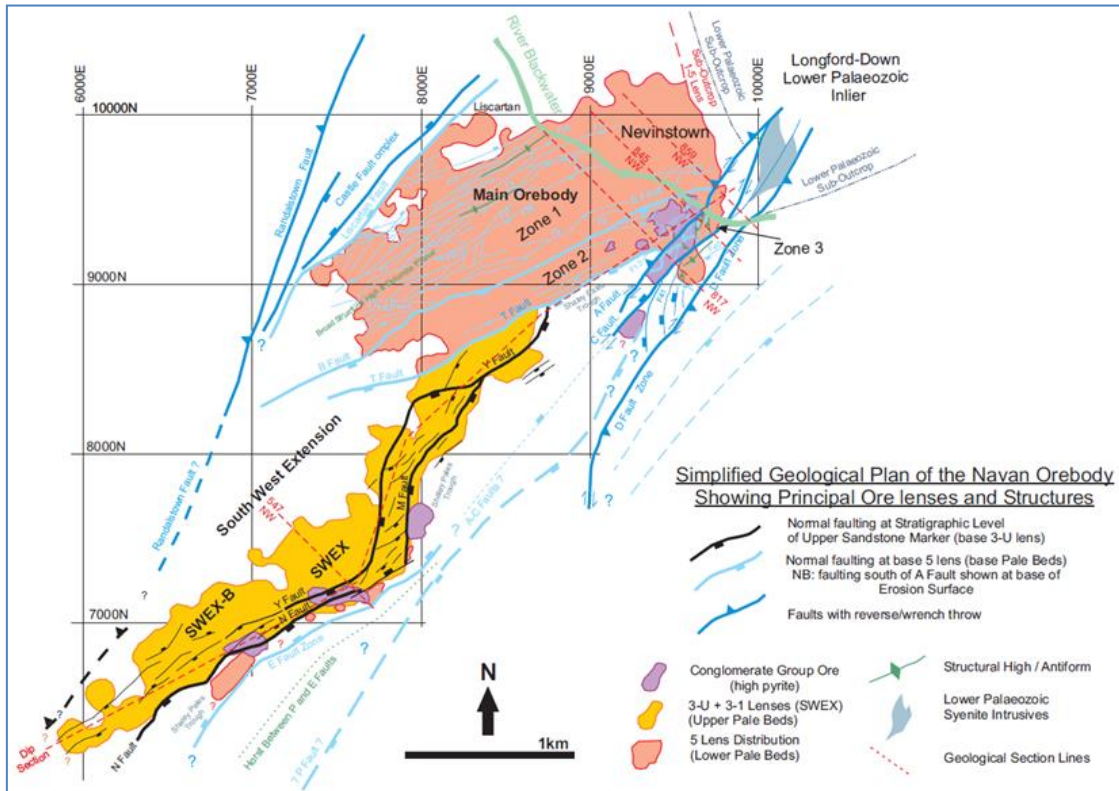


FIGURE 3.3 THE NAVAN OREBODY’S MAIN SECTIONS

3.3.1 THE NEVINSTOWN OREBODY

The Nevinstown orebody is an uninterrupted northern continuation of the 'main orebody' currently being mined by Boliden Tara Mines DAC. The orebody is present at the surface level of the Nevinstown townland and dips steeply below the River Blackwater into the property of Boliden Tara Mines DAC.

Mining will follow the same cyclic pattern as currently persists resulting in the removal of ore underground followed by the filling of the voids using slag-cement and waste sand material that remains after the ore treatment process. The surface characteristics and features of the Nevinstown townland will be left unaltered after the mining in the area is completed.

Most of the ore in the Nevinstown orebody is already extracted and the void backfilled however due to cost reduction and technical advance some parts of the Nevinstown Orebody that previously were classed as not minable are now part of the Life of Mine plan.

Approximately 2M tonnes remaining in the Nevinstown orebody and will be mined at an average rate of c.250k tonnes per annum.

The proposed development will include the mining of the area know as the "Crown Pillar".

The Crown Pillar or mining blocks N8 and N9 are situated in the north-eastern part of the Nevinstown orebody where the orebody outcrops on the surface just north of the river Blackwater.

The "Crown Pillar" resource is some 735k tonnes with typically 9% zinc and 2% lead. The proposed stope size is 10m wide, up to 30m long and approximately 22m high leaving a pillar to surface of 8m. The remaining "crown pillar" will be supported by cablebolts from the development drifts above the stopes.

The stopes will be filled immediately after the ore is extracted with slag-cement stabilised backfilling using continues pour backfilling minimising the risk of water from the river entering the mine.

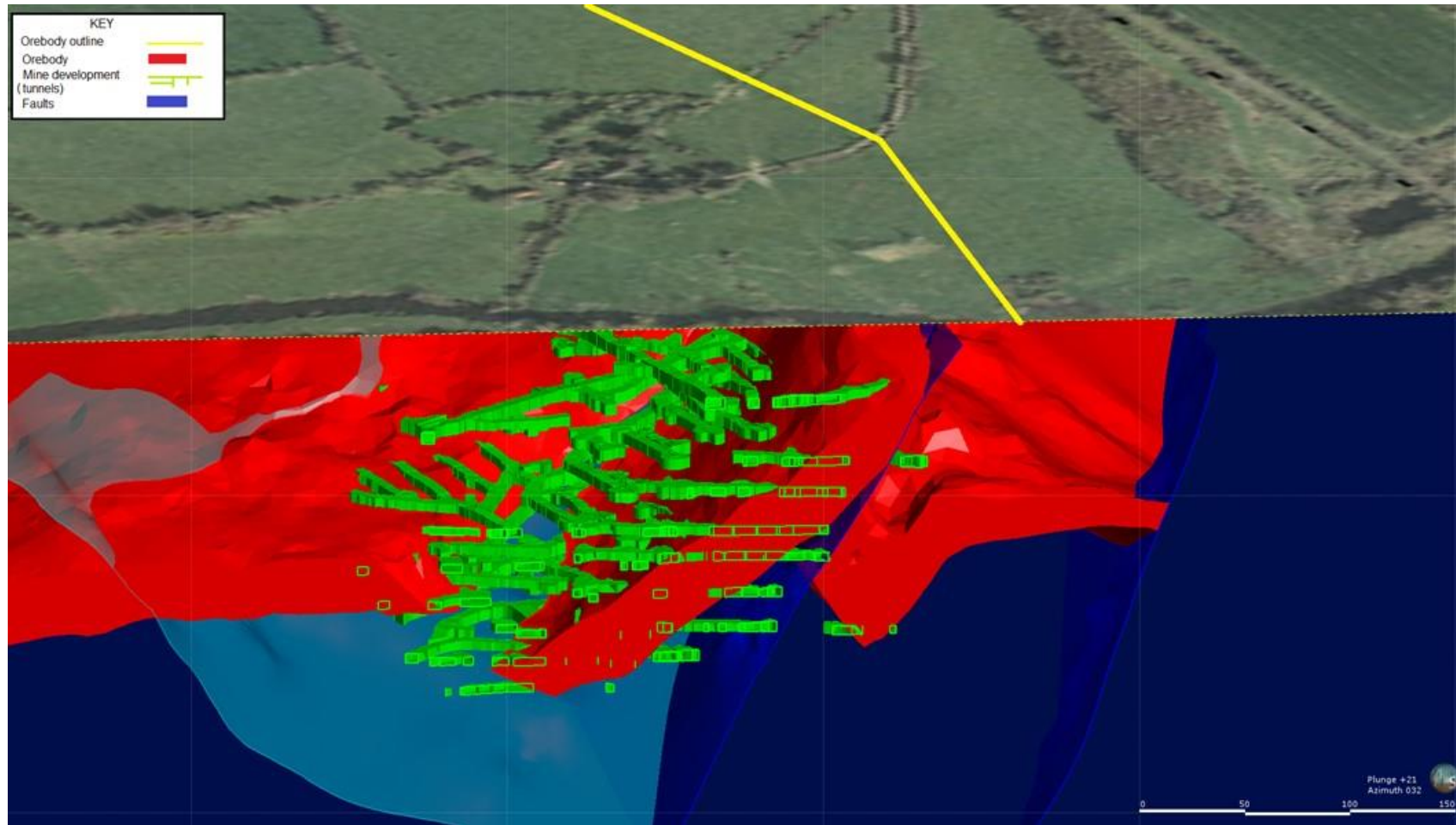


Figure 3.4 Cross section through the Nevinstown orebody (Southers boundary, Blackwater river)

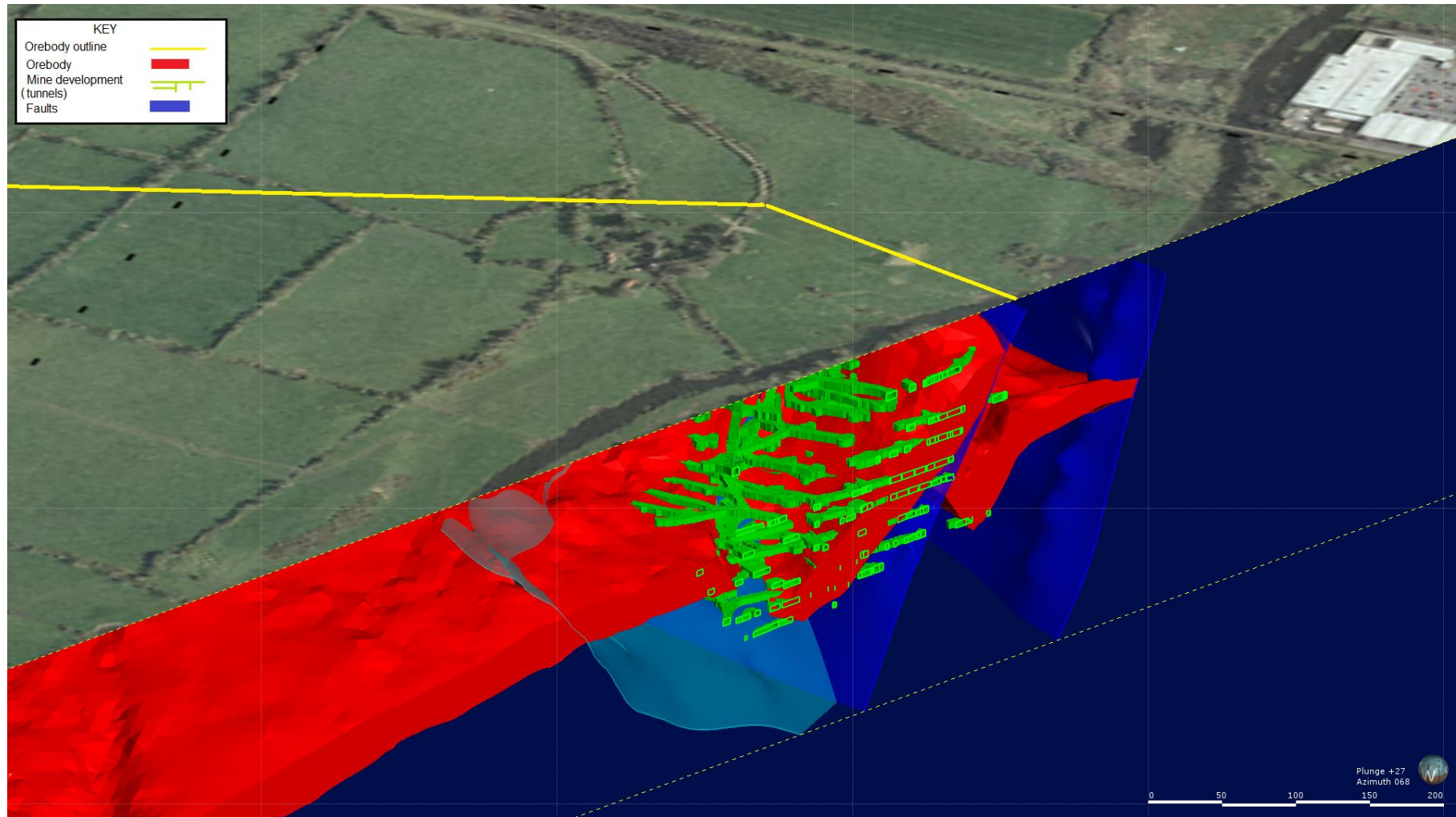
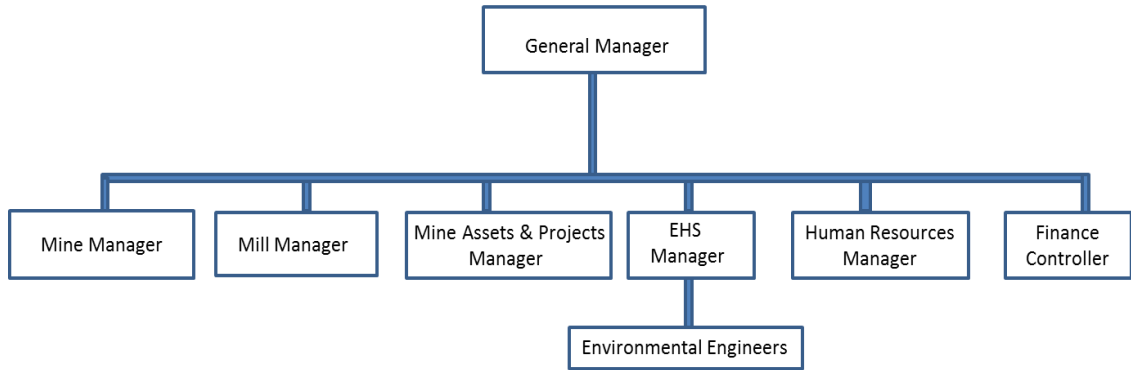


Figure 3.5 Cross section through the orebody

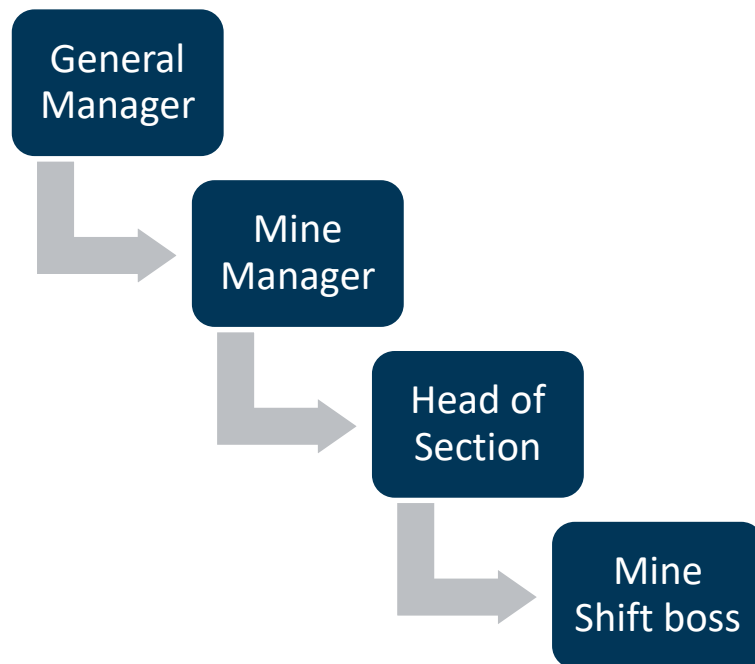
3.4 MANAGEMENT STRUCTURE & ORGANISATIONAL CHART

The current management structures are presented below:

3.4.1 GENERAL MANAGEMENT



3.4.2 MINE MANAGEMENT



Prior to any mining activity a design process is completed. The design cover all aspects of the mining such as ground support during mining of both tunnels and stope (mining units), sequence of mining to ensure stability during and after the ore extraction, backfilling of open void, ventilation and pumping of process water.

All construction drawings are issued in writing to the mining crews by the Mine Planning and Technical Services section within the Mine Department. As the development (tunnelling) progresses the accuracy of the mining is checked by the mine surveying team. After the extraction of a mining unit (stope) and sometimes during the mining, the open void is scanned to assess over/under break and adjustments to drill and blasting plans are made when required.

Shiftbosses supervise the ongoing activities on an ongoing basis and all activities are recorded in the shiftlog. On a weekly/monthly basis, engineers will conduct inspection of ground support, ventilation and the backfilling of open voids.

Mining is undertaken in accordance with a mine design and development plan. This is a condition of the original planning permission granted by An Bord Plenala.

The plan includes

- The mine design criteria to be adopted for detailed mine planning and design (to ensure stability during mine development, ore extraction and post-closure)
- A geotechnical risk assessment of potential water and mud inflows into the mine and the mitigation measures to be implemented, if any, arising from this assessment.
- Strength and stiffness of the backfill materials
- Details on underground structures, faults and cavities
- Details of surface and underground monitoring including (surface precise levelling: station locations, base station locations, survey methodology (accuracy and frequency), displacement monitoring, stress measurements, strength and stiffness measurements on the backfill materials.

The mine plan and design criteria are constantly under review and reported to the local authority every two years.

The review includes:

- a detailed review of the mine design criteria;
- the geotechnical risk assessment;
- surface subsidence; and surface and underground monitoring.
- proposed modifications, if any, to the design and monitoring of the workings, and the basis for such modifications,

3.4.3 ENVIRONMENTAL MANAGEMENT AT TARA

Underground mining work is planned and carried out with a strong awareness of the impact on the surface environment. Blasting is designed to minimise vibration effects on surface and all water used in the mine is clarified before pumping to surface for further treatment.

Tara has always been conscience of its responsibility and commitment to the local community and the environment. From the start, focus was placed on environmental management and sustainable development, and 2017 saw the 46th year of Tara's environmental department existence. The department began its life as the Conservation department, its primary function to assess the potential impacts of the then developing mine. Tara's location within 1km of the town of Navan surrounded by dwellings and high-quality agricultural land and underlying the River Blackwater (a recently designated SAC and SPA) presented many environmental challenges.

In the intervening years environmental management at Tara has evolved and developed in line with changes in the industry, changes in technology and the enactment of new environmental legislation. Today Tara operates to the highest environmental standards and has an independently certified Environmental Management System ISO 14001 in place. Environmental impact assessment continues to be carried out during the planning phase of any extension of mining operations.

The key objective of environmental management at Tara is to maintain a balance between using methods and techniques that increase efficiency and precision while minimising the environmental impact.

All company activities are carried out and governed by the Company's Industrial Emissions License (IEL) which is currently being reviewed by the Environmental Protection Agency (EPA).

Tara's most significant environmental aspects are protecting air and water quality and the management of tailings. An extensive monitoring programme is in place to ensure compliance and activities have negligible impact on the local environment. Air and water discharge quality as well as noise and vibration levels are measured continuously in the vicinity of the mine and the tailings management facility. The quality and ecological status of surface water and groundwater, soil and vegetation is also routinely monitored.

A closure plan for both the Mine site and the Tailings Management Facility is in place and will be reviewed periodically in consultation with the EPA as the mine approaches closure.

Tara operates an 'open door' policy with respect to environmental practice, monitoring and control and has a dedicated Environmental Centre where all environmental data can be scrutinised by the public thus ensuring constructive, flexible and open dialogue.

3.5 THE MINING OPERATION DESCRIBED

As stated earlier the necessary infrastructure, both surface and underground, to facilitate the proposed development is already in place. It is however though necessary to describe the mining/processing cycle to put the proposed development in context.

1. Overall annual production will remain at c. 2.5 million tonnes. The Nevinstown development will contribute to the annual total. This is not an intensification of production.
2. The Nevinstown ore resources are estimated at c. 2,000,000 tonnes
3. Nevinstown ore will be mine at an annual rate of c. 250,000 tonnes over an eight year period

Ore production encompasses the drilling, blasting and removal of the ore from underground deposits. Broken ore is delivered to one of five underground primary crushers and reduced in size to less than 150 millimeters before being hoisted to the surface. Ore is then fed to an autogenous grinding mill, which grinds the ore to a fine powder which is then pumped as aqueous slurry to metallurgic flotation cells. Within the flotation cells, galena (Lead sulphide) and sphalerite (zinc sulphide) are differentially separated, while undesirable minerals such as pyrite are depressed. Differential flotation and selective depression of minerals are enhanced by chemical additives to the flotation chamber feed.

Once the target minerals have been extracted the tailings stream is cycloned to separate the coarse sand fraction from the finer slimes fraction. The coarse fraction of tailings is pumped, to the underground mined out areas. In so doing, approximately 45% of the tailings are used underground to backfill mined voids. The tailings used for backfilling is stabilised, chemically and physically, by mixing with Portland cement.

The remaining fines fraction tailings is pumped as an aqueous slime to the Tailings Storage Facility (TSF) located some 2.5 km north of the processing plant in the townland of Randalstown. On an annual basis approximately 1.2 million tonnes of tailings are deposited for permanent storage in the TSF.

There is sufficient tailing capacity in the existing tailings storage facility to facilitate the resulting tailings from the proposed development.

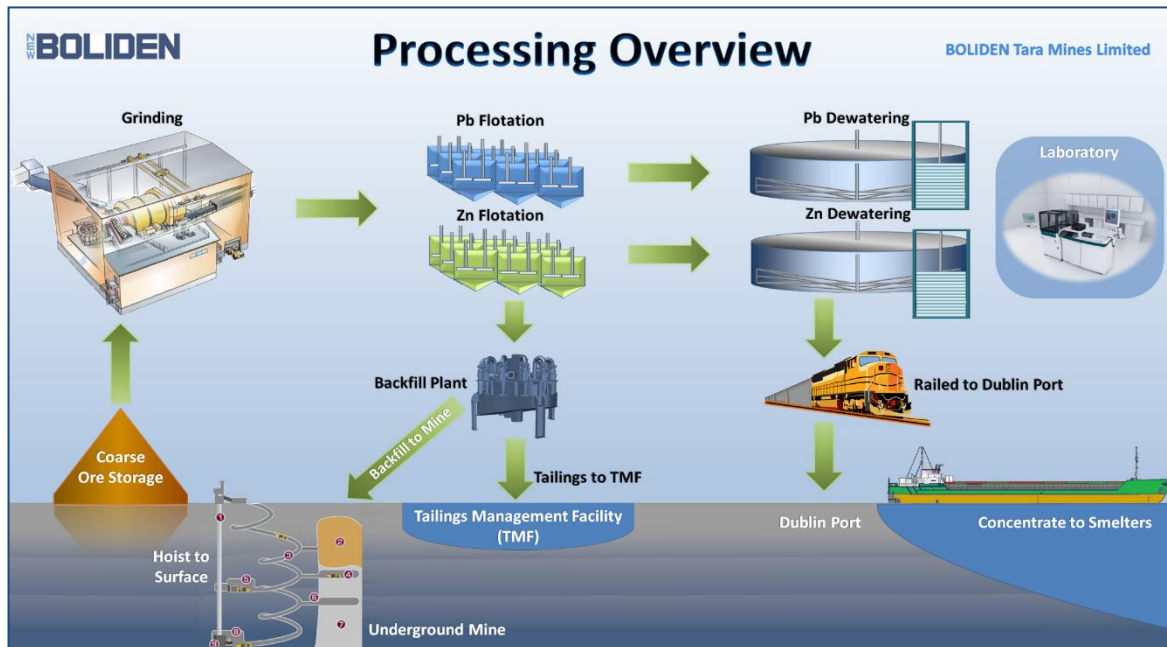


FIGURE 3.6 MINING AND PROCESSING FLOW DIAGRAM

Prior to any mining activity a design process is completed. The design covers all aspects of the mining such as ground support during mining of both tunnels and stope (mining units), the sequence of mining to ensure stability during and after the ore extraction, backfilling of open void, ventilation and pumping of water.

All plans and drawings are issued in writing to the mining crews by the *Mine Planning and Technical Services* section within the *Mine Department*. As the development (tunnelling) progresses the accuracy of the mining is checked by the *mine surveying team*.

After the extraction of a mining unit ("Stope") and sometimes during the mining, the open void is scanned to assess over/under break and adjustments to drill and blasting plans are made when required.

Shiftbosses supervise the ongoing activities on a continuous basis and all activities are recorded in the shift-log. On a weekly/monthly basis, mine engineers conduct inspection of ground support, ventilation and the backfilling of open voids.

3.5.1 MINE DEVELOPMENT (TUNNELLING)

Development takes place in two phases: main development and exploration, in which sections of the orebody are outlined and made accessible for eventual mining and stope development. This involves the drilling, blasting, and recovery of the stope and pillar ore. Both forms of development are important sources of ore, contributing up to 400,000 tonnes annually to the total production target.

Mine development is planned to allow access to the orebody at varying levels and to prepare sections of the orebody for mining. Development drifts are driven at different dimensions depending on their intended purpose, for example a main haulage drift will have larger dimensions than a drift designed for ventilation purposes. It is necessary to have a significant amount of development in place before large-scale ore production commences. All development work is accessed from the existing mine and all ore resulting from development will be transported to the underground crushers / conveyor systems.

Tunnel Development CYCLE

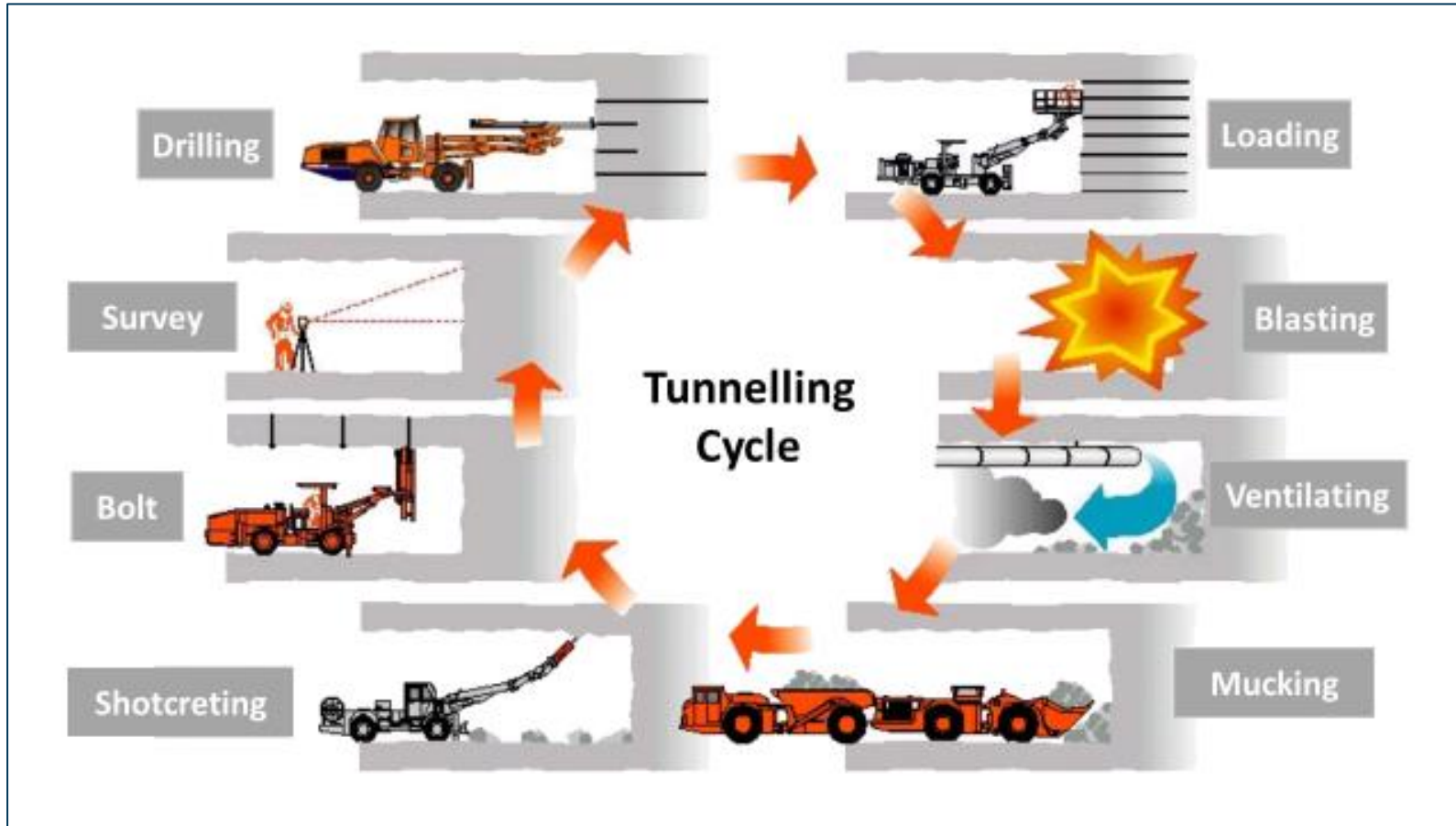


FIGURE 3.7 TUNNELING

CYCLE

3.5.2 DRILLING

The first activity in the tunnelling cycle is the **drilling of blast holes**. The blast holes are drilled using a twin boom drill rig (“Jumbo”).

The jumbo is navigated and all drill holes are positioned according to a predefined drill plan.

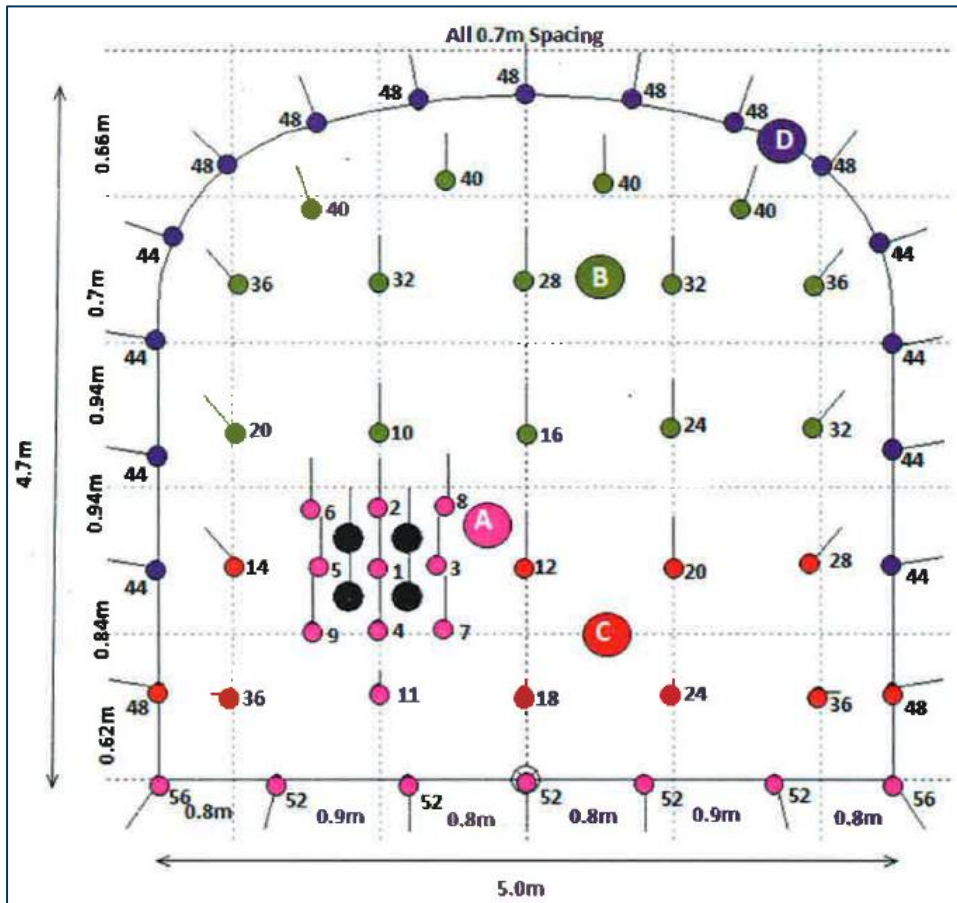


FIGURE 3.8 DRILL & BLAST PLAN:

The purpose of the drill plan is to ensure correct distribution of the explosives in order to minimise ground vibrations and damage to the final tunnel walls.

3.5.3 LOADING

The next step is the **loading of explosives**. Each blast hole is charged as per the *drill and blast plan* using a computerised charging unit. The charging unit is configured to deliver the correct kg's of explosives per blast hole. After loading is completed, the explosives are set off – **blasted**. Following ventilation where the blast fumes are removed from the tunnel by the use of air brought to the face (blind end of the tunnel) via a ventilation duct.

3.5.4 MUCKING

Following blasting, the broken rock is **mucked** (removed from the face) and trucked to the final destination. Ore is taken to a crusher and hoisted to surface, waste rock is left underground in an empty stope or crushed and hoisted to surface.

3.5.5 SCALING

After the broken rock is removed, the perimeter of the tunnel is **scaled** (checked for loose rocks) and the tunnel is ground supported. The type of ground support depends on the rock conditions and the purpose of the tunnel. Typically the back (ceiling) of the tunnel and part of the walls are covered by shotcrete (sprayed concrete containing steel fibres) before the tunnel is systematically bolted (resin grouted rebar's in a predefined pattern).

When the tunnel is finished, the exact location and dimensions of the tunnel is surveyed and the information entered in the survey database.

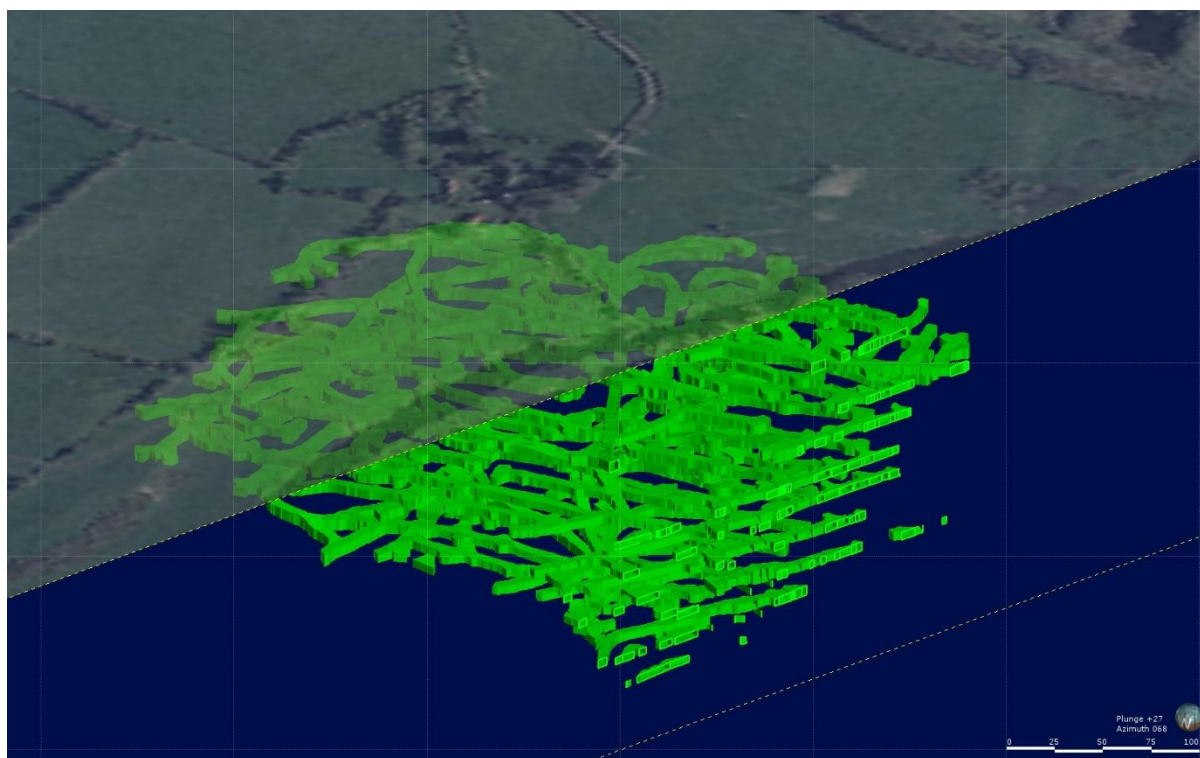


FIGURE 3.9 EXISTING MINE DEVELOPMENT HEADINGS (TUNNELS) NEVINSTOWN OREBODY.

3.6 PRODUCTION MINING (STOPING)

Mine production is the generation of large tonnages of ore from stopes and pillars. All ore produced is transported by trucks and scoops to the primary crushers located underground.

Generally, stopes and pillars are laid out with their long axes parallel to strike. This has reduced the amount of footwall development in waste and facilitated stope access through haulage pillars that are essentially aligned down dip.

Stope and pillar dimensions have evolved over time from an initial 12.5m width for both, to the present less rigid dimensions. Widths for both are now determined on a case by case basis and are controlled by local features such as ore thickness, bedding planes, faults, joints, and adjacent openings. Heights are also variable and also depend on the thickness of the ore ranging from 10m to 80m. Average unit sizes are in the region of 25,000–30,000 tonnes per stope/pillar, giving rise to a total requirement of up to 80 stoping units per year in order to maintain the production figure of 2.5 – 2.6 million tonnes from stoping and pillar mining.

Blasting is carried out using emulsion based explosives where the broken ore is removed from the stope and taken to one of the crushing stations either by loader or truck depending on the distance of travel. The blasting/mucking sequence continues until the stope is completely mined out, after which it is subsequently filled with tailings sands, cement and/or development waste, the proportions of which are determined by location and adjacent mining plans.

Underground primary crushing results in the reduction of the ore size to less than 150mm, at rates of up to 800 tonnes per hour. Crushed ore is carried by conveyor to a storage bin of 3600t capacity located adjacent to the production shaft, where it is fed to the shaft skip loading pockets. The ore hoisting cycle is automatic, the control of the ore feeders, transfer conveyors and skip loading being regulated by the hoisting cycle and the weigh cells at each loading pocket. Ore is hoisted into two 15.5t capacity bottom dump skips running in balance, tipped into a small bin at the head-frame and then conveyed to a 35,000t surface storage building.

Cycle (Refer to Figures 3.10 thru 3.13 Longitudinal sections.)

3.6.1 STOPE DEVELOPMENT:

Drifts (tunnels) are driven from the access drift to the end of the stope (mining unit) on the hanging wall (upper) level and foot wall (lower) level. The drifts are driven using conventional drill & blast. After the blasted rock is mucked out, the ground is supported using rock bolts and shotcrete (sprayed concrete containing steel fibres) as directed by the geotechnical engineer.

3.6.2 CABLE BOLTING:

After the completion of the hanging wall drift, the crown/sill pillar (roof beam) is further supported using cement grouted cable bolts.

3.6.3 PRODUCTION DRILLING

After the cable bolting is completed, blast holes are drilled from the foot wall (lower) drift. The holes are charged with emulsion (pumped bulk) explosives. Each stope (mining unit) will be opened in several blasts.

3.6.4 MUCKING OF ORE

After each blast the broken ore (rock) is removed from the stope (mining unit) using a remote controlled loader.

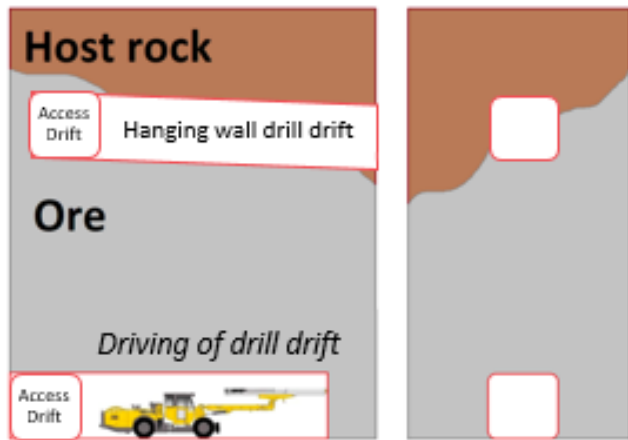


FIGURE 3.10 DRIVING OF DRILL DRIFT

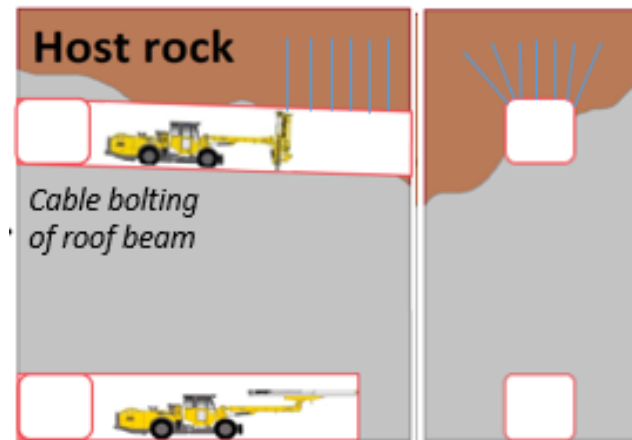


FIGURE 3.11 CABLE BOLTING ROOF

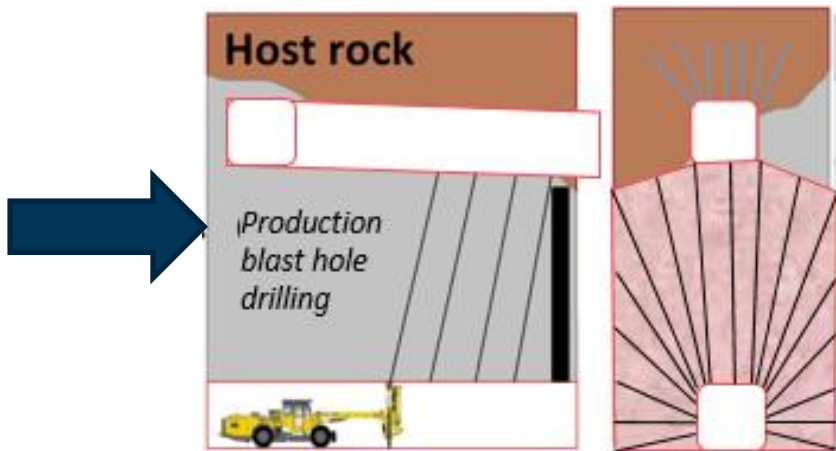


FIGURE 3.12 PRODUCTION BLAST HOLE DRILLING

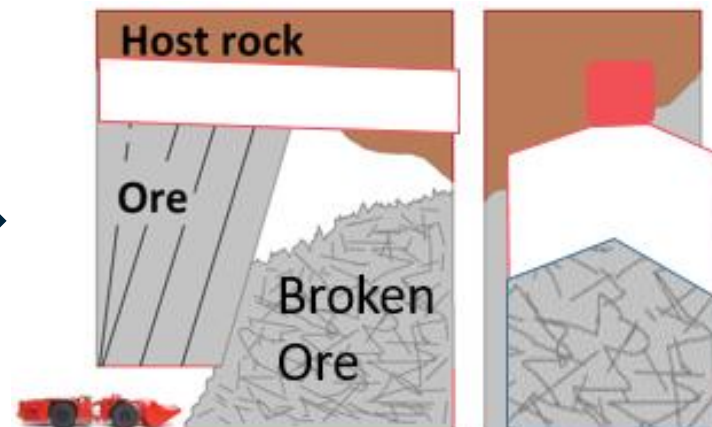


FIGURE 3.13 MUCKING (REMOVING) BROKEN ORE

3.6.5 BACKFILLING

The purpose of backfilling is to fill mined out stopes underground, to maximise the amount of orebody mined and to maximise the storage capacity at the tailings storage facility.

Flotation tailings in the processing plant are pumped into primary and secondary cyclones. The overflow product from the cyclones consists of finer slimes which make up about 55% of the tailings produced. These slimes are pumped to the TSF. The underflow product from the cyclones consist coarser sands (45% of the tailings). It is these coarse sands that are used in the backfilling process.

The coarse sands collected from the underflow of the cyclones are mixed with cement in a sand to cement ratio of roughly 25:1 in a backfill mix tank. The backfill sands can be pumped underground via a continuous backfill pour where sands are pumped directly into the backfill mix tank where cement is added before being pumped underground via boreholes to the required mine area. If a continuous backfill pour is not feasible the sands can be stored in backfill sand tanks on surface and mixed with cement at a later date when backfilling is required.

If the mine cannot take a backfill pour and the backfill storage tanks are full the mill can pump 100% of flotation tails to the TSF.

On average approximately 1.2 million tonnes of tailings are pumped to the TSF per annum.

The voids left by the mining of stopes and pillars are filled with cycloned sand, which is produced in the concentrator from tailings and directed to the stopes through surface pipelines and boreholes that connect with the haulage levels. This operation is an essential part of the mining cycle, and close scheduling is required to meet production targets. The recovery of approximately 45% of the coarser mill tailings for backfill provides sufficient material to replace the ore mined from the stopes and pillars. Maximum fill recovery and utilisation also ensure efficient use of the available volume of the surface tailings management facility.

To facilitate the mining of pillars between the sand-filled stopes, the sand is given cohesion, by the addition of cement at dosage rates of between 3% and 9%, depending on planned exposures. Pillar voids are usually filled with un-cemented sand and/or waste rock. A blended cement consisting of 90%-95% ground granulated blast-furnace slag and 5%-10% normal Portland cement is used. Each stope filling operation is carefully planned to optimise future ore recovery from the pillars, and the economics of designed cement additions are continually analysed.

3.6.5.1 BACKFILLING STAGE 1

When all the ore is removed from the unit, a bulkhead (retaining wall) is built at the upper and lower level after drainage towers are installed. Cement stabilised sand is pumped into the stope (mining unit) via a pipe on the hanging wall (upper) level. The upper drift is driven at a down dip gradient ensuring tight filling (backfill tight to the ceiling) of the stope. Any potential unfilled void will be closest to the access drift.

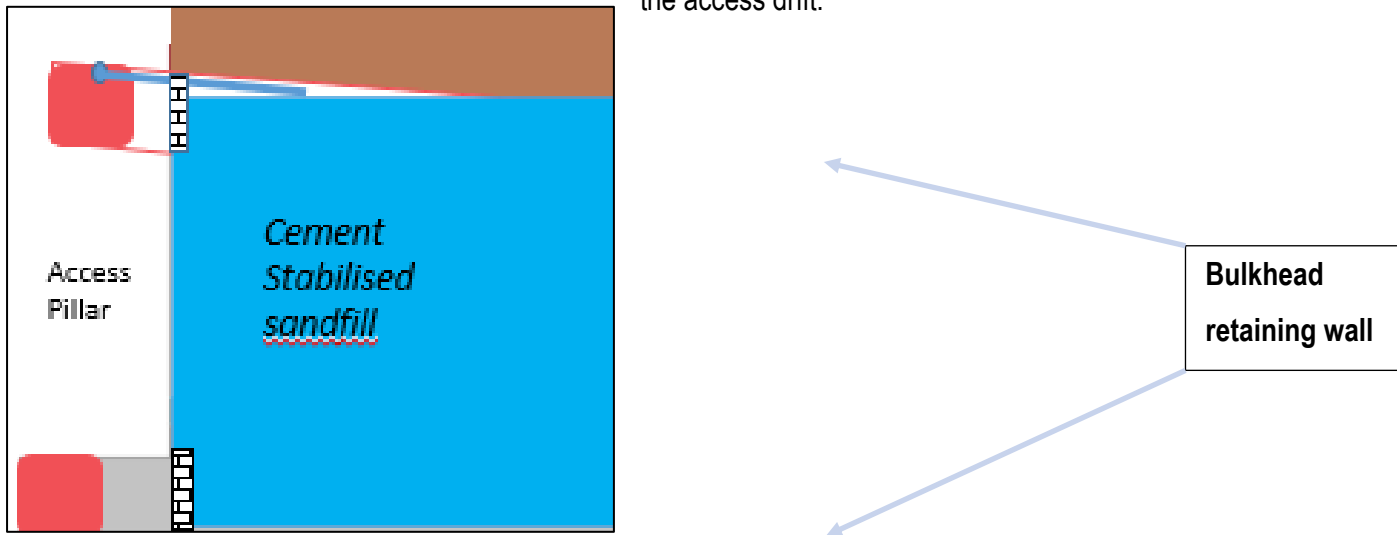


FIGURE 3.14 BACKFILLING STAGE 1

3.6.5.2 BACKFILLING STAGE 2

Before extraction of the access pillar, the bulkhead on the upper level will be partially removed and any void left from the initial backfilling of the mining unit will be filled during the filling of the access pillar stope (mining unit).

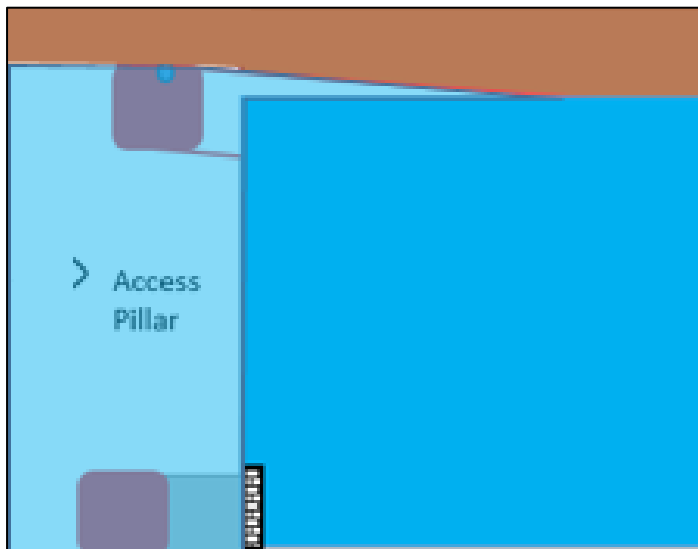


FIGURE 3.15 BACKFILLING STAGE 2

3.6.5.3 WASTE ROCK BACKFILLING

The annual tonnage of waste rock mined in pursuit of ore is c.400,000 tonnes, most of which is recovered from remote parts of the mine in locations of future mining. Some waste rock is placed in stopes while some is brought to surface. The surplus waste stockpile has been classified as a reusable product by the EPA; subject to specific conditions (EPA Ref. P0516-01/ap12dh.doc). Much of the surplus rock is now used for backfilling and mine stabilisation purposes.

3.6.5.4 CONCRETE AND SHOTCRETE

There are two separated concrete plants, also known as batching plants. Both plants combine various ingredients to form concrete products. Some of these inputs include sand, water, aggregate (rocks, gravel, etc.) and cement. There are no air emissions from the plants, all dust is collected in filters and returned to the mixer.

One plant is utilised for the production of large concrete blocks used for underground construction while the other plant produces shotcrete. The large concrete blocks are used to close off access to the stopes prior to filling with backfill.

Shotcrete is a concrete based mix which is sprayed through a hose at high velocity on to a rock surface for support. It can be impacted onto any type or shape of surface, including vertical or overhead areas. The quantity of shotcrete used has increased in recent years as the mine progress deeper into the south western sector of the orebody.

The positive impacts of the onsite production of concrete products include the reuse of surplus mine rock (when available) and the reduction in road traffic as previously all concrete had to be imported from offsite sources.

3.6.6 SERVICES AND MOBILE EQUIPMENT

The efficient operation of the mine is critically dependent on a variety of mobile equipment designed specifically for the underground mining. Most of the scoops operate by remote control and are all equipped with noise insulated cabins for operator safety and comfort. The mobile fleet is powered by diesel engines.

The production and the development drilling fleet is all electro-hydraulically driven, incorporating the most up to date features, including the facility to programme the machines to drill while unattended. To assist the efficient running of the operation many service backup vehicles are used for shotcreting, loading explosives, pipe handling, bulkhead building, materials handling and other tasks. Mobile equipment includes 4x4 wheel drive vehicles, some of which are fitted with scissor lifts for general maintenance, while others are used for personnel transport.

3.6.6.1 MINING EQUIPMENT MAINTENANCE

Assigning and crewing of appropriate equipment is an essential element to achieve mining targets, as is preventative maintenance systems and speedy attention to breakdowns.

Table 3.2 presents a list of available mobile equipment. Equipment will be deployed to the Nevinstown mining on a pro rata basis.

TABLE 3.2 MOBILE EQUIPMENT EMPLOYED

Equipment Type	Number in use
Development Jumbo Drill	5
Load Haul Dump machines	16
Trucks: Toro 45t capacity	11
Long-hole Drilling machines	5
Ground support bolters	4
Cable-bolters	2
Scaling machines	4
Personnel and light vehicles	40
Utility vehicles used to install services etc.	8
Explosives charging vehicles	6
Shot-crete machines	3
Bulk shot-crete transport vehicles	6

Maintenance of the fleet is carried out by an experienced work force on a continuous shift pattern in 3 workshops, one on surface and two underground. The mobile equipment fleet is the most up to date available to the mining industry and requires a very skilled work force to maintain. This requires continuous training and up skilling of all technical personnel. In addition to preventative maintenance Tara has a rebuild and replacement programme for the heavy equipment, and this is guided by availability and cost per hour of the units during their working life.

3.6.7 FIXED PLANT MECHANICAL MAINTENANCE

In Boliden Tara Mines, the ore handling system consists of 5 underground jaw crushers and 13 conveyor belts. The throughput ranges from 350 to 1000 tph. The newest crusher - No. 5 Crusher was commissioned in 2003. This is a METSO Nordberg crusher, one of only 2 crushers this size in the world. The crusher weight is 122 tonnes with a throughput of 1000 tph, Jaw size of 2000 x 1500 mm and powered by a 400 kW motor.

Conveyors are monitored by plc control with graphic display around the site. All conveyors are protected by magnets to remove tramp metal. Conveyors lead from all crushers to the Coarse Ore Bin located near the Production Shaft.

All ore hoisting is through the Production Shaft. The shaft is 350m deep, 5m diameter, concrete lined and commissioned in 1977. Twin skips in balance are used with a skip load of 14 tonnes. The hoisting speed is 7.6 m/s working out at 38 skips per hour making a hoisting capacity of 540 tonnes per hour. All ore hoisting is automatic and a complete system overview and control is available to the Mine Department.

The mine pumping systems have to cater for 3 types of water entering the mine: groundwater, service water and water contained in hydraulic backfill. Average volumes are: 80m³/hour, 160m³/hour and 220m³/hour respectively. Water is pumped from working areas by Flygt submersible pumps to local area sumps. Water is pumped to surface from the Main Pump Station, at an average flow rate of 550 m³/hour.

All of the above fixed plant is looked after by a 24/7 maintenance crew. There are approx. 400 individual assets. To this end Tara Mines is currently installing a computer maintenance management system (MAXIMO) to control the maintenance required on each asset. This will help achieve stable and sustainable fixed plant reliability, in essence moving from a reactive situation to a more proactive approach to maintenance. This together with safety initiatives like the personal management safety system, service level agreements, with improved planning and scheduling will help to safely achieve the agreed mine targets for the future.

3.6.8 VENTILATION

The large lateral extent of the orebody, together with the variations in its thickness and depth, calls for a ventilation system that can be adapted to demand as the mining locations change. There are two primary reasons for mine ventilation:

- to provide oxygen rich air for underground operators and machines,
- to remove and dilute concentrations of noxious gases so as to render them harmless.

The extensive use of underground diesel equipment requires large volumes of fresh air to be passed through the mining access routes. Ventilation is by a 'pull' system whereby the fans are on the exhaust end of the system creating a negative flow. The noxious gases to be removed are the emissions from the underground diesel equipment; these are carbon monoxide, carbon dioxide and nitrous oxides. In addition the gases generated as by-products of blasting are also removed and these are carbon monoxide, carbon dioxide, sulphur dioxide, ammonia and hydrogen sulphide. However blasting gases are all removed in the short period following blasting. Exhaust gases are removed from the mine via Return Air Ventilation Raises (RARs). There are a total of seven return air raises currently in operation.

3.6.9 MINE DRAINAGE

Water enters the mine in three ways:

- as natural ground water,
- as service water for the mining operations,
- as transport for the backfill.

The lowest pump station is fully automated, where variable speed slurry pumps operate to remove the dirty water. This water is pumped directly to the main pump station located in the shaft pillar where it is screened, clarified and pumped to the surface. The water entering the clarification system is screened to remove the >3mm material, and clarified with the use of a lamella thickener. An organic polymer is added to induce rapid settlement. A rake at the bottom directs the mud to the central discharge point where a mud pump lifts it to the mill tailings pump box on surface. Clean water overflow collects in two holding sumps, where clean water pumps then lift it 416m to the surface pond where it can be reused. The total pumping capacity of the mine is 21,600 m³/d while the current total inflow to the mine is 13,000 m³ / day.

3.7 PLANNED NEVINSTOWN PRODUCTION

The planned mining in Nevinstown as per the current life of mine plan, can be divided into two sections

- main *development* (**Crown Pillar and Z1NEV**) and
- completion of *existing mining blocks* (**N2 to N6**) Figure 3.16.

The planned mining is based on the currently known resources and forecasted long-term metal prices and may be subject to change.

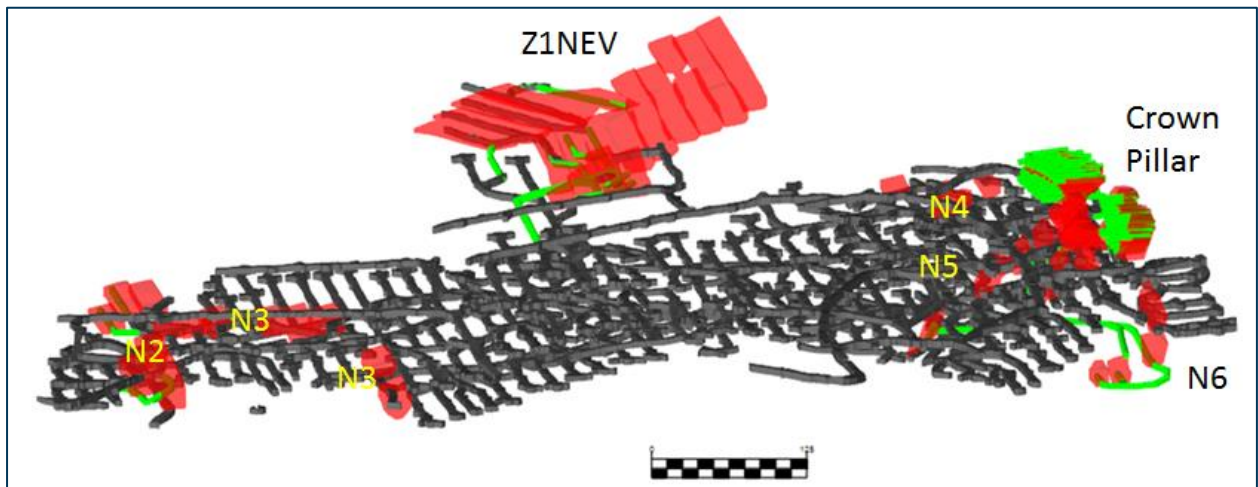


FIGURE 3.16 ISOMETRIC VIEW OF NEVINSTOWN. PLANNED DEVELOPMENT (TUNNELLING) IN GREEN, PLANNED STOPING IN RED. EXISTING DEVELOPMENT IN GREY.

3.7.1 CONCEPTUAL BLOCK DESIGN CROWN PILLAR MINING

TABLE 3.3 CROWN PILLAR ESTIMATES

Zone	Tunnels km	Production Ore			Devt Ore		Total Ore Tonnes	Total Waste Tonnes
		Tonnes	Zn%	Pb%	Tonnes	Zn+Pb		
Crown Pillar	3,0	203,411	7.48	1.68	131,316	7.33	334,727	44,134

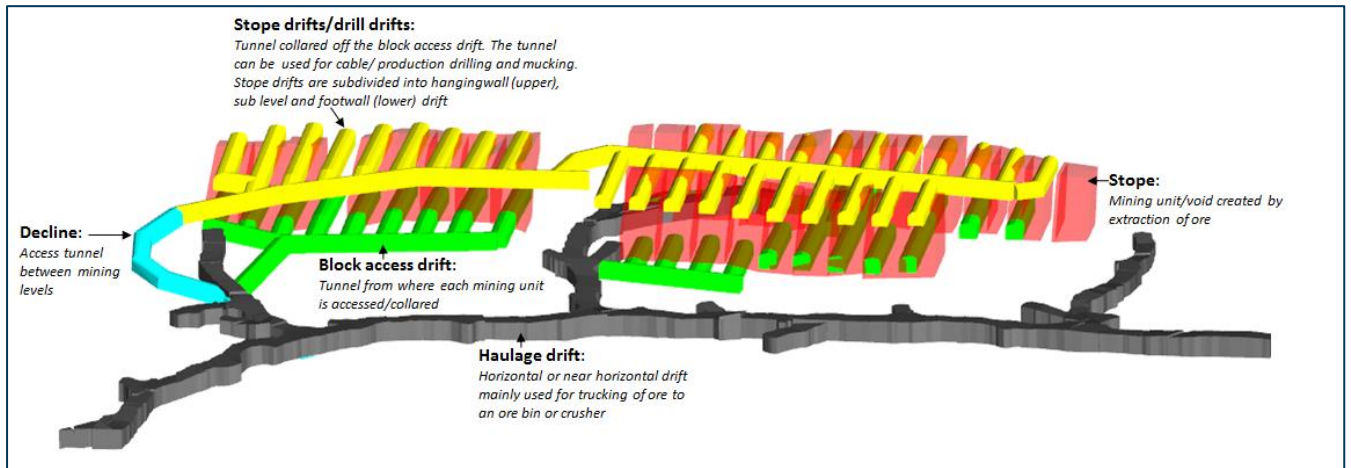


FIGURE 3.17 CONCEPTUAL DESIGN FOR THE MINING OF THE CROWN PILLAR

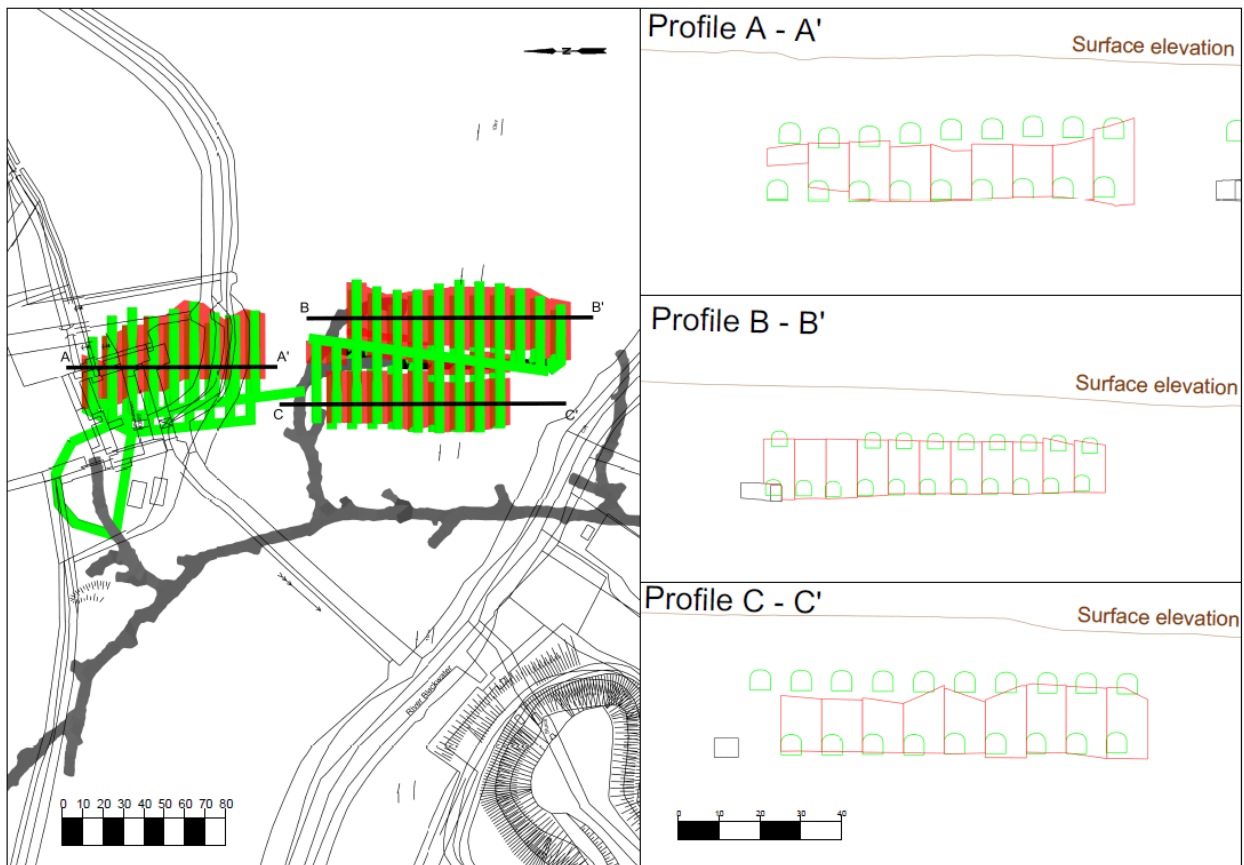


FIGURE 3.18 CROWN PILLAR VERTICAL SECTIONS

3.7.2 CONCEPTUAL BLOCK DESIGN Z1NEV MINING

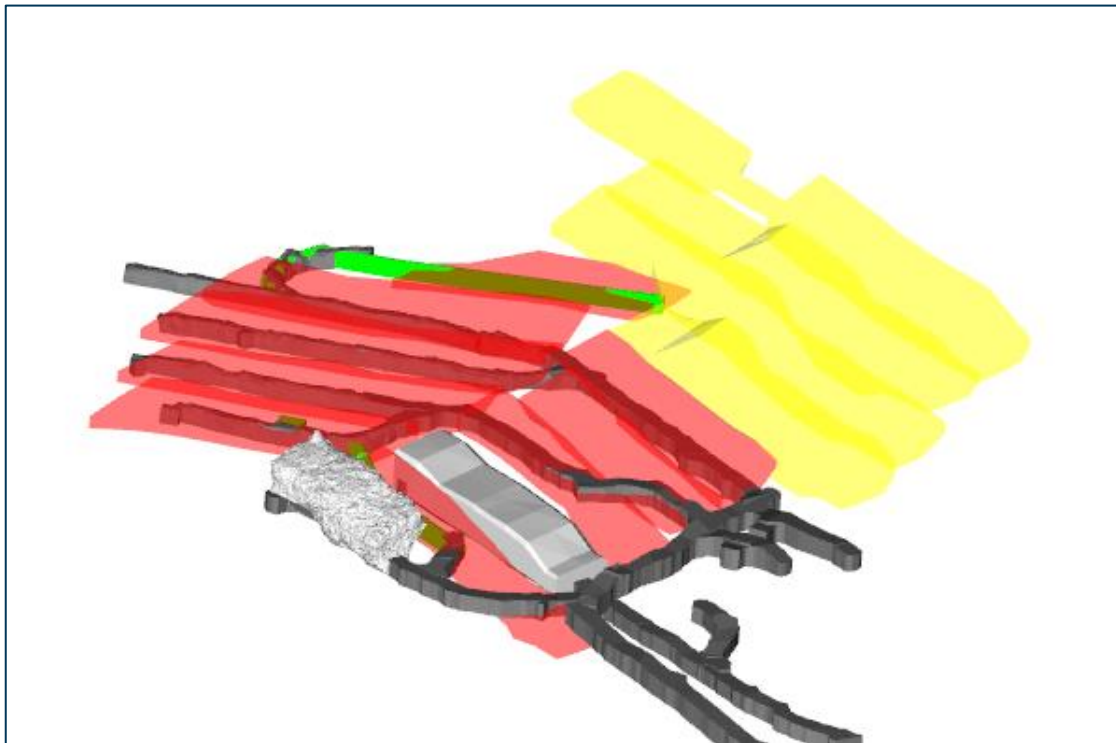


FIGURE 3.19 CONCEPTUAL DESIGN FOR THE MINING OF Z1NEV

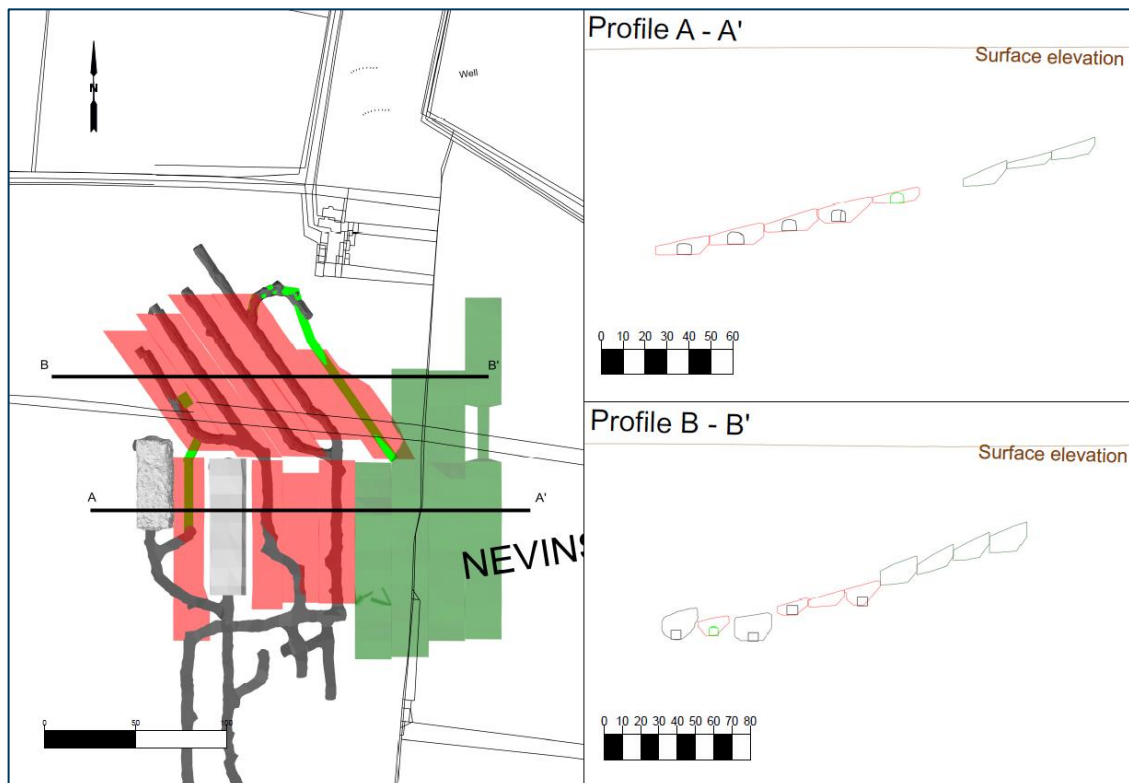


FIGURE 3.20 Z1NEV VERTICAL SECTIONS

3.7.3 Z1NEV MINING SEQUENCE

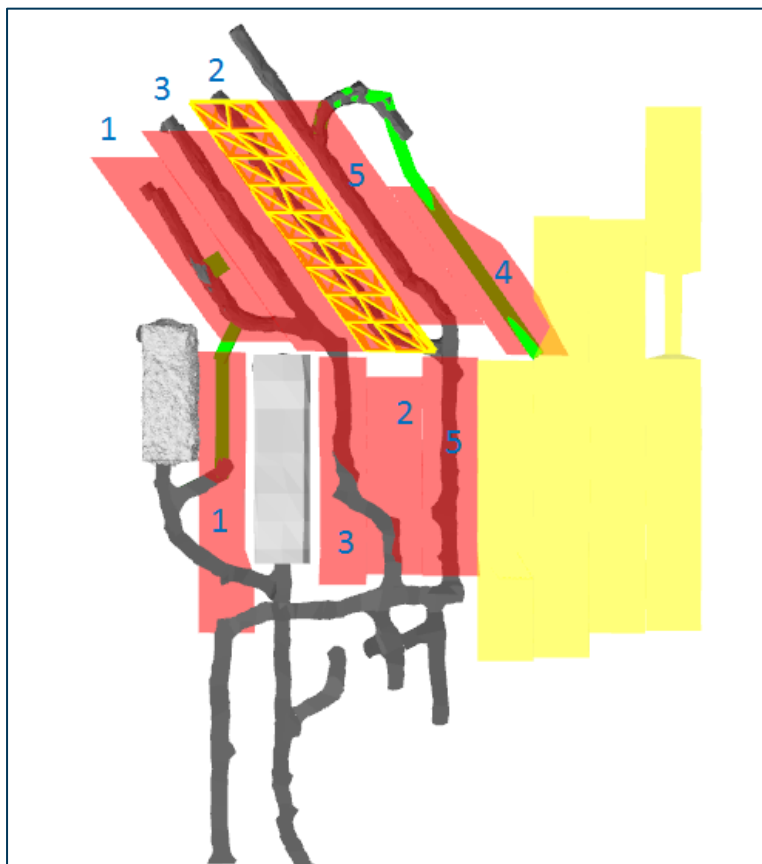


FIGURE 3.21 THE MINING SEQUENCE IN THE Z1NEV IS A SEQUENCE OF PRIMARY AND SECONDARY MINING UNITS. (THE DESIGN FOR THE AREA IN YELLOW IS NOT COMPLETED)

TABLE 3.4 Z1NEV ESTIMATES

Zone	Tunnels	Production Ore			Dev Ore		Total Ore	Dev Waste
	km	Tonnes	Zn%	Pb%	Tonnes	Zn+Pb	Tonnes	Tonnes
Z1NEV	2,1	657,730	4.34	0.75	96,255	4.58	753,985	22,761

3.7.4 COMPLETION OF EXISTING MINING BLOCKS (N2 TO N6)

TABLE 3.5 N2, N3, N4, N5 AND N6 ESTIMATES

Zone	Tunnels	Production Ore			Dev Ore		Total Ore	Dev Waste
	km	Tonnes	Zn%	Pb%	Tonnes	Zn+Pb	Tonnes	Tonnes
N2,N3, N4, N5, N6	5,6	862,732	6.52	1.34	93,863	5.05	956,595	233,373

3.8 ORE PROCESSING

Mined ore is hoisted to the surface for processing.

The ore is comprised of zinc and lead sulphide minerals, other minerals and limestone.

TABLE 3.6 TYPICAL COMPOSITION OF ORE.

Ore Constituents	Percentage (%)
Lead	1.5 – 3.0
Zinc	7.0 – 9.0
Iron	2.0 – 5.0
Magnesium Oxide	6.4
Barium Oxide	4.4
Copper	0.004
Calcium Oxide	24.0
Silver	17 gm/dmt

The mineral particles must be physically liberated from the host rock in order to selectively recover the lead and zinc metal during the froth flotation stages. The minerals are tightly bound together within the ore and the separation is achieved in a number of processing stages. The process of reducing the ore particle size is known as comminution.

3.8.1 GRINDING

The first stage is the crushing of the ore to minus 150mm in jaw crushers underground. After being hoisted to surface, this material passes to the coarse ore storage building from which it travels to the new *Autogenous grinding circuit*. The ore then passes to the autogenous grinding circuit and is mixed with water. The Autogenous grinding circuit reduces the ore particle size to less than 120 microns, a size range where the mineral particles and the host rock can be separated. Autogenous Mills use large particles of ore instead of steel balls for grinding media. The finely ground ore slurry is then pumped to the flotation stage of the process where the lead and zinc minerals are recovered respectively.

After grinding the finely ground ore slurry is then pumped to the flotation stage of the process where the lead and zinc minerals are separated from the host rock. The finely ground ore slurry is pumped from the grinding circuit to the flotation stage of the process.

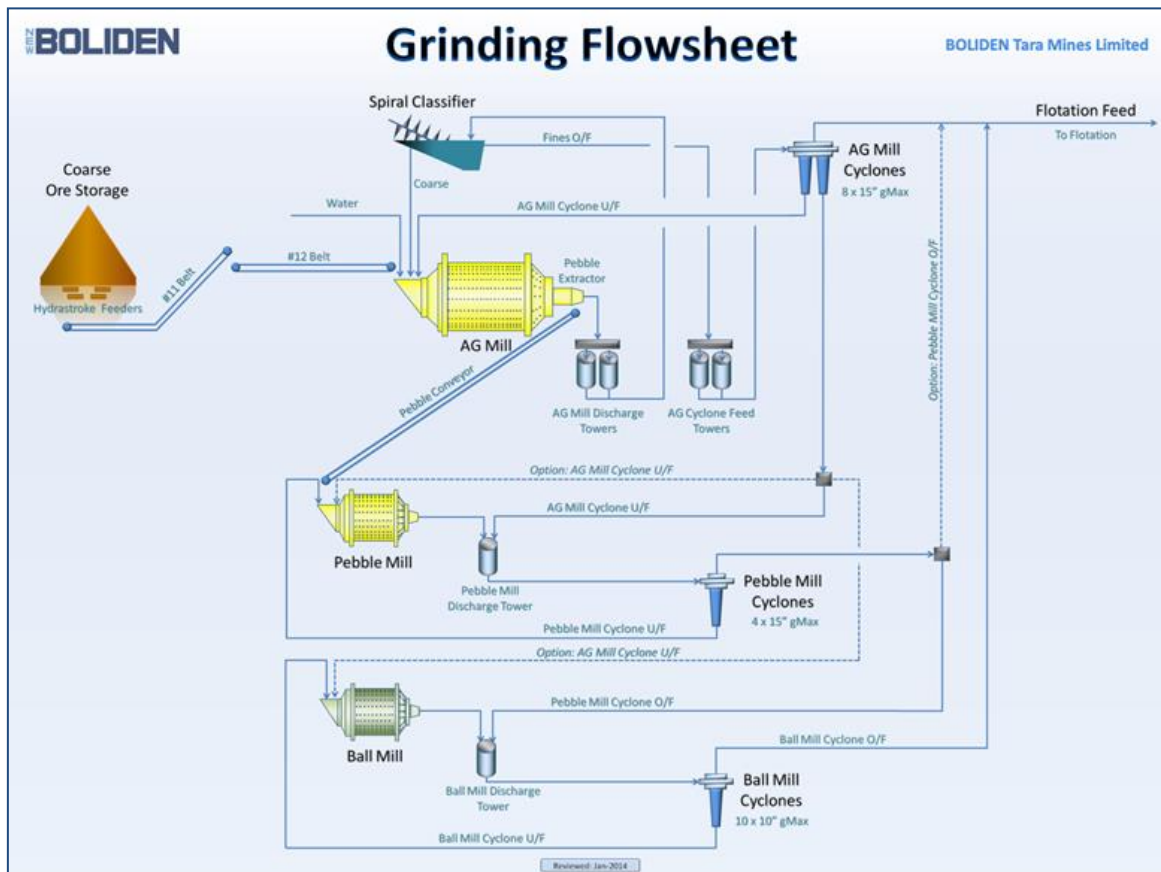


FIGURE 3.22 GRINDING FLOW DIAGRAM

3.8.1.1 FLOTATION

The objective of the flotation circuit is to recover the maximum amount of lead and zinc minerals to produce a highly concentrated product of target quality, i.e. of target metal content.

The flotation process is divided into two distinct sequential stages. Lead minerals are recovered in the first stage followed by recovery of zinc minerals in the second stage.

Flotation is used to firstly extract the lead mineral particles to produce a lead concentrate. The tails from the lead flotation circuit is the feed to the zinc flotation circuit where the zinc minerals are floated to produce a zinc concentrate.

The flotation circuit consists of a series of tank-like cells in which there is a rotating agitator, which stirs the mixture of ground ore and water. Chemical reagents are added, one of which promotes frothing. Other agents alter the surface properties of the mineral particles and cause them to be attracted to bubbles generated by forcing air through the mixture by the agitators. These bubbles, coated with mineral particles, rise to the top of the mixture as a froth, and overflow the lips of the cells into collection troughs or launders.

Different combinations of reagents are used to selectively remove different minerals. Lead minerals are removed in the lead circuit and the remaining material is transferred to the zinc circuit for the removal of the zinc minerals.

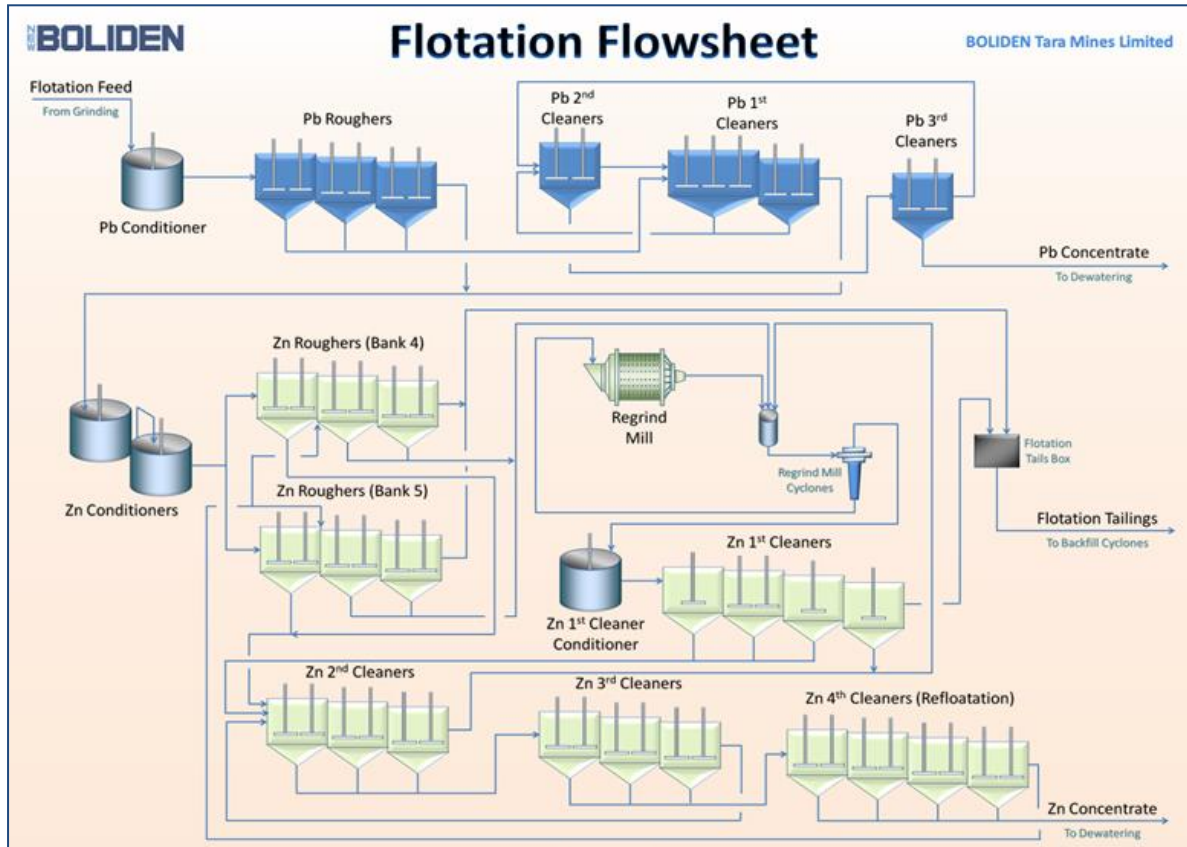


FIGURE 3.23 FLOTATION FLOW DIAGRAM

3.8.1.2 DEWATERING

Following flotation, the resultant Pb and Zn concentrates have a very high water content and need to be dewatered. The concentrates are dewatered separately using thickening and filtration in *Metso* pressure filters.

Zinc concentrate is automatically distributed between a 15m high-rate thickener and / or the 29 m *Eimco* thickener. The High Rate thickener automatically regulates its feed valve to maintain a constant bed mass, and the balance of zinc concentrate production is automatically diverted to the conventional thickener. Flocculent addition to each thickener is automatically regulated and independently controlled. The overflow water is used in the grinding circuit.

Four independent monopump underflow systems, two per thickener, operate to supply a stock tank. From the Stock tank a centrifugal slurry pump fills each filter to the correct pressure. The two filters, each with an approximate capacity exceeding 40 tonnes per hour, dewater the total Zinc concentrate production to a final moisture content of < 8.5 %. Filtrate water is returned to a thickener, and the filter cakes are conveyed to the concentrate store.

The lead flotation concentrate is pumped to a thickener, the overflow of which returns to the grinding circuit. The thickener underflow system is fully automated and maintains a fixed level of controlled slurry density in a surge tank. The thickened lead concentrate is then pumped to two *Mesto* Pressure Filters which have a throughput total capacity of approximately 20 t/h with residual moisture of less than 6%. The pressure filter and conveyor system are fully automated.

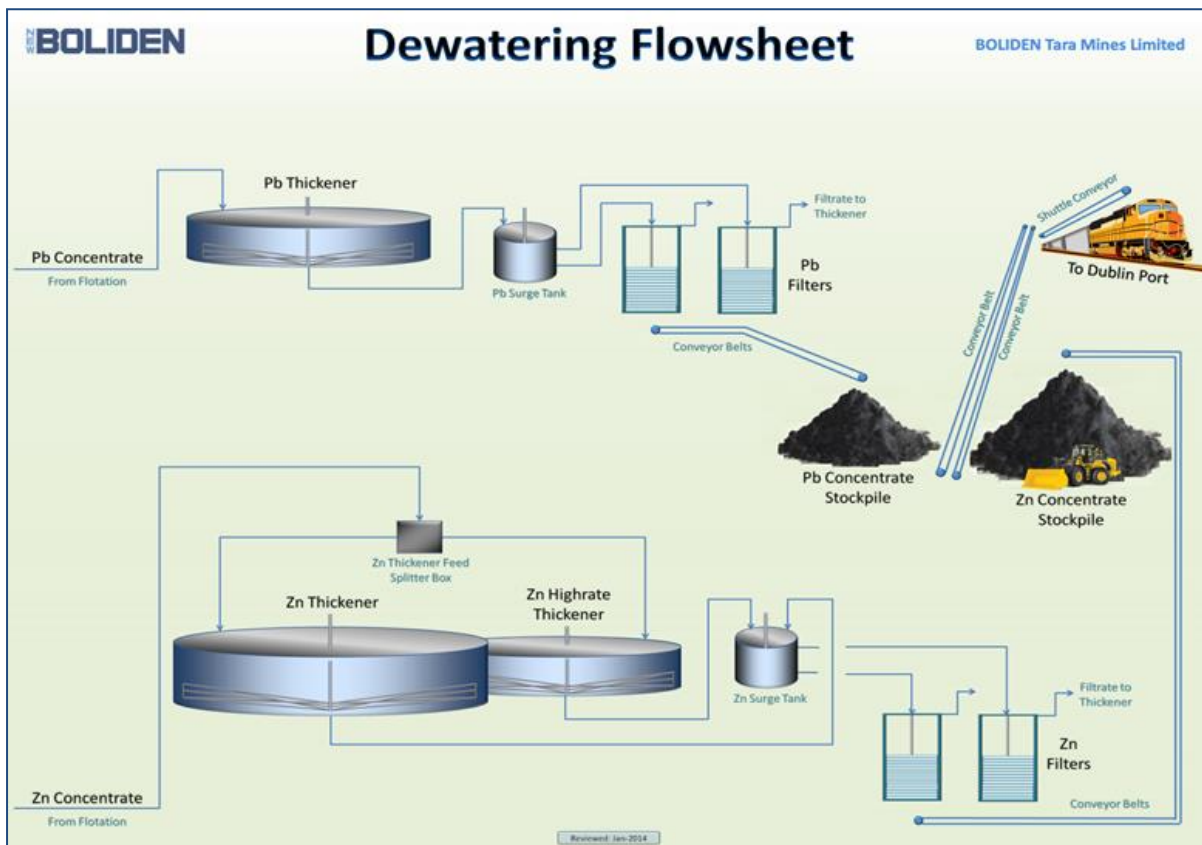


FIGURE 3.24 DEWATERING FLOW DIAGRAM

3.8.1.3 CONCENTRATE STORAGE

Following dewatering the residual moisture content is less than 9% for zinc concentrate and for 6% lead concentrate. The final products produced at the mine are Zinc concentrate (56% Zn by weight) and Lead concentrate (65% Pb by weight). This material is conveyed to a 30,000 tonne capacity storage building, where it is loaded onto 55 tonne train wagons for rail transport to Dublin. From Dublin the concentrate is shipped to various smelters in Europe.

The concentrate Loadout building has two air extraction points IPPC L Ref A2-3 and A2-4. The Loadout system was upgraded following the installation of the new zinc pressure filter drying system. As a result the larger ventilation stack (Emission Point Ref. A2 -3) has been de-commissioned. The smaller ventilation stack (Emission Point Ref. A2-4) only operates when train loading is in progress.

Concentrate is reclaimed from the storage pile by a front-end loader which feeds a conveyor system. Separate loading hoppers and conveyors are employed for the lead and zinc concentrates, but the shuttle conveyor is common to the two systems and incorporates a lid-lifter to handle the pressed-steel wagon covers. Each wagon stands on a rail-scale during loading, and the entire procedure is automated. Each train passes through an automated wagon washer before leaving the site prior to dispatch to Dublin Port. From time to time concentrate is transported by road to Drogheda using covered trucks, which are loaded inside the concentrate store and washed before leaving the site.

An on-site laboratory checks the quality of the ore and concentrates being produced. Annually the laboratory receives 25,000-30,000 samples on which quality control analyses are carried out.

3.8.2 EFFLUENT DISCHARGE

There are three sources of water that are considered process water. These are as follows:

- Water ingress to the mine that is pumped out to maintain a suitable dry working environment
- Surface run-off
- Water from processing plant.

Water from these three sources is collected, pumped and treated prior to discharge to the River Boyne at Emission Point Reference SW1.

All water from the process plant is pumped to the TSF. This water is recycled back to the reclaim pond in the mine site after suspended solids have settled at the TSF. Minewater and surface run-off, representing a low risk effluent are treated in the onsite water treatment system.

The water treatment system comprises three stages of clarification in sediment-aeration ponds prior to discharge to the River Boyne.

At present, all minewater is pumped and collected at a central underground pumping station. The water enters a large settling sump where suspended solids settle out. The water is pumped to the surface via rising pipework infrastructure within the production shaft.

The pumped water is directed from underground outfalls to a minewater pond, acting as a primary settlement pond. Overflow from this minewater pond decants by controlled overflow to a secondary stage of settlement/clarification in the Reclaim Water Ponds. Water from the Reclaim Water Pond decants, via a controlled overflow, to a Clear Water Pond (Discharge pond).

The discharge from the Clear Water Pond to the River Boyne is via a weir structure, which measures and controls the discharge. The rate of discharge from the Clear Water Pond is dictated by the flow in the River Boyne, as a minimum dilution rate of >100:1 is required under licence conditions.

An automatic hydrometric gauging station has been installed on the River Boyne. This gauging station provides a real time record of water levels and flow in the River Boyne. Discharge from the site is controlled based on River Boyne flows.

Discharge at SW2 is clean groundwater, derived from the Nevinstown mine area which has minimal or no contact with the orebody. This groundwater is collected in a dedicated reservoir and pumped directly

to surface for discharge to the River Blackwater. Discharge is recorded and controlled from the Processing Departments automated ABB system.

The water system supplies the Processing and Mining operations and also manages the significant intake of water from the underground workings. The process water at Tara is re-circulated and re-used in the underground mining and surface milling processes. Potable water from the Navan town urban supply network is used for canteens and other utilities. Surface rainwater from the mine site and tailings dam facilities is also collected and becomes part of the overall Tara water system.

Because of the recirculation system, Tara accumulates an excess of water (> 600 m³/h) which must be carefully managed. Retention of water is not possible over long periods as this may have an adverse effect on the operation of the tailings management facility. The excess water is discharged to the river Boyne under licence conditions. The discharged water flow and quality is continuously monitored and controlled to satisfy the conditions specified in the licence.

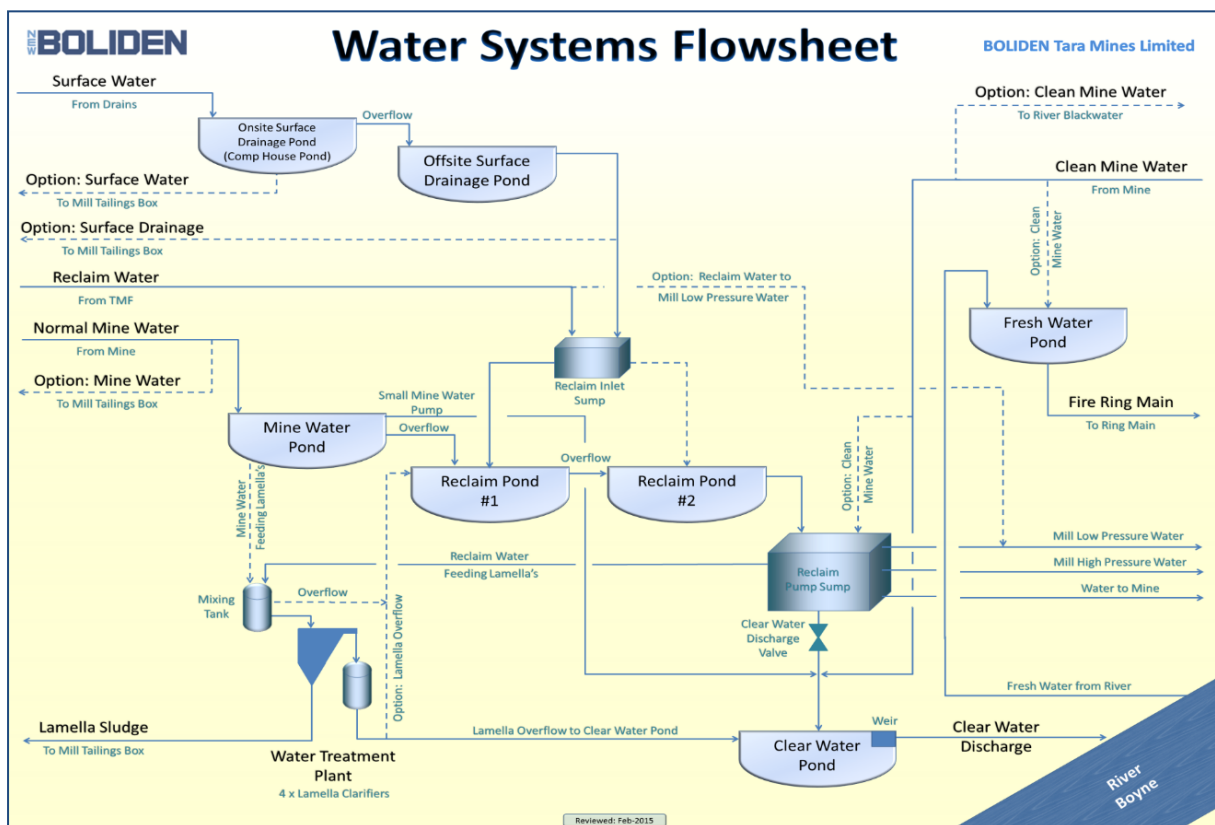


FIGURE 3.25 WATER SYSTEM FLOW DIAGRAM

3.8.1 TAILINGS MANAGEMENT

There are approximately 2M tonnes of ore remaining in the Nevinstown orebody that will be mined at an average rate of c.250k tonnes per annum.

The approx. 2 million tonnes of ore will yield c.340k tonnes of metal concentrates and c.1.65 million tonnes of tailings.

Of the 1.65 million tonnes of tailings sands produced, c. 750k tonnes will be returned underground as cemented backfill in the conventional manner. The remaining 910k tonnes will be placed in the tailings storage (TSF) facility at Randalstown.

There is sufficient storage capacity in the permitted TSF to accommodate the tailings from the Nevinstown ore. The TSF enables aeration to take place and allows suspended solids to settle out leaving clear water for recirculation and re-use in the processing plant.

The tailings storage facility has been the subject of an extensive EIA and planning process in the recent past and is not dealt with further in this assessment (planning reference is PL 17. 247707 (Meath Planning Ref NA /160408)).

4 BIODIVERSITY

4.1 INTRODUCTION

This report is a record of the flora and fauna present within the Nevinstown study area (Figure 4.1) and provides an assessment of the ecological status of the survey area.

Although there will be no surface infrastructure associated with the development, and thus no significant impact on the ecology of the Nevinstown survey area, it is located in an ecologically sensitive location. The River Blackwater, one of the primary components of the River Boyne and River Blackwater Special Area of Conservation and the River Boyne and River Blackwater Special Protection Area runs adjacent to the survey area (thus Appropriate Assessment of the proposal is required). This report, therefore, comments on the existing ecology of the survey site, and makes recommendations for the enhancement of the site as regards the biodiversity resource present.

There will be no additional surface infrastructure associated with this development. The necessary infrastructure, both underground and on surface, for its operation is already in place; including administration, mining and processing facilities, tailings storage capacity, ventilation, effluent discharge facilities and road/rail links to Dublin Port.

There will be no impacts on the surface of the Nevinstown survey site as regards biodiversity. The potential impacts of the proposed resumption of underground mining in the Nevinstown orebody on biodiversity concerns the cumulative impact of the full life-cycle of the ore extraction, processing and transport.

The potential impacts of the “full life-cycle” of the ore extraction, processing and transport, inclusive of cumulative impacts are examined in the Natura Impact Statement (NIS) accompanying this planning permission application.

The primary potential impact of the overall mining operation identified in the NIS is a potential for impacts on hydrology/water quality.

The EPA Guidelines as to the information to be contained in Environmental Impact Assessment Reports (2017) states that “...*The EIAR should avoid duplication of assessment ...A biodiversity section of an EIAR, for example, should not repeat the detailed assessment of potential effects on European sites contained in a Natura Impact Statement, but it should refer to the findings of that separate assessment...*”.

The comprehensive and detailed NIS, which clearly assesses the baseline environment and any potential impacts of the proposed development as regards the full life cycle of the ore extraction, processing and transport on the most sensitive ecological/biodiversity receptors within 15 km of the proposed development (and indeed within 15 km of the entire area for which the Industrial Emissions Licence applies) concludes:

“...there will be no risk of adverse effects on Qualifying Interest habitats or species, nor the attainment of specific conservation objectives, either alone or in-combination with other plans or projects, for the relevant Natura 2000 sites. The ecological integrity of the Natura 2000 sites concerned (connected with qualifying interests for which the sites have been designated) will not be significantly impacted...”

The NIS document stipulates the mitigation measures required, as per the EPA Guidelines (2017).

The location of the proposed development site is illustrated in Figures 4.1 and 4.2.



FIGURE 4.1 SITE LOCATION MAP



FIGURE 4.2 NEVINSTOWN STUDY AREA

The objectives of this flora and fauna survey are

- To survey the ecological habitats within the study area;
- To produce a habitat map for the study area to Fossitt Level 3;
- To highlight elements or particular areas of specific potential for biodiversity or conservation interest (including any as highlighted in the County Meath Biodiversity Action Plan);
- To identify the potential presence and effectiveness of ecological corridors and/or stepping stones within the study area, linking the study area to adjoining areas of potential biodiversity interest; and
- To assess and make recommendations on conservation priorities regarding the identified biodiversity resource of the site.

The comprehensive and detailed NIS submitted with the planning application, clearly assesses the baseline environment and any potential impacts of the proposed development as regards the full life cycle of the ore extraction, processing and transport on the most sensitive ecological/biodiversity receptors within 15 km of the proposed development (and indeed within 15 km of the entire area for which the Industrial Emissions Licence applies) is presented in a separate report (Natura Impact

Statement). Details regarding the potential impacts, mitigation measures, etc. as concerns the entire mining operation (cumulative impacts) are not repeated here in order to avoid unnecessary duplication of assessment as per “The EPA Guidelines as to the information to be contained in Environmental Impact Assessment Reports (2017)”

4.2 SURVEY METHODOLOGY

4.2.1 DESK STUDY

4.2.1.1 NPWS DATABASE

The primary body consulted with regard to matters involving ecology within the Republic of Ireland is the National Parks and Wildlife Service (NPWS). Its role is:

- To secure the conservation of a representative range of ecosystems and maintain and enhance populations of flora and fauna in Ireland;
- To implement the EU Habitats and Birds Directives;
- To designate and advise on the protection of Natural Heritage Areas (NHA) having particular regard to the need to consult with interested parties;
- To make the necessary arrangements for the implementation of National and EU legislation and policies and for the ratification and implementation of the range of international Conventions and Agreements relating to the natural heritage;
- To manage, maintain and develop State-owned National Parks and Nature Reserves.

The desk study as pertaining to this survey involved querying the NPWS database for information pertaining to habitats and species of conservation concern, in addition to designated sites (Special Areas of Conservation (SAC), Special Protection Areas (SPA), Natural Heritage Areas (NHA) and Proposed Natural Heritage Areas (pNHA)) occurring in the vicinity of the proposed development.

4.2.1.2 NBDC DATABASE

In addition to consulting the NPWS database, the National Biodiversity Data Centre Database was consulted regarding species of conservation concern recorded as occurring within the 2 km square in which the proposed development site is located.

4.2.1.3 COUNTY MEATH DEVELOPMENT AND NATIONAL/MEATH BIODIVERSITY ACTION PLANS

It is an objective (NH OBJ 1) of the 2013 – 2019 Meath County Development Plan to:

- “...Implement, in partnership with the Department of Arts, Heritage and the Gaeltacht, relevant stakeholders and the community, the objectives and actions of Actions for Biodiversity 2011 – 2016; Ireland’s National Biodiversity Plan that relate to the remit and functions of Meath County Council and the County Meath Biodiversity Plan and any revisions thereof...”

The National Biodiversity Action Plan (2011 – 2016) recommended, amongst other actions that:

- (1) Each local Authority to publish a Local Biodiversity Action Plan or review existing plans; and
- (2) Each local Authority designate a suitably qualified officer for natural heritage conservation matters in its area.

The primary function of the County Meath Biodiversity Action Plan is to;

“...provide a framework and series of actions to conserve, enhance and raise awareness of Meath’s rich biodiversity and to maximise the contribution that it makes to social, economic and environmental well-being of the county, taking into account local, national and international, including European priorities...”

As part of this desk study, the current Meath Biodiversity Action Plan was examined, and habitats of ecological value in a national and local context (as identified within the Meath Biodiversity Action Plan) were identified. Having been informed by field surveys, the desk study would make possible the recognition of any potential impacts on such habitats allowing potential impacts to be taken into account during the drawing up of mitigation measures.

4.2.2 SURVEY METHODOLOGY - FIELD SURVEYS

4.2.2.1 BOTANICAL/HABITAT SURVEYS

4.2.2.1.1 GENERAL VEGETATION SURVEYS

Field surveys of vegetation were carried out during July and August of 2017 by Dr Patrick Moran and Dr Emma Reeves, within the optimal timeframe for such surveys. Nomenclature follows “Webb’s An Irish Flora” (2012 – 8th Edn) and “Mosses and Liverworts of Britain and Ireland a Field Guide” (2010) The botanical and habitat survey consisted of walk-over surveys through the Nevinstown site. The surveys recorded all species of flora observed occurring within the study area. The botanical survey placed particular emphasis on rare, protected or annexed habitats/species by reference to -

- a) Irish Plant Red Data Book;
- b) Habitats listed on Annex I of the EU Habitats Directive;

- c) Species listed on Annex II of the EU Habitats Directive; and
- d) Ecological stepping stones and ecological corridors (as covered under Article 10 of the EU Habitats Directive).

In addition to a complete species list, written descriptions of all habitats within the receiving environment were recorded, to include the dominant species occurring within each habitat. Photographs of representative areas of each habitat are presented. An evaluation of the ecological significance of flora and habitats occurring within the site relative to surrounding habitats was also undertaken. A detailed hedgerow survey was undertaken based on the Hedgerow Appraisal System (Foulkes *et al* 2013).

4.2.2.1.2 SPECIES OF INVASIVE ALIEN PLANTS LISTED ON PART (1) OF THE THIRD SCHEDULE OF THE EC (BIRDS AND NATURAL HABITATS) REGULATIONS OF 2011

The human introduction of alien plant species into ecosystems (intentionally or unintentionally) is historically a common-place occurrence. The vast majority of these alien plant species, when introduced into a foreign ecosystem for which they are not adapted, will die without specific care. In a small number of cases, however, these plants can come to dominate the ecosystem into which they have been introduced and become “Invasive”. There is presently a great deal of concern regarding the potential for invasive plant species to threaten the species composition, community structure and overall biodiversity of native Irish habitats. Invasive species can change the character and/or condition of an ecosystem over an extensive area through several mechanisms, depending on the species of plant and the nature of the habitat. Given the location of the Nevinstown site, immediately adjacent to the River Blackwater, specific cognisance was given to the potential presence of Alien Invasive Plant Species within the survey area. There are more than 30 species on the Third Schedule of the European Communities (Birds and Natural Habitats) Regulations of 2011. Riparian systems are particularly vulnerable to plant invasions owing largely to the naturally high disturbance frequencies within riparian habitats and the rapidity with which an invasive can spread utilising the medium of flowing water. In addition, there has been an historic tendency for people to plant “ornamental” species beside water. As a result, the vast majority of the species listed on the Third Schedule are associated broadly with riparian systems, occurring within the water course, or proliferating along the bank (see Table 4.1).

Of the species listed in Part (1) of the Third Schedule, three species are of particular note owing to the location of the Nevinstown site and the potential for spread along the Rivers Blackwater and Boyne (these three species are known to occur within the River Boyne and River Blackwater SAC):

- Japanese Knotweed (*Fallopia Japonica*);

- Himalayan Balsam (*Impatiens glandulifera*); and
- Giant Hogweed (*Heracleum mantegazzianum*).

It is imperative that should any of these species be identified as occurring within the Nevinstown site that an Invasive Species Management and Control Plan is drawn up and implemented in order to completely eradicate any populations of these plants from the survey area.

TABLE 4.1: LIST OF PLANT SPECIES APPEARING ON THE THIRD SCHEDULE

Common Name	Latin Name	Associated with freshwater habitats
American skunk-cabbage	<i>Lysichiton americanus</i>	Yes
Red alga	<i>Grateloupia doryphora</i>	No
Brazilian giant-rhubarb	<i>Gunnera manicata</i>	Yes
Broad-leaved rush	<i>Juncus planifolius</i>	Yes
Cape pondweed	<i>Aponogeton distachyos</i>	Yes
Cord-grasses	<i>Spartina (all species hybrids)</i>	No
Curly waterweed	<i>Lagarosiphon major</i>	Yes
Dwarf eel-grass	<i>Zostera japonica</i>	No
Fanwort	<i>Cabomba caroliniana</i>	Yes
Floating pennywort	<i>Hydrocotyle ranunculoides</i>	Yes
Fringed water-lily	<i>Nymphoides peltata</i>	Yes
Giant hogweed	<i>Heracleum mantegazzianum</i>	Yes
Giant knotweed	<i>Fallopia sachalinensis</i>	Yes
Giant-rhubarb	<i>Gunnera tinctoria</i>	Yes
Giant salvinia	<i>Salvinia molesta</i>	Yes
Himalayan balsam	<i>Impatiens glandulifera</i>	Yes
Himalayan knotweed	<i>Persicaria wallichii</i>	Yes
Hottentot-fig	<i>Carpobrotus edulis</i>	No
Japanese knotweed	<i>Fallopia japonica</i>	Yes
Large-flowered waterweed	<i>Egeria densa</i>	Yes
Mile-a-minute weed	<i>Persicaria perfoliata</i>	Yes
New Zealand pigmyweed	<i>Crassula helmsii</i>	Yes
Parrot's feather	<i>Myriophyllum aquaticum</i>	Yes
Rhododendron	<i>Rhododendron ponticum</i>	No
Salmonberry	<i>Rubus spectabilis</i>	Yes
Sea-buckthorn	<i>Hippophae rhamnoides</i>	No
Spanish bluebell	<i>Hyacinthoides hispanica</i>	No
Three-cornered leek	<i>Allium triquetrum</i>	No
Wakame	<i>Undaria pinnatifida</i>	No
Water chestnut	<i>Trapa natans</i>	Yes
Water fern	<i>Azolla filiculoides</i>	Yes
Water lettuce	<i>Pistia stratiotes</i>	Yes
Water-primrose	<i>Ludwigia (all species)</i>	Yes
Waterweeds	<i>Elodea (all species)</i>	Yes
Wireweed	<i>Sargassum muticum</i>	Marine/transition

4.2.3 HABITAT MAPPING

Field maps were prepared utilising a base-map provided by Boliden Tara Mines Ltd and ESRI Digital Globe Satellite Imagery. Field maps were prepared prior to surveys, allowing the surveyor to mark pertinent information (habitat type, location of unusual species, etc.) on field maps. These field maps

were then utilised to generate a habitat map in ArcGIS 10.2. Habitat mapping was carried out based on “Best Practice Guidance for Habitat Survey and Mapping” (Smith *et al* 2011).

4.2.4 BIRD SURVEYS

4.2.4.1 GENERAL BIRD SURVEY – SUMMER BIRD SURVEYS

The breeding bird survey identifying evidence of breeding (such as chicks, egg-shells, etc.). Also, any species present during the surveys were, in line with the Precautionary Principle, presumed to be breeding at, or in the vicinity of the proposed development site. Bird Watch Ireland and the RSPB NI have agreed a list of priority bird species for conservation action on the island of Ireland. These Birds of Conservation Concern in Ireland are published in a list known as the BoCCI List. In this BoCCI List, birds are classified into three separate lists (Red, Amber and Green), based on the conservation status of the bird and hence conservation priority. The Red List birds are of high conservation concern, the Amber List birds are of medium conservation concern and the Green List birds are not considered threatened.

Bird surveys were carried on 25th and 31st of July 2017 utilising transects through the study area following a modified common bird census or Brown & Shepherd survey. Transects were walked at a slow pace, with all bird species observed noted and recorded. Where any indications of breeding (juvenile birds, eggs, nest remains, etc.) were observed, they were recorded.

The purpose of bird surveys was to:

- Record any priority species (Annex I, Red or Amber listed) occurring within or adjacent to the proposed development site during the survey period (July/August), which were assumed to be breeding populations; and
- Identify any areas of habitat of particular interest with regard to avian biodiversity.

4.2.4.2 KINGFISHER SURVEY

The importance of the biodiversity of Ireland’s waterways is reflected in the designation of many of our waterways under the Birds and Habitats Directives. A number of species of European significance occur on our waterways including the Kingfisher (*Alcedo atthis*), which is listed on Annex I of the EU Birds Directive. In 2010 (Cummins *et al*), six major river systems - the Rivers Barrow, Blackwater (Munster), Boyne, Clare, Moy and Nore (in addition to two smaller systems, the Rivers Gill and Illen) – were surveyed in order to assess the distribution and abundance of Kingfisher in representative

habitats throughout Ireland. Kingfisher were recorded on all river systems surveyed. Given the location of the survey area adjacent/within a Special Protection Area designated for Kingfisher (River Boyne and River Blackwater SPA), a Kingfisher survey was carried out along the riparian habitat present within the survey area. Kingfisher are known to occur along this stretch of the Blackwater. The primary goal of Kingfisher surveys was:

- (1) To identify if suitable habitat for nesting Kingfisher exists within the site; and
- (2) To note any indications of foraging Kingfisher within the survey areas.

Kingfisher surveys were carried out on the 31st of July and the 9th of August 2017, under optimal conditions (clear visibility, no rain, no wind), based on the methodology as presented in “Assessment of the distribution and abundance of Kingfisher *Alcedo atthis* and other riparian birds on six SAC river systems in Ireland” (Cummins *et al*, 2010) – which was prepared by Birdwatch Ireland for the NPWS.

4.2.4.3 (BREEDING) WADER SURVEY (LAPWING, CURLEW, REDSHANK, ETC.)

In tandem with the general bird survey, a (breeding) wader survey was carried out at the site (it was too late in the season to carry out a breeding wader survey, but presence of waders such as Lapwing, Curlew or Redshank on site would be indicative of possible breeding). These surveys were based on the methodology being utilised for the 2015 National breeding Curlew Survey.

4.2.4.4 RAPTORS

It was deemed that a dedicated raptor survey of the site was not required owing to the habitats present (almost entirely GA1, Improved Agricultural Grassland). Raptors observed during the bird surveys were noted.

4.2.5 MAMMAL SURVEYS

4.2.5.1 GENERAL MAMMAL SURVEY (INCLUDING BADGER)

General mammal surveys were carried out in August of 2017. Surveys included surveys of the Nevinstown site through direct observations (seeing the animal), observation of faeces, prey remains, shelters, hair, etc. and the deployment of three trail cameras (see Figure 4.4.3) along wildlife trails observed during field surveys. These trail cameras are equipped with an infrared flash, enabling the capture of both still and video footage at night without being detected. A comprehensive survey of hedgerows and associated banks for indications of Badger setts was carried out. Trail cameras were deployed between the 9th and 16th of August 2017 at the indicated locations.

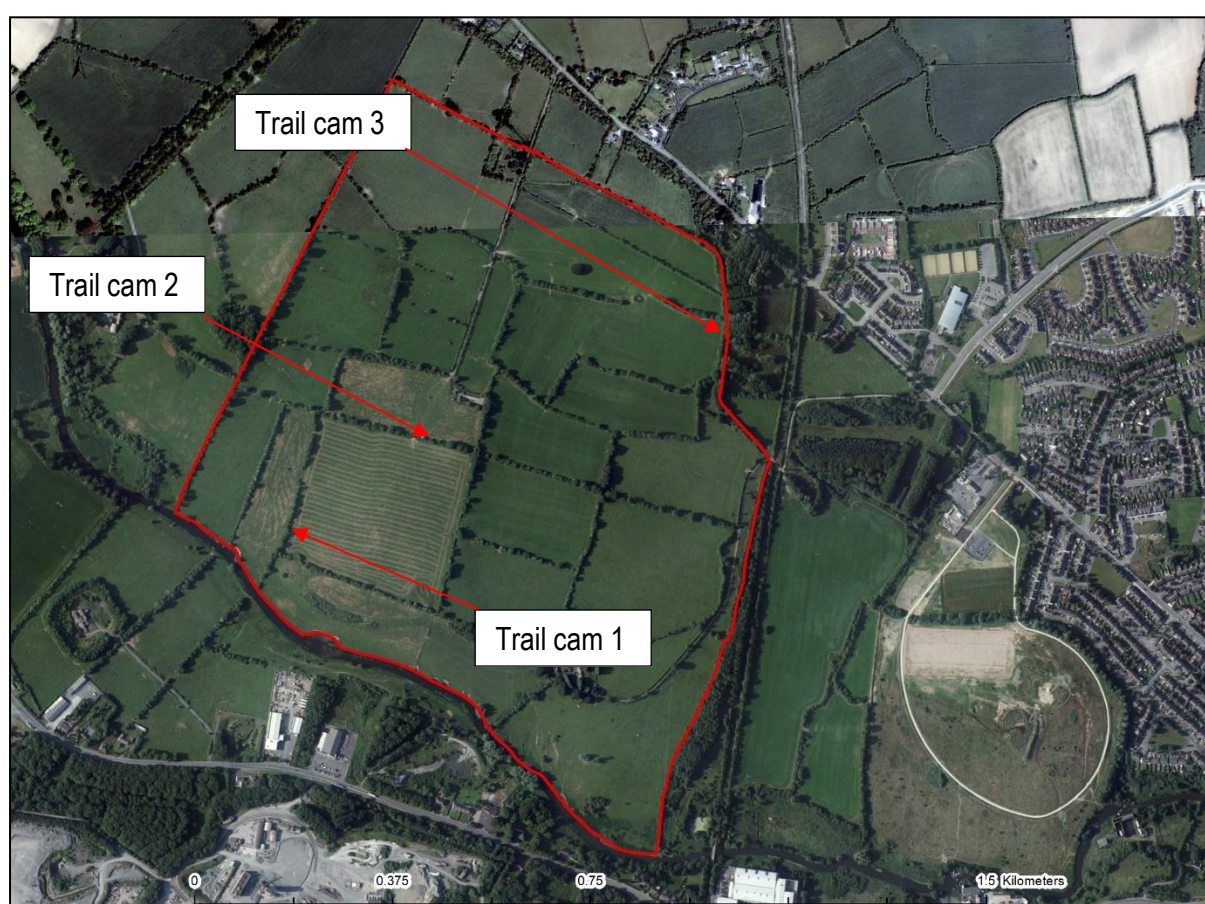


FIGURE 4.3 LOCATIONS OF DEPLOYED TRAIL CAMERAS

4.2.5.2 OTTER SURVEY

Otter (*Lutra lutra*) is a primarily piscivorous species, depending largely on salmonids but also consuming frogs, crayfish, etc. Otter surveys were carried out in tandem with Kingfisher surveys on the 31st of July and under optimal conditions based on the methodology as presented by NPWS in the Irish Wildlife Manual 76 (National Otter Survey of Ireland 2010/12 – Reid *et al.*, 2013), with a survey being carried out for spraints (but also recording other signs, such as footprints, fish remains, slides, etc.) along the transect.

4.2.5.3 BAT SURVEYS - SUMMER

Bat surveys were carried out during the August 2017 utilising two Pettersson D500x Ultrasound recording units. These units are ultrasound recording units, intended for long-term recording of bat calls. The triggering system allows the device to start recording as a sound is detected. The D500X detects the full spectrum of ultrasound and records in real time. It provides much more detailed data than either frequency division or time expansion detectors. The D500x unit was pre-programmed to record all bat-passes occurring during the period between 30 minutes before sunset and 30 minutes after sunrise throughout the survey periods. The unit is powered by an external battery, with 128 GB of internal memory, which is more than sufficient to allow unbroken surveying of all bat activity during the survey period.

Following an initial day-time survey on the 9th of August 2017, two Pettersson D500x units were deployed, one along the River Blackwater and one roughly in the centre of the footprint of the survey area to assess the level of activity of bats within the survey area. Activity at these locations was recorded between the 9th of August and the 16th of August. The locations of the monitors are illustrated in figure 4.4.

4.2.5.4 BAT SURVEY – VACINITY OF MINE ENTRANCE

In addition, following a request for Further Information in December 2017, any potential use of the Nevinstown area of the mine itself (underground) by bats for roosting purposes was assessed during the period 24th to 30th April 2018. This survey was undertaken to establish if any bat activity occurred within the Nevinstown area of the mine itself. This was considered very highly unlikely, as the entrance to the mine is approximately 1 km from the Nevinstown area (underground) and any bats choosing to roost this far under-ground would waste a very significant amount of energy “light sensing” bck and

forth between the roosting site and the entrance to the mine. In addition, constant disturbance (noise and light) underground makes it highly unlikely that any bats would roost within the mine. A Pettersson D500x unit was placed at the mine entrance to record any bat activity between the 24th and the 30th of April (the optimal time for detecting increases in bat activity around hibernation roosts).



FIGURE 4.4 MAP IDENTIFYING LOCATIONS OF PETERSSON D500X UNITS



Plate 4.1 Mine entrance



Plate 4.2 Placement of Pettersson at mine entrance, with microphone directed down the mineshaft to detect any bats emerging

4.2.6 OTHER SPECIES OF CONSERVATION CONCERN

4.2.6.1 WHITE-CLAWED CRAYFISH

The White-clawed Crayfish is the only crayfish species (currently known to be) found in Ireland. It is classified as vulnerable and rare in the IUCN Red List of threatened animals and listed under Annex II of the EU Habitats Directive. Ireland is now thought to hold some of the best European stocks of this species, under least threat from external factors (Reynolds 1998). Habitat requirements are good water quality (above 50% oxygen saturation, BOD below 3 ppm) and moderate summer water temperatures (below 20°C). Of note, while they may tolerate disturbance to a certain extent, they are sensitive to acidity and heavy metals. Apart from the River Blackwater itself, there is largely an absence of suitable freshwater habitat occurring within the Nevinstown Survey Area, with only one small water course/drain containing water present during the period of the surveys.

This is reflected in the NBDC records for this species downstream of the Knockumber facility (see Figure 4.5).

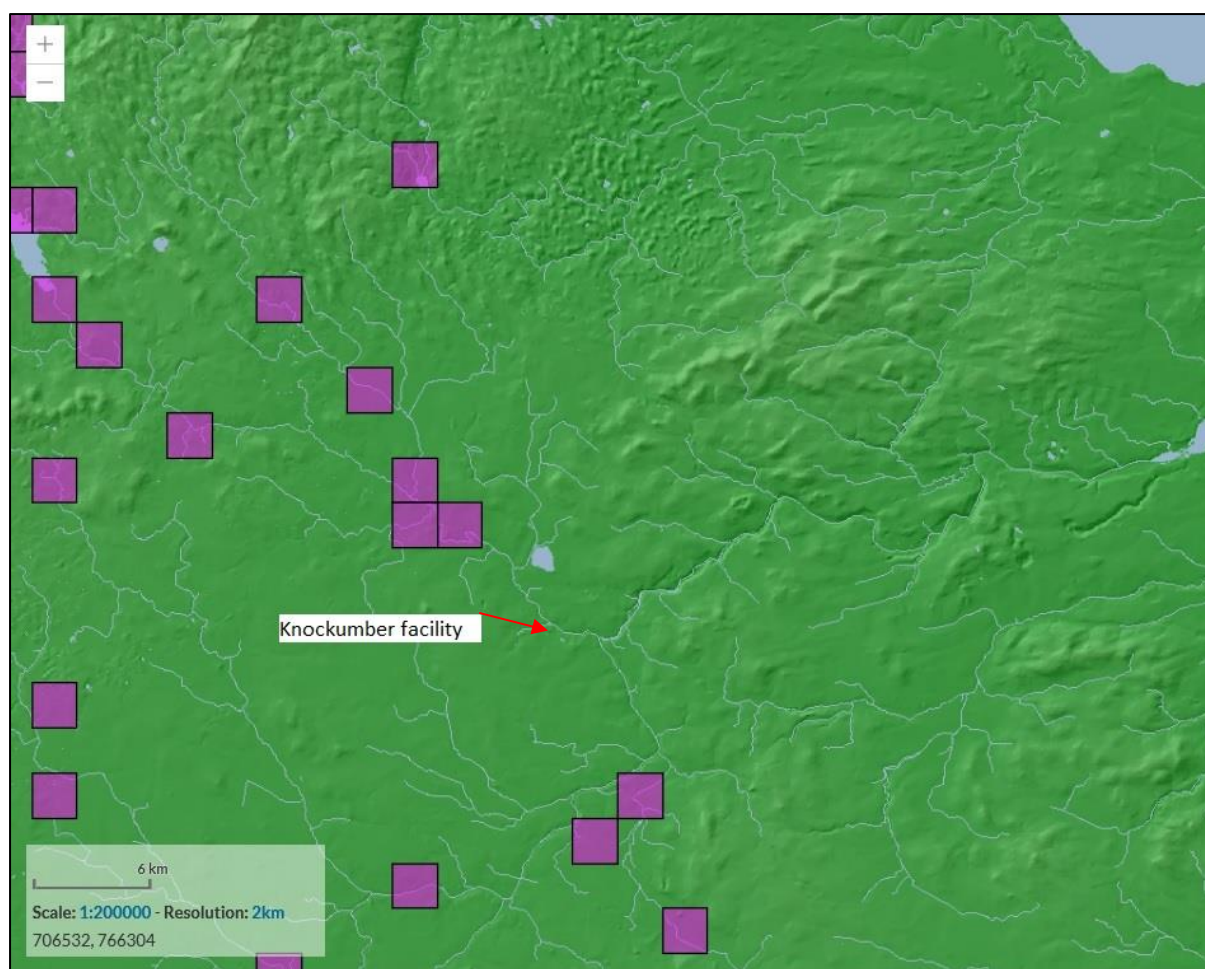


FIGURE 4.5 RECORDS OF *AUSTROPOTAMOBIOUS PALLIPES* IN THE VICINITY OF THE MINING OPERATION (NBDC)

4.2.6.2 COMMON FROG AND SMOOTH NEWT

The Common Frog (*Rana temporaria*) is described in the Ireland Red List No.5 as “...*adaptable species with broad range of habitats used ... Have adapted well to garden ponds in UK. Spawns in early spring and then spends rest of the year on land..... Hibernates, typically from November to February. Tadpoles, young frogs and adult frogs all subject to significant levels of predation and populations subject to local booms and declines...*”. A small, ephemeral population of Common Frog is considered likely to occur within Nevinstown, as this species is ubiquitous in suitable habitat from time to time. Given the nature of water courses/bodies within the survey area, the habitat is not suitable for breeding frogs.

The Smooth Newt (*Lisotriton vulgaris*) is described in the Ireland Red List No. 5 as “...*Breeds in ponds and still water ditches where pH >5. Shows preference for vegetated water bodies with surrounding*

terrestrial habitats that provide cover for foraging and hibernation ...Eggs are laid individually, rather than in clumps or strings, leading to protracted breeding season (March July) during which adults remain in breeding ponds ... Egg and tadpole development is temperature dependent. Forage on land for invertebrate prey July to October. Hibernate November – February...”. The habitat occurring within the Nevinstown site is largely unsuitable for this species. No specific surveys for this species were carried out owing to the unsuitability of the habitat present. The findings of the 2010 – 2014 Newt Survey does indicate that this species occurs in the vicinity in suitable habitat (see Figure 4.6).

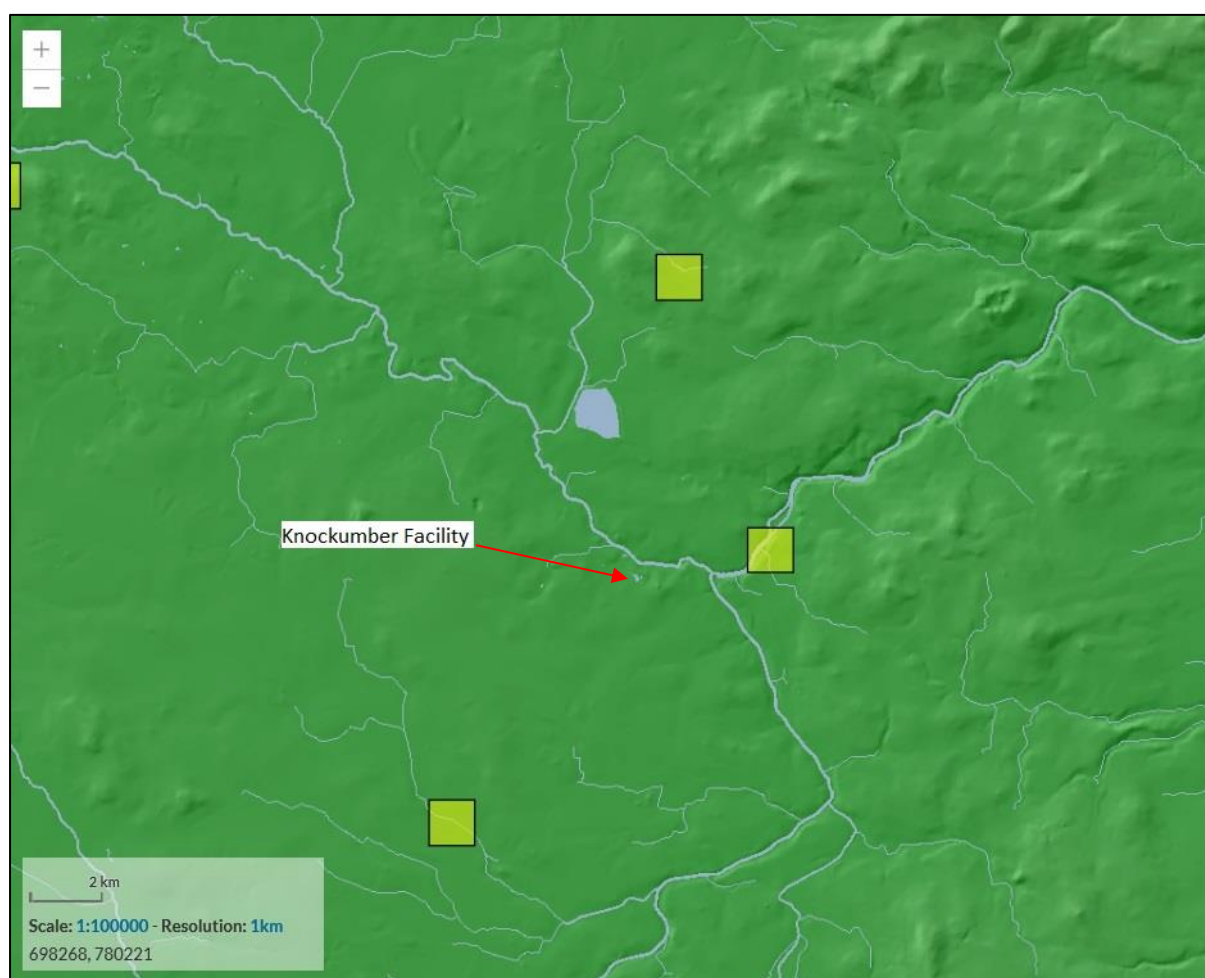


FIGURE 4.6 RECORDS OF *LISOTRITON VULGARIS* IN THE VICINITY OF THE MINING OPERATION (NBDC)

4.2.6.3 COMMON LIZARD

The Common Lizard (*Lacerta vivipara*) is described in the Ireland Red List No. 5 as “...Long active season in Ireland with emergence from hibernation as early as the first week in March and autumn records as late as the end of October.... Associated with coastal and heathland habitats, but also locally in rural gardens, stone walls and roadside verges ... Needs good habitat structure with open patches for basking and foraging and areas of cover for protection from predators Feeds on a wide

range of invertebrates...". The habitat currently occurring within Nevinstown is suitable and having identified suitable basking areas during initial walk over surveys, these areas were examined for the presence of basking Common Lizard on the morning of July 31st, 2017.

4.2.7 GIS

Habitat mapping was achieved utilising standard methodologies and according to best practice (Smith *et al* 2011). Habitats having been identified and surveyed from field maps, field maps were digitised, using the OSI 1:5000 vector base-map (as provided in DWG format by Boliden Tara Mines Ltd). Habitats were mapped as polygons or lines.

4.3 RESULTS – DESK STUDY

4.3.1 NATIONAL PARKS AND WILDLIFE SERVICE DATABASE

This section of the desk study primarily involved the consultation of the NPWS data-base, which is publicly accessible. A GIS-based analysis of sites designated for conservation interests (Special Area of Conservation (SAC), Special Protection Area (SPA), Natural Heritage Area (NHA) and Proposed Natural Heritage Area (pNHA)) occurring within 5 km of the Nevinstown site was carried out. There are no NHAs or pNHAs occurring within 5 km of the proposed development site. There is one site designated as a SAC (River Boyne and River Blackwater SAC), one site designated as a SPA (River Boyne and River Blackwater SPA) and one site designated as a pNHA (Boyne Woods) occurring within 5 km of the proposed development. Of note, there is a section of the Nevinstown site within the River Boyne and River Blackwater SAC. Maps indicating the location of these designated sites are indicated in **Error! Reference source not found.**, **Error! Reference source not found.**, and **Error! Reference source not found.**4.9. The proximity of the proposed development to these Natura 2000 sites, and the presence of a S-P-R linkage indicates that Appropriate Assessment of the proposed development is required.



FIGURE 4.7 LOCATION OF NEVINSTOWN STUDY AREA RELATIVE TO SACs



FIGURE 4.8 LOCATION OF NEVINSTOWN STUDY AREA RELATIVE TO SPAS

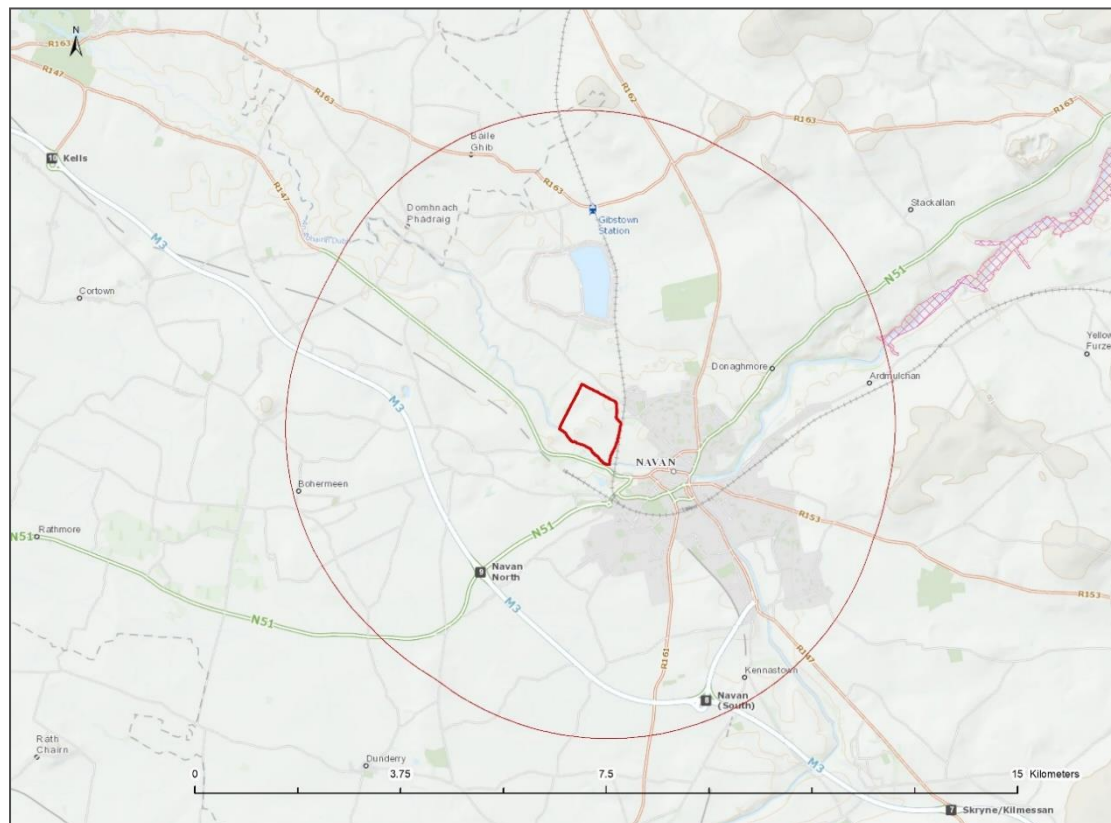


FIGURE 4.9 LOCATION OF NEVINSTOWN STUDY AREA RELATIVE TO PNHAS

A description of the two Natura 2000 sites is provided overleaf, based primarily on the Natura 2000 form for each site (including information regarding qualifying interests, threats/vulnerabilities and the conservation status of the individual sites). Much of this information is presented in tabular form with specific codes. For readers unfamiliar with these codes, they are available from http://bd.eionet.europa.eu/activities/Natura_2000/reference_portal. There is also presented information regarding the conservation status of qualifying interests (of SACs) on a national scale – this information is sourced from the 2013 publication (NPWS) “The Status of EU Protected Habitats and Species in Ireland”.

River Boyne and River Blackwater SAC – site code 002299

This site comprises most of the freshwater element of the River Boyne from upriver of the Boyne Aqueduct at Drogheda, the Blackwater River as far as Lough Ramor and the principal Boyne tributaries, notably the Deel, Stoneyford and Tremblestown Rivers. This system drains a considerable area of Counties Meath and Westmeath and smaller areas of Cavan and Louth. The underlying geology is Carboniferous Limestone for the most part with areas of Upper, Lower and Middle well represented. In the vicinity of Kells Silurian Quartzite is present while close to Trim are Carboniferous Shales and Sandstones. The rivers flow through a landscape dominated by intensive agriculture, mostly of improved grassland but also cereals. Much of the river channels were subject to arterial drainage schemes in the past. Natural flood-plains now exist along only limited stretches of river, though often there is a fringe of reed swamp, freshwater marsh, wet grassland or deciduous wet woodland. Along some parts, notably between Drogheda and Slane, are stands of tall, mature mixed woodland. Substantial areas of improved grassland and arable land are included in site for water quality reasons. There are many medium to large sized towns adjacent to but not within the site.

The main channel of the Boyne contains a good example of alluvial woodland of the *Salicetum albo-fragilis* type which has developed on three alluvium islands. Alkaline fen vegetation is well represented at Lough Shesk, where there is a very fine example of habitat succession from open water to raised bog. The Boyne and its tributaries is one of Ireland's premier game fisheries and offers a wide range of angling, from fishing for spring salmon and grilse to sea trout fishing and extensive brown trout fishing. The site is one of the most important in eastern Ireland for *Salmo salar* and has very extensive spawning grounds. The

site also has an important population of *Lampetra fluviatilis*, though the distribution or abundance of this species is not well known. *Lutra lutra* is widespread throughout the site. Some of the grassland areas along the Boyne and Blackwater are used by a nationally important winter flock of *Cygnus cygnus*. Several Red Data Book plants occur within the site, with *Pyrola rotundifolia*, *Poa palustris* and *Juncus compressus*. Also occurring are a number of Red Data Book animals, notably *Meles meles*, *Martes martes* and *Rana temporaria*. The River Boyne is a designated Salmonid Water under the EU Freshwater Fish Directive.

A synopsis of the threats and pressures associated with the site (as indicated in the Natura 2000 form) is presented in TABLE 4.2.

TABLE 4.2: IMPACTS AND ACTIVITIES WITH HIGH IMPACT ON THIS SITE

Negative Impacts				Positive Impacts			
Rank	Threats and pressures [code]	Pollution (optional) [code]	inside/outside [i o b]	Rank	Activities, management [code]	Pollution (optional) [code]	inside/outside [i o b]
H	A04		i	H	F02.03		i
H	B		i	M	G01.02		i
M	J02		i	M	G01.01		i
H	A01		o				
H	A08		i				
H	A08		o				
H	A01		i				
H	F02.03		i				
M	G01.01		i				
M	B		o				
M	E03		i				
H	E01.03		o				
H	E01		o				
H	D01.02		i				
H	A04		o				
H	D01.02		o				
M	G01.02		i				

Rank: H = high, M = medium, L = low

The primary conservation objective of this site is to maintain or restore the favourable conservation condition of the Annex I habitat(s) and/or the Annex II species for which the SAC has been selected:

[7230] Alkaline Fens

Alkaline fens are typically calcareous basin or flush fen systems with extensive areas of species-rich small sedge communities. These fen systems are often a complex mosaic of habitats, with co-occurring tall sedge beds, reedbeds, wet grasslands, springs and open-water. The habitat is characterised by a broad range of small to medium *Carex* spp., carpets of brown mosses and high species diversity

including black bog-rush (*Schoenus nigricans*), blunt-flowered rush (*Juncus subnodulosus*), devil's bit scabious (*Succisa pratensis*), hemp agrimony (*Eupatorium cannabinum*) and purple moor-grass (*Molinia caerulea*). This habitat requires a high water table, a calcareous, low nutrient water supply and minimal water level fluctuation. Low intensity mowing and/or grazing are also very important for maintaining species richness. In Ireland, the most extensive areas of alkaline fens are thought to occur in lowland basins underlain by limestone groundwater bodies with a karstic or poorly productive flow regime. Alkaline fens within upland and lowland flushes, along the fringes of calcareous lakes (e.g. Lough Corrib) and within turloughs, dune slacks and machair are thought to be more limited in local extent but more widespread. The current distribution and range maps provide a more refined estimate of the national habitat extent since 2007, but further survey is needed. Some losses of fen habitat are considered to have occurred since the Directive came into force, though the magnitude of the loss is unknown. The main pressures were identified as peat extraction, wetland reclamation and infilling. Wetland habitats are afforded additional protection under recent Agriculture Environmental Impact Assessment Regulations, however the Overall Status is considered to be Bad due to the pressures outlined; the overall trend is Unknown due to the absence of a national survey for this habitat.

[91EO] Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (*Alno-Padion*, *Alnion incanae*, *Salicion albae*)

Riparian forests of ash (*Fraxinus excelsior*) and alder (*Alnus glutinosa*) occurs on heavy soils which are periodically inundated by the annual rise of river levels, but which are otherwise well drained and aerated during low water. The herbaceous layer includes many tall species such as remote sedge (*Carex remota*), gypsywort (*Lycopus europaeus*), common nettle (*Urtica dioica*) and water avens (*Geum rivale*). In addition, there are gallery forests of tall willows alongside river channels and occasionally on river islands, where the tree roots are almost continuously submerged. They are dominated by white willow (*Salix alba*), common osier (*S. viminalis*) and almond willow (*S. triandra*), sometimes with grey willow (*S. cinerea*) but alder is relatively rare. This habitat has suffered considerable historic losses and is highly fragmented. Non-native and invasive species especially sycamore (*Acer pseudoplatanus*) and beech (*Fagus sylvatica*), and problematic native species such as bramble (*Rubus fruticosus*) and common nettle (*Urtica dioica*) (a consequence of under grazing) are regarded as the main pressures impacting this habitat. The Overall Status is assessed as Bad due to these ongoing pressures and highly fragmented nature of this habitat. There have been national efforts to remove non-native and invasive plant species reinstate correct hydrological regimes and generally to improve the conservation status of alluvial woodlands. Some substantial areas have been rehabilitated, and this is the main reason for the improving trend reported since the 2007 assessment.

[1099] *Lampetra fluviatilis*

The river lamprey (*Lampetra fluviatilis*) breeds in freshwater rivers and streams. Adults spawn in spring, excavating shallow nests in gravels and stones. After hatching, the larvae called ammocoetes drift or swim downstream to areas of river bed with a fine silt composition. They burrow into this bed material and live as filter feeders over a period of years before transforming into young adult fish. As adults they are parasitic, attaching to and feeding on larger fish in coastal waters. They can grow to 30cm at maturity at which stage they re-enter freshwater to spawn. The adult fish die after spawning. River and brook lamprey are indistinguishable as larvae, living as filter feeders in sediment. The mature adult forms are clearly distinguishable on the basis of body size. The two types of lamprey are considered by many in the same context as the brown trout / sea trout pairing, with a similar absence of genetic discriminators. Lamprey surveys in Ireland have necessarily focussed on juvenile lamprey. Consequently, the vast majority of available data relates to “*Lampetra* sp.” and cannot be assigned to one species or the other. For the above reasons the brook lamprey and the river lamprey are assessed jointly. There are extensive areas of suitable habitat and no significant pressures impacting these species. The Overall Status is therefore assessed as Favourable.

[1106] *Salmo salar*

The range of the Atlantic salmon (*Salmo salar*) extends in an arc from northern Portugal in the east, to New England, United States in the west. Salmon use rivers to reproduce and as nursery areas. Eggs are deposited during the winter in a depression, called a redd, excavated in river gravels. The eggs develop protected within the substrate and during spring hatch into alevins, which in turn develop into fry. The fry feed for the summer and over the autumn, gradually becoming parr. Fry and parr feed primarily upon invertebrates. The Irish population generally comprises fish that spend two winters (small numbers spend one or three winters) in freshwater before going to sea, in spring, as smolts at around 10-25cm in length. Adults spend one to three years at sea where growth rates are much greater. They feed upon crustaceans and fish (e.g. capelin and sandeels) as they migrate to feeding grounds in the North Atlantic. The majority of Irish fish spend one winter at sea before returning to their natal rivers, mainly during the summer, as grilse. Smaller numbers spend two or even three winters at sea, returning mainly in spring, hence “spring” salmon. There has been a recent stabilisation of the numbers of salmon spawning in Ireland and an increasing number of salmon rivers meeting their conservation limits, however low rates of marine survival are of concern. Different units were used to measure population size in 2007; there is no genuine change in the overall population estimate. There are numerous threats to the freshwater habitat and vigilance is required to ensure the maintenance of good

quality habitat which salmon require to thrive. The salmon population is still low in comparison to previous decades and so, in the absence of a recovery, the Overall Status is assessed as Inadequate.

[1355] *Lutra lutra*

Dramatic declines, leading in some cases to extinctions, occurred in many European otter (*Lutra lutra*) populations during the latter half of the 20th Century, however, Ireland has remained a stronghold for the species. Otters have two basic requirements: aquatic prey and safe refuges where they can rest. In Ireland, otter populations are found along rivers, lakes and coasts, where fish and other prey are abundant, and where the bank-side habitat offers plenty of cover. The otter is an opportunistic predator with a broad and varied diet. In coastal areas fish, crabs and molluscs are known to be eaten. In freshwater areas a variety of fish from sticklebacks to salmon and eels will be taken, while crayfish and frogs can be important locally or seasonally. The main threats to the otter include habitat destruction (including river drainage and the clearance of bank-side vegetation); pollution, particularly organic pollution resulting in fish kills; and accidental deaths (road traffic and fishing gear). The otter is currently widespread throughout Ireland and present in a wide variety of habitat types. Previous concerns about population decline have been allayed and the latest estimate puts the population at approximately 15-20,000 animals. Therefore, the Overall Status is assessed as Favourable.

A synopsis of the conservation status of this site is provided in TABLE 4.3 AND 4.4

TABLE 4.3: CONSERVATION ASSESSMENT OF ANNEX I HABITAT OCCURRING AT THE SITE

Annex I Habitat types						Site assessment			
Code	PF	NP	Cover [ha]	Cave [number]	Data quality	A B C D	A B C		
						Representativity	Relative Surface	Conservation	Global
7230			23.21		M	B	C	B	B
91E0			23.21		M	B	B	B	B

TABLE 4.4: SPECIES REFERRED TO IN ARTICLE 4 OF DIRECTIVE 2009/147/EC AND LISTED IN ANNEX II OF DIRECTIVE 92/43/EEC AND SITE EVALUATION FOR THEM

Species			Population in the site							Site assessment				
G	Code	Scientific Name	S	NP	T	Size		Unit	Cat.	D.qual.	A B C D	A B C		
						Min	Max				Pop.	Con.	Iso.	Glo.
B	A038	Cygnus cygnus			w	50	200	i		G	C	B	C	B
F	1099	Lampetra fluviatilis			r				P	M	C	B	C	B
M	1355	Lutra lutra			p				P	M	C	A	C	A
F	1106	Salmo salar			r				C	M	C	B	C	B

River Boyne and River Blackwater SPA – site code 004232

The River Boyne and River Blackwater SPA is a long linear site that comprises stretches of the River Boyne and several of its tributaries: most of the site is in Co Meath but it extends also into Counties Cavan, Louth and Westmeath. It includes the following river sections: The River Boyne from the M1 motorway bridge, west of Drogheda, to the junction with the Royal Canal, west of Longwood, Co Meath; the River Blackwater from its junction with the River Boyne in Navan to the junction with Lough Ramor in Co Cavan; the Tremblestown River (and Athboy River) from the junction with the River Boyne at Kilnagross Bridge to the bridge in Athboy, Co Meath; the Stoneyford River from its junction with the River Boyne to Stonestone Bridge in Co. Westmeath; the River Deel from its junction with the River Boyne to Cummer Bridge, Co. Westmeath. The site includes the river channel and marginal vegetation. The River Boyne and River Blackwater SPA supports nationally important numbers of *Alcedo atthis*.

Other species which occur within the site include *Cygnus olor*, *Anas crecca*, *Anas platyrhynchos*, *Phalacrocorax carbo*, *Ardea cinerea*, *Gallinula chloropus*, *Gallinago gallinago* and *Riparia riparia*.

A synopsis of the threats and pressures associated with the site (as indicated in the Natura 2000 form) is presented in Table 4.5.

TABLE 4.5: IMPACTS AND ACTIVITIES WITH HIGH IMPACT ON THIS SITE

Negative Impacts				Positive Impacts			
Rank	Threats and pressures [code]	Pollution (optional) [code]	inside/outside [i o b]	Rank	Activities, management [code]	Pollution (optional) [code]	inside/outside [i o b]
H	D01.02		o	L	X		i
M	J02		i				
H	D01.02		i				
H	E01		o				
H	E01.03		o				

Rank: H = high, M = medium, L = low
 Pollution: N = Nitrogen input, P = Phosphor/Phosphate input, A = Acid input/acidification, T = toxic inorganic chemicals, O = toxic organic chemicals, X = Mixed pollutions
 i = inside, o = outside, b = both

The primary conservation objective of this site is to maintain or restore the favourable conservation condition of the bird species listed as Special Conservation Interests for this SPA:

- Kingfisher (*Alcedo atthis*)

A synopsis of the conservation status of this site is provided in TABLE 4.6.

TABLE 4.6: SPECIES REFERRED TO IN ARTICLE 4 OF DIRECTIVE 2009/147/EC AND LISTED IN ANNEX II OF DIRECTIVE 92/43/EEC AND SITE EVALUATION FOR THEM

Species			Population in the site							Site assessment				
G	Code	Scientific Name	S	NP	T	Size		Unit	Cat.	D.qual.	A B C D		A B C	
						Min	Max				Pop.	Con.	Iso.	Glo.
B	A229	Alcedo atthis			r	19	19	p		G	C	B	C	B
B	A052	Anas crecca			w	166	166	i		G	C	B	C	C
B	A053	Anas platyrhynchos			w	219	219	i		G	C	B	C	C
B	A028	Ardea cinerea			w	44	44	i		G	C	B	C	C
B	A017	Phalacrocorax carbo			w	36	36	i		G	C	B	C	C

Boyne Woods pNHA – site code 001592

There does not appear to be a site synopsis document regarding the Boyne Woods pNHA within the NPWS pNHA site synopsis portfolio. This site is approximately 172 Ha in size, and is located just under 5 km from the Nevinstown survey area.

4.3.2 NBDC DATABASE

The NBDC database was accessed on 05/09/17 to query records from within the 2 km grid square in which the survey area is located (N86P). The species of conservation concern as recorded within this 2km grid square are illustrated in **Error! Reference source not found.** Of note, *Austropotamobius pallipes*, *Lisotriton vulgaris*, *Rana temporaria* and *Lacerta vivipara* are not included in this list.

TABLE 4.7: SPECIES RECORDED WITHIN N86P, WITHIN WHICH THE SURVEY AREA OCCURS

Scientific name	Common name
<i>Actitis hypoleucos</i>	Common Sandpiper
<i>Alcedo atthis</i>	Common Kingfisher
<i>Anas platyrhynchos</i>	Mallard
<i>Ardea cinerea</i>	Grey Heron
<i>Buteo buteo</i>	Common Buzzard
<i>Carduelis cabaret</i>	Lesser Redpoll
<i>Carduelis carduelis</i>	European Goldfinch
<i>Certhia familiaris</i>	Eurasian Treecreeper
<i>Columba oenas</i>	Stock Pigeon
<i>Cygnus olor</i>	Mute Swan
<i>Emberiza schoeniclus</i>	Reed Bunting
<i>Gallinula chloropus</i>	Common Moorhen
<i>Hirundo rustica</i>	Barn Swallow
<i>Phasianus colchicus</i>	Common Pheasant
<i>Pyrrhula pyrrhula</i>	Common Bullfinch
<i>Riparia riparia</i>	Sand Martin
<i>Saxicola torquata</i>	Stonechat
<i>Vanellus vanellus</i>	Northern Lapwing
<i>Chimarra marginata</i>	
<i>Caenis luctuosa</i>	Angler's Curse
<i>Meles meles</i>	Eurasian Badger

4.3.3 COUNTY MEATH DEVELOPMENT AND BIODIVERSITY ACTION PLANS

It is an objective (NH OBJ 1) of the 2013 – 2019 Meath County Development Plan to:

- *“...Implement, in partnership with the Department of Arts, Heritage and the Gaeltacht, relevant stakeholders and the community, the objectives and actions of Actions for Biodiversity 2011 – 2016; Ireland’s National Biodiversity Plan that relate to the remit and functions of Meath County Council and the County Meath Biodiversity Plan and any revisions thereof...”*

The primary function of the County Meath Biodiversity Action Plan is to “...provide a framework and series of actions to conserve, enhance and raise awareness of Meath’s rich biodiversity and to maximise the contribution that it makes to social, economic and environmental well-being of the county, taking into account local, national and international, including European priorities...”

As part of the desk study, habitats of ecological value in a national and local context as identified within the Meath Biodiversity Action Plan were identified, and having been informed by the field surveys, any potential impacts on such habitats were recognised and taken into account during the drawing up of mitigation measures.

The (Draft) County Meath Biodiversity Action Plan 2015 – 2020 has a number of primary objectives:

- (1) To raise awareness of biodiversity in Meath, it’s value and the issues facing it. The flora and fauna surveys carried out at Nevinstown (in addition to any future monitoring and mitigation/habitat enhancement measures) will be submitted with the planning permission application. In addition to records of unusual species being submitted to the National Biodiversity Data Centre, this document will be publically available, and will raise awareness of the biodiversity within the Nevinstown site, on the outskirts of Navan town, and the benefits to biodiversity when any mitigation/habitat enhancement measures are put in place.
- (2) To better understand the biodiversity of Meath. Associated with the proposed development, is a comprehensive monitoring program, which will provide in-depth information regarding a number of species of key importance to biodiversity within Meath, with particular regard to Otter, Kingfisher and bats. Through monitoring of key species of conservation concern at the site, the overall understanding of the biodiversity of the site, and the County, will be greatly enhanced.
- (3) To conserve and enhance habitats and species in Meath, taking into account of national and local priorities. Associated with the proposed development, are a number of prescribed

mitigation measures, which are designed to enhance the conservation status of a number of habitats and species of conservation concern within the proposed development footprint.

The proposed development, therefore, complies with Objectives (1) – (3) of the (Draft) Meath Biodiversity Action Plan 2015 – 2020.

A number of the proposed actions of the (Draft) Meath Biodiversity Action Plan 2015 – 2020 are of particular note with regards to the proposed development:

- In accordance with Action 3 of the “Proposed Objectives and Actions of the (Draft) Meath Biodiversity Action Plan 2015 – 2020”, all records collected as part of the ecological surveys undertaken will be submitted to the National Biodiversity Data Centre through their online record submission system.
- In accordance with Action 5 of the “Proposed Objectives and Actions of the (Draft) Meath Biodiversity Action Plan 2015 – 2020”, the monitoring of Alien Invasive Species within the proposed development footprint will be undertaken as part of the post development monitoring.
- In accordance with Action 21 of the “Proposed Objectives and Actions of the (Draft) Meath Biodiversity Action Plan 2015 – 2020”, which aims to “...*Commission an inventory of all sites of local nature conservation importance by utilising existing survey data (e.g. hedgerow, wetland and trees surveys) and further fieldwork in under surveyed areas. List the sites in any future County Development Plans to guide planning decisions...*”, monitoring of the proposed development site and all associated mitigation/enhancement measures will be monitored providing an in-depth analysis of the flora and fauna present within the Nevinstown survey area.

4.4 RESULTS – FIELD SURVEYS

4.4.1 BOTANICAL/HABITAT SURVEYS

In excess of 150 species were recorded within the Nevinstown survey area. A full species list of all species of flora occurring within the survey area (aquatic species occurring in the river are not included) is presented in Appendix I. A stylised habitat map is presented in Appendix II. A description of the habitats observed, and the dominant species present within habitat types are presented in the following sections, along with photographs of representative areas of habitat. Grassland Habitats

4.4.1.1 DEPOSITING/LOWLAND RIVERS

Forming the southern boundary of the Nevinstown site is the River Blackwater.

4.4.1.2 IMPROVED AGRICULTURAL GRASSLAND (GA1)

Virtually the entire survey area is comprised of Improved Agricultural Grassland – GA1. While there is variation in the degree of improvement, with some fields a monoculture sward of *Lolium perenne*, presumably being used for silage, and other fields being grazed by cattle or sheep that have not recently been reseeded or fertilised. These fields tend to have a variety of grass species, with *Lolium perenne* less dominant. Here, species such as *Cynosurus cristatus*, *Alopecurus pratensis*, *Anthoxanthum odoratum*, *Arrhenatherum elatius* and *Agrostis stolonifera* compete with *Lolium*. There are some fields in which little management has taken place recently, and these fields are dominated by rank grasses and *Cirsium arvense*. These areas of improved grassland do grade, especially on slopes and beside the River Blackwater, into more semi-natural grassland. The GA1 habitat is, in general more diverse than typical GA1, and this is reflected in the abundance and diversity of seed-eating bird species occurring within this habitat.



FIGURE 4.10 GENERAL HABITAT PRESENT WITHIN NEVINSTOWN (GA1). TWO LINEAR FIELDS RECENTLY CUT FOR SILAGE ARE VISIBLE TO THE LEFT HAND SIDE OF THE AERIAL IMAGE – THESE FIELDS WERE PARTICULAR SPECIES POOR, A MONOCULTURE OF *LOLIUM PERENNE*



FIGURE 4.9: RANK GA1 REVERTING TO SEMI NATURAL GRASSLAND

4.4.1.3 GS1 – SEMI-IMPROVED DRY CALCAREOUS GRASSLAND

In some areas of the site where fields slope down to the river, there is grassland present of a more semi-natural type, probably best characterised as semi-improved GS1. *Lolium perenne* is virtually absent, and there are a multitude of grasses, forming a rather short sward, with a wide variety of species including *Festuca rubra*, *Festuca ovina*, *Briza media*, *Cynosurus cristata*, *Anthoxanthum odoratum* and *Agrostis capillaris*. The herb component in this habitat is relatively rich, with species such as *Daucus carota*, *Achillea millefolium*, *Knautia arvensis*, *Hypochaeris radicata*, *Leontodon autumnalis*, *Gallium verum* and *Lotus corniculatus*. This habitat is limited to a small number of areas, but much of the grassland in the vicinity would likely revert to this grassland type if the fields were managed in a less-intensive fashion.



FIGURE 4.12 AREA OF SLOPING GRASSLAND WITH MANY SPECIES TYPICAL OF GS1

4.4.1.4 GM1 – FRESHWATER MARSH

There are significant areas adjacent to the River Blackwater where the Improved Agricultural Grassland grades into habitat best described as GM1, although *Iris pseudacorus* and *Cirsium arvense* are prevalent throughout, likely owing to heavy grazing as evidenced by poaching and a close-grazed

sward. The sward is dominated by *Agrostis stolonifera* and *Holcus lanatus*. These areas of habitat are likely flooded partially during the winter and spring and there is a variety of herbaceous species associated with wet conditions, such as *Senecio aquatica*, *Veronica beccabunga*, *Mentha aquatica*, *Samolus valerandi*, *Phalarus arundinacea*, *Spharganium erectum* and *Typha latifolia*. Damselflies were abundant throughout this habitat, with Banded Demoiselle and Blue-tailed Damselfly. Of note, there was damage to the river-bank within this habitat owing to cattle drinking points, and this should be addressed, as extensive damage is being caused to the river bank, and there is an associated impact on water quality owing to both sedimentation and contamination with faeces/urine.



FIGURE 4.13 AERIAL IMAGE ILLUSTRATING GRADING OF GA1 INTO GM1 - THE GM1 HABITAT IN THE BACKGROUND OF THE IMAGE IS WITHIN THE SAC



FIGURE 4.14 GM1 HABITAT ADJACENT TO RIVER BLACKWATER - IRIS IS PREVALENT, BUT THIS IS LIKELY OWING TO GRAZING



FIGURE 4.15 *SENECIO AQUATICA* IS ABUNDANT WITHIN THE GM1 HABITAT

4.4.1.5 WOODLAND AND SCRUB HABITATS

There is no distinct woodland habitat present within the Nevinstown survey area. There is an area of woodland adjacent to the site, beside which Badger faeces were found, and it is likely that there is a sett within this woodland habitat. There is an extensive hedgerow network within the Nevinstown site, and many mature trees, both native and non-native. There is also an avenue of mature trees (conifers and deciduous) associated with the derelict Nevinstown House.

4.4.1.6 WL1/WL2

There is an extensive hedgerow network present within the Nevinstown site, of a species composition typical for the area, dominated by *Fraxinus excelsior*, *Crataegus monogyna* and *Sambucus nigra*. There are, however, numerous species such as *Corylus avellana*, *Ulmus glabra*, *Euonymus europaeus* and *Prunus institia* that would indicate that much of the hedgerow network is of considerable age. There are numerous mature Oak trees within the hedgerow network also. The presence of many of these hedgerows on the 1st Edition OSI map, including stretches of hedgerow demarcating the Nevinstown townland boundary would appear to support this conclusion. There are numerous species within the ground layer of the hedgerows also indicating that the hedgerows are of considerable age, such as *Geranium robertianum* and *Geum urbanum*. The hedgerow network provides an invaluable ecological corridor. A detailed spatial database of the hedgerow network is being prepared, such that this essential ecosystem service can be maintained and enhanced in the future. This hedgerow survey was carried out based on the Hedgerow Appraisal System of Foulkes *et al* (2013). One potential outlier badger sett was discovered, but following the placement of a trail camera adjacent, and lacking any signs of occupation by Badger, it is likely that this is, in fact utilised intermittently by fox. The movement of livestock within many of the hedgerows (several hedgerows comprise a double hedgerow and dry ditch) have impacted on the structural diversity of the hedgerows and species composition.



FIGURE 4.16 AERIAL IMAGE ILLUSTRATING THE EXTENSIVE HEDGEROW NETWORK PRESENT WITHIN THE NEVINSTOWN STUDY AREA



FIGURE 4.17 MATURE TREES ASSOCIATED WITH NEVINSTOWN HOUSE

The hedgerow network is of particular importance with regards to the avifauna and local bat population, in addition to being of historic importance owing to their age. The hedgerow network provides connectivity between the corridor provided by the River Blackwater and the larger landscape.



FIGURE 4.18: TREE-LINED AVENUE ASSOCIATED WITH NEVINSTOWN HOUSE



FIGURE 4.19: MATURE OAK (*QUERCUS ROBUR*) IN THE CENTRE OF ONE OF THE FIELDS

4.4.1.7 WS1

There are present throughout the Nevinstown site, small, isolated patches of scrub habitat. The largest area of this habitat is associated with a steeply sloping field, dominated by *Ulex europaeus*, but with several other common species such as *Rubus fruticosus* agg present also. There is a rabbit warren present within this area of scrub habitat, and the population of rabbits likely supports local predators including Fox and Common Buzzard. It is also likely that Stoat occur here, although there was no evidence for this species observed. There are also present other, less established areas of scrub throughout the site, mostly small areas where lack of management has resulted in a succession of grassland habitat toward scrub, with rank grasses, *Rubus fruticosus* agg and *Prunus spinosa* dominating. Many of these areas are progressing toward woodland habitat, with saplings abundant, most particularly of *Fraxinus excelsior* and *Acer pseudoplatanus*. Although *Acer pseudoplatanus* is a non-native, with the spread of Ash die-bank, this species may become an invaluable component of Irish hedgerows in future years if the native Ash population suffers a fate similar to *Ulmus procera* following the introduction of Dutch Elm Disease.



FIGURE 4.20 AREA OF GORSE-DOMINATED SCRUB ON STEEP SLOPE



FIGURE 4.21 AREA OF GRASSLAND REVERTING TO SCRUB WITHIN THE NEVINSTOWN SITE

4.4.1.8 BL3 – BUILDINGS AND ARTIFICIAL SURFACES

There are a small number of derelict buildings throughout the Nevinstown site. The only buildings of potential importance as regards ecology are those associated with Nevinstown House. There are numerous outbuildings and derelict dwelling areas, surrounded by mature trees, making the building a potential roosting site for numerous species of bat. During the site surveys, buildings were visited and inspected for suitability for bat roosts, and any signs of occupation by bats. While there is great potential for these buildings to provide excellent roosting conditions for bats, during both summer and winter, and for providing suitable nesting sites for bird species such as Barn Owl, there were no visible signs of occupation by significant numbers of bats or owls, and relatively little in the way of suitable habitat. While this habitat currently supports relatively little in the way of biodiversity, it could be managed such as to be an important site for both roosting bats and nesting Barn Owl.

There is present a lime lime-kiln within the site also.



FIGURE 4.22 NEVINSTOWN HOUSE AND OUTBUILDINGS



FIGURE 4.23 BUILDING INTERIORS

4.4.2 SPECIES LISTED ON THE 3RD SCHEDULE OF THE EC (BIRDS & NATURAL HABITATS) REGS 2011

No Alien Invasive Plant Species listed on the Third Schedule of the European Communities (Birds and Natural Habitats) Regulations of 2011 were identified as occurring within the Nevinstown survey area.

4.5 BIRD SURVEYS

4.5.1 GENERAL BIRD SURVEYS

A total of 27 species of bird were observed to occur within the survey area (see Table 4.8). Several Buzzard, likely a breeding pair and their fledged young were regularly sighted over the survey area. A female Sparrowhawk was observed on two occasions. Surprisingly, no Kestrel were observed, which reflects the general decline in this species over the last decade. A good diversity of seed and insect-eating species were recorded within the survey area, most notably, at least two male Yellowhammer were present within the site, and could be heard singing. Yellowhammer are Red-listed (breeding) and have undergone a decline associated with changes in agricultural practices, largely owing to a decline in both seeds and invertebrates. Kingfisher were regularly observed along the River Blackwater, both during targeted Kingfisher surveys and during other surveys. The River Blackwater is a primary component of the River Boyne and River Blackwater SPA, the qualifying interest of which is the Kingfisher. Other riparian species observed included Moorhen, Mallard and Grey Heron.

TABLE 4.8: BIRDS OBSERVED TO BE PRESENT ON SITE

Common Name	Latin Name	BoCCI Status
Sparrowhawk	<i>Accipiter nisus</i>	Amber
Kingfisher	<i>Alcedo atthis</i>	Amber
Mallard	<i>Anas platyrhynchos</i>	Green
Grey Heron	<i>Ardea cinerea</i>	Green
Buzzard	<i>Buteo buteo</i>	Green
Goldfinch	<i>Carduelis carduelis</i>	Green
Greenfinch	<i>Carduelis chloris</i>	Amber
Wood Pigeon	<i>Columba palumbus</i>	Green
Hooded Crow	<i>Corvus corone cornix</i>	Green
Rook	<i>Corvus frugilegus</i>	Green
Jackdaw	<i>Corvus monedula</i>	Green
Mute Swan	<i>Cygnus olor</i>	Amber
Yellowhammer	<i>Emberiza citrinella</i>	Red

Common Name	Latin Name	BoCCI Status
Robin	<i>Erithacus rubecula</i>	Amber
Moorhen	<i>Gallinula chloropus</i>	Green
Swallow	<i>Hirundo rustica</i>	Amber
Pied Wagtail	<i>Motacilla alba yarrellii</i>	Green
Blue Tit	<i>Parus caeruleus</i>	Green
Great Tit	<i>Parus major</i>	Green
Pheasant	<i>Phasianus colchicus</i>	Green
Magpie	<i>Pica pica</i>	Green
Dunnock	<i>Prunella modularis</i>	Green
Goldcrest	<i>Regulus regulus</i>	Amber
Starling	<i>Sturnus vulgaris</i>	Amber
Wren	<i>Troglodytes troglodytes</i>	Green
Blackbird	<i>Turdus merula</i>	Green
Song Thrush	<i>Turdus philomelos</i>	Green

4.5.2 KINGFISHER SURVEYS

Targeted Kingfisher surveys were carried out on the 31st of July (06:00) and the 9th of August 2017 (11:00), under optimal conditions (clear visibility, no rain, no wind). Kingfisher were observed on both occasions, flying up and down the stretch of the River Blackwater. On the morning of the 31st of July, three Kingfisher in close succession were observed to fly downstream. The habitat on the northern bank of the River within Nevinstown is not suitable for nesting Kingfisher, with the bank of the River not steep enough, or high enough to provide suitable habitat. Cattle accessing the River have disturbed the bank heavily, and the access of cattle to the River should be prevented. There were numerous boughs overhanging the River suitable for hunting Kingfisher.

4.5.3 WADER SURVEYS

No species of wader such as Curlew, Lapwing, Redshank, etc. were observed within the survey area during any surveys. Given the susceptibility of these species to disturbance during breeding (many of which are ground-nesting), the proximity of the site to Navan and the regular use of the site as an amenity, most particularly by dog walkers – in combination with the application of modern farming practices on site, it is highly unlikely that the area would be used for breeding by waders.

4.5.4 RAPTORS

Although a dedicated raptor survey was not undertaken, Common Buzzard and Sparrowhawk were observed during the survey of Nevinstown. Until recently, Kestrel were the most commonly observed bird of prey throughout much of the country. The absence of Kestrel within the survey area reflects the decline in Kestrel (and increase in Buzzard) numbers on a national scale.

4.6 MAMMAL SURVEYS

4.6.1 GENERAL MAMMAL SURVEYS (INCLUDING BADGER)

General mammal surveys were carried out throughout the survey period. Evidence was observed for Fox (*Vulpes vulpes*), Badger (*Meles meles*), Rabbit (*Oryctolagus cuniculus*), Brown Rat (*Rattus norvegicus*), Pygmy Shrew (*Sorex minutus*), Woodmouse (*Apodemus sylvaticus*) and Hare (*Lepus timidus hibernicus*) during the general mammal surveys. There were no indications observed of an active Badger sett within the survey area, and this was corroborated by the lack of any evidence of the presence of Badger on any of the trail cameras deployed. Badger faeces were observed on the eastern boundary of the site, adjacent to woodland and it is highly likely that there is a sett within this woodland habitat. The trail cameras were most frequently triggered by cattle, which have largely free access to the hedgerows through the site and take shelter within the hedgerows during inclement weather. Rabbits also frequently triggered the trail cameras as did cats. Fox were observed on two of the three cameras deployed, and likely several foxes hold territories within the survey area. There was a surprising lack of mammal activity in general, however, which may be associated with a lack of cover within the hedgerows owing to cattle access, and the presence of numerous cats hunting throughout the survey area. At one of the locations in a more heavily utilised (by humans) habitats, only birds triggered the trail cameras, indicating a paucity of general wildlife activity here.

4.6.2 OTTER SURVEY

Given the nature of the habitat present within the survey area, it is almost certain that Otter utilise the site from time to time. It is unlikely that there are any Holts present on the northern bank of the River Blackwater as it has been heavily disturbed by cattle access. At no point throughout surveys or targeted survey period was any evidence of Otter observed.

4.6.3 BAT SURVEYS

The identification of bats from the calls recorded on the Pettersson D500X was accomplished through a combination of sound-analysis software (Batsound 4.2, Kaleidoscope and Sonochiro) and manual interpretation.

4.6.3.1 RIVERSIDE

One Pettersson D500x unit was deployed alongside the River Blackwater between the 9th and 16th of August, with the microphone facing upstream in order to determine bat activity over the River Blackwater. There were almost 1500 bat passes recorded over the 7 nights of surveys, comprising

seven of the nine species known to be resident in Ireland – Leisler’s Bat, Daubenton’s Bat, Common Pipistrelle, Soprano Pipistrelle, Nathusius’ Pipistrelle, Brown Long-eared Bat and Whiskered Bat. The most commonly recorded species was Soprano Pipistrelle (484 passes), followed by Daubenton’s Bat (448 passes), Leisler’s Bat (386 passes), Common Pipistrelle (126 passes), Nathusius’ Pipistrelle (44 passes), Brown Long-eared Bat (2 passes) and Whiskered Bat (1 pass). A detailed breakdown of bat passes by date, time and species is given in Appendix 4.3.

4.6.3.2 AGRICULTURAL LAND

One Pettersson D500x unit was deployed within habitat reflecting the general habitat occurring at Nevinstown, GA1 with WL1, between the 9th and 16th of August, with the microphone facing into an improved agricultural field along a hedgerow. There were 442 bat passes recorded over the 7 nights of surveys, comprising six of the nine species known to be resident in Ireland – Leisler’s Bat, Common Pipistrelle, Soprano Pipistrelle, Nathusius’ Pipistrelle, Brown Long-eared Bat and Natterer’s Bat. The most commonly recorded species by far was Leisler’s Bat (284 passes, almost 6% of the total), followed Common Pipistrelle (115 passes), Soprano Pipistrelle (27 passes), Brown Long-eared Bat (9), Nathusius’ Pipistrelle (4 passes) and Natterer’s Bat (2 passes). A detailed breakdown of bat passes by date, time and species is given in Appendix 4.4.

4.6.3.3 ADDITIONAL SURVEY AT MINE ENTRANCE (APRIL 24TH – 30TH 2018)

As would be expected, given the degree of disturbance within the mine, and the distance between the Nevinstown area and mine entrance (underground – over 1 km), no bat activity was detected during the survey.

4.7 OTHER SPECIES OF CONSERVATION CONCERN

4.7.1 WHITE-CLAWED CRAYFISH

A targeted White-clawed Crayfish was not carried out. Areas of suitable riparian habitat were investigated for any indications of White-clawed Crayfish. In addition, any bird pellets observed by the River were checked for Crayfish remains. No indications of Crayfish occurring on in the riparian zone were observed. White-clawed Crayfish are sensitive to heavy metals such as Lead and Zinc. Given the proximity of ore-bearing rock to the surface, it is likely that any water courses/bodies may contain comparatively high concentrations of these heavy metals relative to areas in which ore does not occur. The small ditch/water course present within the survey area is not suitable habitat for White-clawed Crayfish.

4.7.2 COMMON FROG AND SMOOTH NEWT

There were no observations of Common Frog during field surveys. As expected, there were no observations of Smooth Newt. The small ditch/water course present within the survey area is not suitable habitat for either Common Frog or Smooth Newt.

4.7.3 COMMON LIZARD

The habitat occurring within Nevinstown does contain habitat suitable for Common Lizard. Early morning surveys of suitable habitat for basking Common Lizard on the morning of July 31st, 2017 yielded no evidence of same.

4.7.4 BUTTERFLIES AND BEES

Although rather late in the season for a Butterfly and Bee survey, any species observed during the survey period were noted and recorded. The species of butterfly observed during surveys are listed in Table 4.9.

TABLE 4.9: BUTTERFLIES NOTED DURING BUTTERFLY SURVEYS

Common Name	Latin Name
Large White	<i>Pieris brassicae</i>
Small White	<i>Pieris rapae</i>
Green-veined White	<i>Pieris napi</i>
Small Tortoiseshell	<i>Aglais urticae</i>
Holly Blue	<i>Celastrinus argiolius</i>
Peacock	<i>Inachis io</i>
Red Admiral	<i>Vanessa atalanta</i>

A minimum of 6 species of Bumblebee/Bee/Mining bee were observed during the surveys (*Bombus terrestris*, *Bombus lapidarius*, *Bombus pascorum*, *Bombus lucorum*, *Apis mellifera* and (likely) *Andrena haemorrhoa*).

4.8 SUMMARY FINDINGS

Although the proposed workings at Nevinstown will have no direct impact on the above-ground habitats present, the series of surveys carried out have provided a baseline of the ecological conditions present within the survey area at Nevinstown. The survey area supports a relatively diverse assemblage of species of flora and fauna, considering the proximity of the site to a major population centre (Navan

town) and the nature of the majority of the habitat present (relatively intensively utilised agricultural land). The site at Nevinstown is immediately adjacent to a major ecological corridor, in the form of the River Blackwater. There is present at the site within Nevinstown an excellent network of hedgerows, many of which appear on the 1st edition OSI map, and which mark Townland Boundaries, connecting the River to the larger countryside.

The habitat alongside the river corridor is of particular importance, supporting eight of the nine species of bat one might expect to find in Co. Meath. Of some importance, Kingfisher were regularly observed along the river corridor, indicating that the species for which the River Boyne and River Blackwater SPA is designated is thriving in the area. While no Otter, or signs of Otter were observed, the southern bank of the river provides more suitable habitat, with longer vegetation, steeper banks and less disturbance associated with livestock and humans. This stretch of the river is doubtless utilised by foraging Otter.

Relatively large areas of Improved Agricultural Grassland habitat in the Nevinstown survey area do not appear to have been reseeded or fertilised in recent times, and as a result there is a relative abundance of grass species (as opposed the typical monoculture of *Lolium perenne*) and this has resulted in the presence of bird species such as the Red-listed Yellowhammer, which is dependent on a good supply of both seeds and invertebrates when breeding. These species have undergone a decline associated with modern, intensive agricultural practices.

While the habitats present do not currently support a large population of native mammals – this is likely owing to the degree of use of the lands as an amenity (primarily as a dog-walking area), and the degree of disturbance of hedgerow habitat owing to the accessibility of hedgerow interiors to livestock. There is also a relatively high population of domestic cats utilising the habitat, likely owing to the proximity of the site to a large number of housing estates.

The habitat present at Nevinstown House has very good potential for supporting a large population of bats through the provision of roosting habitats, both summer and winter. The habitat currently present is rather lacking in roosting opportunities, but this could be improved greatly. This habitat also has the potential to provide suitable habitat for Barn Owl.

In summary, while the Nevinstown survey area is basically agricultural land on the outskirts of a major population centre, there is a relatively high diversity of species of both flora and fauna present owing to the “Relatively” un-intensive agricultural practices in use, predominantly in the southern section of the

site adjacent to the River Blackwater. There are, however, a number of relatively simple habitat management protocols that could be put in place that would greatly enhance the biodiversity resource present. Some of the suggested management measurements are outlined in Appendix 4.5.

4.8.1 CUMULATIVE IMPACTS OF MINING OPERATION AS A WHOLE

There will be no additional surface infrastructure associated with this development. The necessary infrastructure, both underground and on surface, for its operation is already in place; including administration, mining and processing facilities, tailings storage capacity, ventilation, effluent discharge facilities and road/rail links to Dublin Port. There will be no impacts on the surface of the Nevinstown survey site as regards biodiversity. The potential impacts of the proposed resumption of underground mining in the Nevinstown orebody on biodiversity concerns the cumulative impact of the full life-cycle of the ore extraction, processing and transport. The potential impacts of the “full life-cycle” of the ore extraction, processing and transport, inclusive of cumulative impacts were examined in the Natura Impact Statement (NIS) accompanying this planning permission application. The primary potential impact of the overall mining operation identified in the NIS is a potential for impacts on hydrology/water quality. The EPA Guidelines as to the information to be contained in Environmental Impact Assessment Reports (2017) states that “...*The EIAR should avoid duplication of assessment ...A biodiversity section of an EIAR, for example, should not repeat the detailed assessment of potential effects on European sites contained in a Natura Impact Statement, but it should refer to the findings of that separate assessment...*”. The comprehensive and detailed NIS, which clearly assesses the baseline environment and any potential impacts of the proposed development as regards the full life cycle of the ore extraction, processing and transport on the most sensitive ecological receptors/biodiversity within 15 km of the proposed development (and indeed within 15 km of the entire area for which the Industrial Emissions Licence applies) concludes:

“...there will be no risk of adverse effects on Qualifying Interest habitats or species, nor the attainment of specific conservation objectives, either alone or in-combination with other plans or projects, for the relevant Natura 2000 sites. The ecological integrity of the Natura 2000 sites concerned (connected with qualifying interests for which the sites have been designated) will not be significantly impacted...” The NIS document clearly, and at length stipulates the mitigation measures required, as per the EPA Guidelines (2017).

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5 AIR

5.1 INTRODUCTION AND SCOPE

The proposed resumption of mining in the Nevinstown orebody will not result in any additional atmospheric emissions.

The necessary mine ventilation is already in place and as it is an underground mine there will be no fugitive dist emissions.

Potential impacts on air quality are therefore confined to the existing facilities. To determine the potential impacts associated with said *Odour Monitoring Ireland Ltd* was commissioned by to perform an air quality modelling study of the existing mine ventilation exhausts (Return Air Raises, RAR) and the lone processing emission i.e. The concentrate loadout ventilation stack.

The following emission points namely:

1. Loadout Ventilation Stack (IEL Reference A2-4)
2. Mine Ventilation Raises (IEL Reference A2-5, A2-6, A2-7, A2-8, A2-9 A2-10 & A2-11)

The following potential pollutants have been assessed:

- Oxides of nitrogen
- Ammonia
- Hydrogen sulphide
- Total Particulates as PM₁₀ and PM_{2.5}
- Zinc,
- Lead,
- Arsenic and
- Cadmium.

The assessment allowed for the examination of proposed short and long term ground level concentrations (GLC's) of compounds as a result of operations and source characteristics of each emission point.

Predicted dispersion modeling GLC's were compared to regulatory / guideline ground level limit values for each monitored pollutant for the cumulative emissions..

5.1.1 SCOPE OF THE WORK

- Calculation of mass emissions of Oxides of nitrogen, Hydrogen sulphide, Ammonia, Oxides of nitrogen, Ammonia, Hydrogen sulphide, Total Particulates as PM₁₀ and PM_{2.5}, Zinc, Lead, Arsenic and Cadmium based on license limit values and volumetric flow rate limits for each emission point.
- Dispersion modeling assessment of predicted cumulative emissions from RAR's and the lone processing emission point operation.
- Assessment of whether the predicted ground level concentrations of pollutants are in compliance with ground level concentration limit values (as taken from SI 271 of 2002, Directive 2008/50/EC and EA H1 Guidance document and factorial limits calculated from CoP 2016 – Code of practice for chemical agents regulations).

5.2 MATERIALS AND METHODS

5.2.1 CALCULATION OF MASS EMISSIONS MONITORING RESULTS

The overall calculated results and desktop review of allowable license limits are contained in *Section 5.3*.

5.2.2 DISPERSION MODELING ASSESSMENT

5.2.2.1 MODEL ASSUMPTIONS

The approach adopted in this assessment is considered a worst-case investigation in respect of emissions to the atmosphere from the emission points operation. These predictions are therefore most likely to overestimate the GLC that may actually occur for each modeled scenario. These assumptions are summarised and include:

- Emissions to the atmosphere from the operations were assumed to occur 24 hours each day / 7 days per week over a standard year at 100% output for all sources. This is very unlikely.
- Five years of hourly sequential meteorological data from Dublin 2011 to 2015 inclusive was used in the modeling screen which will provide statistical significant

results in terms of the short and long term assessment. The worst case year 2015 was used for data presentation. This is in keeping with current national and international recommendations (EPA Guidance AG4). In addition, AERMOD incorporates a meteorological pre-processor AERMET PRO. The AERMET PRO meteorological preprocessor requires the input of surface characteristics, including surface roughness (z_0), Bowen Ratio and Albedo by sector and season, as well as hourly observations of wind speed, wind direction, cloud cover, and temperature. The values of Albedo, Bowen Ratio and surface roughness depend on land-use type (e.g., urban, cultivated land etc) and vary with seasons and wind direction. The assessment of appropriate land-use type was carried out to a distance of 10km from the meteorological station for Bowen Ratio and Albedo and to a distance of 1km for surface roughness in line with USEPA recommendations.

- Cumulative maximum GLC's + Background were compared with relevant air quality objects and limits.
- All emissions were assumed to occur at maximum potential emission concentration and mass emission rates for each scenario and were assumed to occur for 24 hours per day, 365 days per year.
- AERMOD Prime (16216r) dispersion modeling was utilised throughout the assessment in order to provide the most conservative dispersion estimates.
- All building wake affects were assessed within the dispersion model.
- Topographical effects on the emission point were considered negligible in the vicinity of the site due to emission point height above ground level and where the maximum predictions were made within the dispersion model.

5.2.2.2 ATMOSPHERIC DISPERSION MODELING OF AIR QUALITY: WHAT IS DISPERSION MODELING?

Any material discharged into the atmosphere is carried along by the wind and diluted by wind turbulence, which is always present in the atmosphere. This process has the effect of producing a plume of air that is roughly cone shaped with the apex towards the source and can be mathematically described by the Gaussian equation.

Atmospheric dispersion modeling has been applied to the assessment and control of emissions for many years, originally using Gaussian form ISCST 3. Once the compound emission rate

from the source is known, (g s^{-1}), the impact on the vicinity can be estimated. These models can effectively be used in three different ways:

- Firstly, to assess the dispersion of compounds;
- Secondly, in a “reverse” mode, to estimate the maximum compound emissions which can be permitted from a site in order to prevent air quality impact occurring;
- And thirdly, to determine which process is contributing greatest to the compound impact and estimate the amount of required abatement to reduce this impact to within acceptable levels (McIntyre et al. 2000).

In this latter mode, models have been employed for imposing emission limits on industrial processes, control systems and existing facilities and processes (Sheridan et al., 2002).

Any dispersion modeling approach will exhibit variability between the predicted values and the measured or observed values due to the natural randomness of the atmospheric environment. A model prediction can, at best, represent only the most likely outcome given the apparent environmental conditions at the time. Uncertainty depends on the completeness of the information used as input to the model as well as the knowledge of the atmospheric environment and the ability to represent that process mathematically. Good input information (emission rates, source parameters, meteorological data and land use characteristics) entered into a dispersion model that treats the atmospheric environment simplistically will produce equally uncertain results as poor information entered into a dispersion model that seeks to simulate the atmospheric environment in a robust manner. It is assumed in this discussion that pollutant emission rates are representative of maximum emission events (i.e. license limits), source parameters accurately define the point of release and surrounding structures, meteorological conditions define the local atmospheric environment and land use characteristics describe the surrounding natural environment. These conditions are employed within the dispersion modeling assessment therefore providing good confidence in the generated predicted exposure concentration values.

5.2.2.3 ATMOSPHERIC DISPERSION MODELING OF AIR QUALITY: DISPERSION MODEL SELECTION

The AERMOD model was developed through a formal collaboration between the American Meteorological Society (AMS) and U.S. Environmental Protection Agency (U.S. EPA). AERMOD is a Gaussian plume model and replaced the ISC3 model in demonstrating compliance with the National Ambient Air Quality Standards (Porter et al., 2003). AERMIC (USEPA and AMS working group) is emphasizing development of a platform that includes air turbulence structure, scaling, and concepts; treatment of both surface and elevated sources; and simple and complex terrain. The modeling platform system has three main components: AERMOD, which is the air dispersion model; AERMET, a meteorological data pre-processor; and AERMAP, a terrain data pre-processor (Cora and Hung, 2003).

AERMOD is a Gaussian steady-state model which was developed with the main intention of superseding ISCST3 (NZME, 2002). The AERMOD modeling system is a significant departure from ISCST3 in that it is based on a theoretical understanding of the atmosphere rather than depend on empirical derived values. The dispersion environment is characterized by turbulence theory that defines convective (daytime) and stable (nocturnal) boundary layers instead of the stability categories in ISCST3. Dispersion coefficients derived from turbulence theories are not based on sampling data or a specific averaging period. AERMOD was especially designed to support the U.S. EPA's regulatory modeling programs (Porter et al., 2003)

Special features of AERMOD include its ability to treat the vertical in-homogeneity of the planetary boundary layer, special treatment of surface releases, irregularly-shaped area sources, a three plume model for the convective boundary layer, limitation of vertical mixing in the stable boundary layer, and fixing the reflecting surface at the stack base (Curran et al., 2006). A treatment of dispersion in the presence of intermediate and complex terrain is used that improves on that currently in use in ISCST3 and other models, yet without the complexity of the Complex Terrain Dispersion Model-Plus (CTDMPLUS) (Diosey et al., 2002).

Input data from stack emissions, and source characteristics were used to construct the basis of the modeling scenarios.

5.2.3 AIR QUALITY IMPACT ASSESSMENT CRITERIA

The predicted air quality impact from the operation of the emission points for each scenario is compared to relevant air quality objectives and limits. Air quality standards and guidelines referenced in this report include:

- SI 180 of 2011 – Air Quality Standards Regulations 2011.
- SI 58 of 2009 - Arsenic, Cadmium, Mercury, Nickel and Polycyclic Aromatic Hydrocarbons in Ambient Air Regulations 2009.
- Ta Luft of 2002 Air Quality Regulations.
- Environmental Guidelines No.1 of 2002,-Guidelines for air emission regulation, Danish EPA.
- Horizontal guidance Note, IPPC H1, Environmental assessment and appraisal of BAT, UK Environment Agency.
- CoP 2016 – Code of practice Chemical Agents Regulations (2016).

Air quality is judged relative to the relevant Air Quality Standards, which are concentrations of pollutants in the atmosphere, which achieve a certain standard of environmental quality. Air quality Standards are formulated on the basis of an assessment of the effects of the pollutant on public health and ecosystems.

In general terms, air quality standards have been framed in two categories; limit values and guideline values. Limit values are concentrations that cannot be exceeded and are based on WHO guidelines for the protection of human health. Guideline values have been established for long-term precautionary measures for the protection of human health and the environment. European legislation has also considered standard for the protection of vegetation and ecosystems.

Where ambient air quality criteria do not exist as in the case for some of the speciated substances of interest, it is usual to use

- 1/100th of the 8-hour time weighted average occupational exposure limit (OEL)-Long term EAL as an annual average.
- 1/500th of the 8 hour MEL time weighted average occupational exposure limit (OEL) - Long term EAL as an annual average.
- 1/10th of the 15-minute time weighted average occupational exposure limit (OEL)-Short term EAL as an hourly average.
- 1/50th of the 15 minute MEL time weighted average occupational exposure limit (OEL) –short term EAL as an hourly average.

Occupational exposure limits are published by the CoP 2016 Chemical Agents Regulations and subsequent reviews.

The relevant air quality standards for the compounds measured are presented in TABLE 5.1

5.2.3.1 AIR QUALITY GUIDELINES VALUE FOR ASSESSED AIR POLLUTANTS

TABLE 5.1 illustrates the guideline and limit values for air quality pollutants assessed.

TABLE 5.1 LIMIT VALUES FOR NAMED TARGET POLLUTANTS.

POLLUTANT	Objective				TO BE ACHIEVED BY
	Concentration	Maximum No. Of exceedence allowed	Exceedence expressed as percentile	Measured as	
Nitrogen dioxide and oxides of nitrogen ¹	300 $\mu\text{g m}^{-3}$ NO ₂	18 times in a year	99.79 th percentile	1 hour mean	19 Jul 1999
	200 $\mu\text{g m}^{-3}$ NO ₂	18 times in a year	99.79 th percentile	1 hour mean	1 Jan 2010
	40 $\mu\text{g m}^{-3}$ NO ₂	--	--	Annual mean	1 Jan 2010
Ammonia (NH ₃)	3,300 $\mu\text{g m}^{-3}$	None	100 th percentile	1 hour mean protection of human health	--
	3.0 $\mu\text{g m}^{-3}$	--	--	Annual mean for protection of SAC, SPA sites Sensitive habitats	--
Hydrogen sulphide (H ₂ S)	140 $\mu\text{g m}^{-3}$	None	100 th percentile	Long term EAL – Annul mean	--
	150 $\mu\text{g m}^{-3}$	None	100 th percentile	Short term EAL - 1 hr mean	--
Particulates (PM ₁₀)	50 $\mu\text{g m}^{-3}$	35 times in a year	90.40 th percentile	24 hour mean	1 Jan 2010
	40 $\mu\text{g m}^{-3}$	None		Annual mean	1 Jan 2005
	20 $\mu\text{g m}^{-3}$	None	--	Annual mean	1 Jan 2010
Particulates (PM _{2.5}) – Stage 1	25 $\mu\text{g m}^{-3}$	None	--	Annual mean	1 Jan 2015
Lead	0.50 $\mu\text{g m}^{-3}$	None	--	Annual mean – Protection of human health	1 Jan 2005
Arsenic	0.006 $\mu\text{g m}^{-3}$	None	--	Target Annual mean – Protection of human health	31 st Dec 2012
Cadmium	0.005 $\mu\text{g m}^{-3}$	None	--	Target Annual mean – Protection of human health	31 st Dec 2012
Zinc	20	None	--	Long term EAL – Annul mean	--

5.3 EXISTING BASELINE AIR QUALITY

The EPA has been monitoring national Air quality from a number of sites around the country. This information is available from the EPA's website. The values presented for PM_{10, 2.5}, NO₂, Lead, Nickel, Arsenic and Cadmium give an indication of expected emissions of the compounds listed in *Table 5.1*. *Table 5.2* illustrates the baseline data expected to be obtained from a Zone D area for classical air pollutants. Since the existing facility is located in a rural area, it would be considered located in a Zone D area according to the EPA's classification of zones for air quality (www.epa.ie). Traffic and industrial related emissions would be medium.

5.3.1 METEOROLOGICAL DATA

Five years of hourly sequential meteorological data was chosen for the modeling exercise (i.e. Dublin 2011 to 2015 inclusive). A schematic wind rose and tabular cumulative wind speed and directions of all five years are presented. All five years of met data was screened to provide more statistical significant result output from the dispersion model. The worst case year 2015 was used for data presentation. This is in keeping with national and international recommendations on quality assurance in operating dispersion models and will provide a worst case assessment of predicted ground level concentrations based on the input emission rate data. Surface roughness, Albedo and Bowen ratio were assessed and characterised around Rosslare met station for AERMET Pro processing.

5.3.2 TERRAIN DATA

Topography effects were not accounted for within the dispersion modeling assessment as terrain was considered simple in the vicinity of the site when compared to the relative height of the emission point and based on the fact that the terrain was relatively flat in the vicinity of the emission points.

TABLE 5.2 BASELINE AIR QUALITY DATA USED TO ASSESS AIR QUALITY IMPACT CRITERION IN A ZONE D REGION.

Parameter	Kilkitt	Castlebar	Claremorris	Longford	Average
Oxides of nitrogen ($\mu\text{g}/\text{m}^3$)	3.0	8.50	-	-	5.75
Particulate matter-PM ₁₀ ($\mu\text{g}/\text{m}^3$)	8.1	11.9	-	-	10
Particulate matter-PM ₁₀ ($\mu\text{g}/\text{m}^3$)	-	-	6	12	9
Lead ($\mu\text{g}/\text{m}^3$)	0.00181	0.00295	-	-	0.00238
Cadmium ($\mu\text{g}/\text{m}^3$)	0.00007	0.00011	-	-	0.00009
Arsenic ($\mu\text{g}/\text{m}^3$)	0.00008	0.00012	-	-	0.00010

Notes: ¹ denotes taken from Key indicators of Ambient air quality 2016, www.epa.ie.

5.3.3 BUILDING WAKE EFFECTS

Building wake effects are accounted for in modeling scenarios through the use of the Prime algorithm (i.e. all building features located within the immediate area of the emission point) as this can have a significant effect on the compound plume dispersion at short distances from the source and can significantly increase GLC's in close proximity to the facility. All building structures and stack heights and orientations were inputted into the dispersion model in order to allow for wake effects to be taken in to account in the calculations.

5.4 RESULTS

This section describes the results obtained from the dispersion modeling assessment of emissions from the named emission points operation located in Boliden Tara Mines facility. All input data and source characteristics were developed in conjunction with engineering drawings and source characteristics for the emission point supplied by Boliden Tara Mines.

5.4.1 DISPERSION MODEL INPUT DATA – SOURCE CHARACTERISTICS

TABLE 5.3 illustrates the source characteristics utilised within the dispersion model for each emission point. Grid reference location, stack height (A.G.L), maximum volume flow and temperature of the emission point(s) are presented within this table for reference purposes.

5.4.2 PROCESS EMISSION DATA

TABLE 5.3 presents the volume flow and concentration data for each parameter.

TABLE 5.4 presents the mass emission rate data for each considered pollutant that was inputted into the dispersion model for each emission point.

This data was based on allowable limit values contained within the Industrial Emissions for the operating facility.

TABLE 5.3 SOURCE CHARACTERISTICS FOR NAMED EMISSION POINTS.

Parameter	Emission Point A2-4	Emission Point A2-5	Emission Point A2-6	Emission Point A2-7	Emission Point A2-8	Emission Point A2-9	Emission Point A2-10	Emission Point A2-11
X coordinate (m)	285115	284892	285343	284629	284626	283950	283314	283304
Y coordinate (m)	267941	268265	268163	268647	268671	268230	266800	266883
Stack height (m)	22.10	3	3	3	3	3	3	3
Orientation	Vertical	Horizontal	Horizontal	Horizontal	Horizontal	Horizontal	Horizontal	Horizontal
Temperature (K)	293	293	293	293	293	293	293	293
Efflux velocity (m/s)	28.68	10.71	10.04	10.87	10.87	10.71	11.39	11.39
Max volume flow (Nm ³ /hr)	15,000	775,000	775,000	580,000	580,000	775,000	1,333,334	1,333,334
Stack tip area (m ²)	0.43 m	20.1	21.44	14.82	14.82	20.1	32.49	32.49
Max building height (m)	20	-	-	-	-	-	-	-
Oxides of nitrogen (mg/Nm ³)	-	20	20	20	20	20	20	20
Total particulates (mg/Nm ³)	10	5	5	5	5	5	5	5
Ammonia (mg/Nm ³)	-	20	20	20	20	20	20	20
Hydrogen sulphide (mg/Nm ³)	-	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Lead (mg/Nm ³)	0.50	-	-	-	-	-	-	-
Arsenic (mg/Nm ³)	0.050	-	-	-	-	-	-	-
Cadmium (mg/Nm ³)	0.050	-	-	-	-	-	-	-
Zinc (mg/Nm ³)	0.50	-	-	-	-	-	-	-

TABLE 5.4 EMISSION DATA FOR EXHAUST EMISSION POINT.

Compound identity	A2-4	A2-5	A2-6	A2-7	A2-8	A2-9	A2-10	A2-11
Oxides of nitrogen (g/s)	-	4.306	4.306	3.222	3.222	4.306	7.407	7.407
Total particulates (g/s)	0.04167	1.076	1.076	0.806	0.806	1.076	1.852	1.852
Ammonia (g/s)	-	1.076	1.076	0.806	0.806	1.076	1.852	1.852
Hydrogen sulphide (g/s)	-	0.002	0.002	0.002	0.002	0.002	0.004	0.004
Arsenic (g/s)	0.00021	-	-	-	-	-	-	-
Lead (g/s)	0.00208	-	-	-	-	-	-	-
Cadmium (g/s)	0.00021	-	-	-	-	-	-	-
Zinc (g/s)	0.00208	-	-	-	-	-	-	-

5.4.3 DISPERSION MODELING ASSESSMENT

AERMOD Prime (16216r) was used to determine the overall ground level impact of emissions. These computations give the relevant GLC's at each 50 and 350-meter X Y Cartesian grid receptor location that is predicted to be exceeded for the specific air quality impact criteria. Receptor elevations were established at 1.80 m height above ground (normal breathing zone). A total Cartesian receptors grid of 9,242 points was established within the dispersion model giving fine grid coverage of 20.25 sq km and a course grid area of 110.25 km sq.

Five years of hourly sequential meteorological data from Dublin (Dublin 2011 to 2015 inclusive) was screened with the worst case year 2015 been used for results presentation. Source characteristics as detailed in *Table 5.3* including emission data contained in *Table 5.4* were inputted into the dispersion model.

Various averaging intervals were chosen to allow direct comparison of predicted GLC's with the relevant pollutant air quality assessment criteria as outlined.

In particular, 1-hour, percentile and annual average GLC's of the pollutants were calculated at distances from the site. Relevant percentiles of these GLC's were also computed for comparison with the relevant Air Quality Standards.

In modeling air dispersion of NO_x from combustion sources, the source term should be expressed as NO₂, e.g., NO_x mass (expressed as NO₂). Some of the exhaust air is made up of NO while some is made up of NO₂. NO will be converted in the atmosphere to NO₂ but this will depend on a number of factors to include Ozone and VOC concentrations. In order to take account of this conversion the following screening is performed.

Use the following phased approach for assessment:

Worst case scenario

35% for short-term and 70% for long-term average concentration should be considered. If PEC (process contribution + "relevant background concentration") exceeds the relevant air quality objective.

No treatments are required for NH₃, H₂S, Total Particulates as PM_{10, 2.5}, Arsenic, Lead, Cadmium and Zinc.

5.5 RESULTS AND DISCUSSION OF RESULTS

AERMOD GIS Pro Prime (Ver. 16216r) was used to determine the overall air quality impact of all emission point operation operations on a cumulative basis at Boliden Tara Mines. TABLE 5.5 illustrate the tabular results obtained from the assessment.

Maximum predicted GLC's are presented within these tables to allow for comparison with regulatory and guideline reports stated in SECTION 5.2.3.

TABLE 5.5 COMPARISON BETWEEN PREDICTED WORST CASE GLC'S + BASELINE NATIONAL AIR QUALITY DATA AND LIMIT VALUES CONTAINED IN TABLE 5.1 FOR CUMULATIVE EMISSIONS FROM OPERATING EMISSION POINTS.

Identity	Cumulative Predicted at worst case receptor ($\mu\text{g m}^{-3}$)	Baseline concentration value ($\mu\text{g m}^{-3}$)	Baseline + Maximum predicted GLC ($\mu\text{g m}^{-3}$)	Impact criterion ($\mu\text{g m}^{-3}$)	% of Criterion
Oxides of nitrogen - 1 hr max 99.79 th percentile ($\mu\text{g/m}^3$)	115	10.5	125.5	200	62.75
Oxides of nitrogen - Max Annual average ($\mu\text{g/m}^3$) ³	8	5.75	13.75	40	34.38
Hydrogen sulphide - 1 hr Max 100 th percentile ($\mu\text{g/m}^3$)	1.5	-	1.5	140	1.07
Hydrogen sulphide – Max annual average ($\mu\text{g/m}^3$)	0.01	-	0.01	150	0.01
Ammonia - 1 hr Max 100 th percentile ($\mu\text{g/m}^3$)	350	-	350	3300	10.61
Ammonia – Max annual average ($\mu\text{g/m}^3$)	1	-	1	3	33.33
Total particulates as PM ₁₀ - 24 hr Max 90.4 th percentile ($\mu\text{g/m}^3$)	6	10	16	50	32.00
Total Particulates as PM ₁₀ – Max annual average ($\mu\text{g/m}^3$)	2.5	10	12.5	40	31.25
Total Particulates as PM _{2.5} – Max annual average ($\mu\text{g/m}^3$)	2.5	9	11.5	25	46.00
Arsenic– Max annual average ($\mu\text{g/m}^3$)	0.0002	0.0001	0.0003	0.006	5.00
Lead– Max annual average ($\mu\text{g/m}^3$)	0.004	0.00238	0.00638	0.5	1.28
Cadmium– Max annual average ($\mu\text{g/m}^3$)	0.0002	0.00009	0.00029	0.005	5.80
Zinc– Max annual average ($\mu\text{g/m}^3$)	0.004	-	0.004	20	0.02

Notes: 1 denotes based on data presented in TABLES 5.3 & 5.4

2 denotes for impact criterion and baseline values see TABLE 5.1 & 5.2

5.5.1 ASSESSMENT OF AIR QUALITY IMPACTS

5.5.1.1 FOR POLLUTANTS FROM CUMULATIVE EMISSION POINTS.

Predictive air dispersion modeling was used to ascertain the maximum ground level concentrations of selected worst case pollutant concentration to allow for comparison with the ground level limit values contained in TABLE 5.1.

TABLE 5.5 presents the comparison between model predictions for cumulative air quality impacts, baseline air quality concentrations for the compounds and the percentage value of the air quality impact criterion at worst case receptor.

As can be observed in TABLE 5.5, the predicted maximum averaging ground level concentration and baseline concentration are presented as a % of the impact criteria's contained in TABLE 5.1.

5.5.1.2 OXIDES OF NITROGEN

The results for the potential air quality impact for dispersion modeling of NO_x as NO₂ based on the emission rates in Tables 5.4 are presented in TABLES 5.5. Results are presented for the maximum predicted percentile emission regime at the nearest worst case receptor location. As can be observed in TABLE 5.5, the maximum GLC+Baseline for NO₂ at the nearest worst case receptor location from the operation of the facility is 125.5 µg/m³ for the maximum 1-hour mean concentration at the 99.79th percentile. When combined predicted and baseline conditions are compared to the limit values stated in TABLE 5.1, this is less than or equal to 62.75% of the impact criterion for cumulative emissions from all sources.

An annual average was also generated to allow comparison with the limit values contained in TABLE 5.1. The maximum predicted annual average + baseline ground level concentration at the nearest worst case receptor location was 13.75µg/m³. When compared the annual average NO₂ air quality impact criterion is less than or equal to 34.38% of the impact criterion for cumulative emissions from all emission points.

5.5.1.3 HYDROGEN SULPHIDE

The results for the potential air quality impact for dispersion modeling of H₂S based on the emission rates in TABLES 5.4 are presented in TABLES 5.5. Results are presented for the maximum predicted 100th percentile emission regime at the nearest worst case receptor location. As can be observed in TABLE 5.5, the maximum GLC+Baseline for H₂S at the nearest worst case receptor location from the operation of the facility is 1.50 µg/m³ for the maximum 1-hour mean concentration at the 100th percentile. When combined predicted and baseline conditions are compared to the limit values stated in TABLE 5.1, this is less than or equal to 1.07% of the impact criterion for cumulative emissions from all sources.

An annual average was also generated to allow comparison with the limit values contained in TABLE 5.1. The maximum predicted annual average + baseline ground level concentration at the nearest worst case receptor location was 0.01 µg/m³. When compared the annual average H₂S air quality impact criterion is less than or equal to 0.10% of the impact criterion for cumulative emissions from all emission points.

5.5.1.4 AMMONIA

The results for the potential air quality impact for dispersion modeling of NH₃ based on the emission rates in TABLES 5.4 are presented in Tables 5.5. Results are presented for the maximum predicted 100th percentile emission regime at the nearest worst case receptor location. As can be observed in TABLE 5.5, the maximum GLC+Baseline for NH₃ at the nearest worst case receptor location from the operation of the facility is 350 µg/m³ for the maximum 1-hour mean concentration at the 100th percentile. When combined predicted and baseline conditions are compared to the limit values stated in TABLE 5.1, this is less than or equal to 10.61% of the impact criterion for cumulative emissions from all sources.

An annual average was also generated to allow comparison with the limit values contained in TABLE 5.1. The maximum predicted annual average + baseline ground level concentration at the nearest worst case receptor location was 1.0 µg/m³. When compared the annual average NH₃ air quality impact criterion is less than or equal to 33.34% of the impact criterion for cumulative emissions from all emission points.

5.5.1.5 PARTICULATE MATTER PM_{10/2.5}

The results for the potential air quality impact for dispersion modeling of Particulate matter based on the emission rates in TABLE 5.4 are presented in TABLES 5.5. Results are presented for the maximum predicted percentile emission regime at the nearest worst case receptor location. As can be observed in TABLE 5.5, the maximum GLC+Baseline for PM₁₀ at the nearest worst case receptor location from the operation of the facility is 16µg/m³ for the maximum 24-hour mean concentration at the 90.40th percentile. When combined predicted and baseline conditions are compared to the limit values contained in TABLE 5.1, this is less than or equal to 32% of the impact criterion for cumulative emissions from all sources.

An annual average was also generated to allow comparison with the limit values. The maximum predicted annual average + baseline ground level concentration at the nearest worst case receptor location was 12.5 µg/m³. When compared, the annual average PM₁₀ air quality impact is less than or equal to 31.25% of the impact criterion for cumulative emissions from all sources.

For PM_{2.5}, the maximum predicted annual average + baseline ground level concentration at the nearest worst case receptor location was 11.5 µg/m³. When compared, the annual average PM_{2.5} air quality impact is less than or equal to 46% of the impact criterion for cumulative emissions from all sources.

5.5.1.6 ARSENIC, LEAD, CADMIUM AND ZINC

An annual average predicted max GLC value was generated for emissions from emission point A2-4 for Arsenic, Lead, Cadmium and Zinc to allow comparison with limit values contained in TABLE 5.1. The maximum predicted annual average + baseline ground level concentration at the nearest worst case receptor location for Arsenic, Lead, Cadmium and Zinc was 0.0030, 0.00638, 0.00029 and 0.004 µg/m³. When compared the annual average air quality impact criterion, all parameters are well within the limit value with predicted values ranging from 0.02 to 5.8% of the impact criterions.

5.6 CONCLUSIONS

Odour Monitoring Ireland Ltd was commissioned by Boliden Tara Mines to perform a dispersion modeling risk analysis study in order to assess the potential air quality impacts associated with the operational Mill / RAR's located in Navan, Co. Meath. Following detailed impact monitoring, desktop review and dispersion modeling assessment, it was demonstrated that no significant environmental impact will exist in the vicinity of the emission point.

The following conclusions are drawn from the study:

1. The assessment was carried out to provide information on the potential cumulative air quality impacts of operational Mill / RARs located in Boliden Tara Mines, Navan, Co. Meath.
2. Specific dispersion modeling was performed for a range of parameters to include Oxides of nitrogen, Ammonia, Hydrogen sulphide, Particulate matter (Pm₁₀ & 2.5), Arsenic, Cadmium, Lead and Zinc.
3. With regard to Oxides of nitrogen, the maximum predicted percentile emission regime at the nearest worst case receptor location. As can be observed in *Table 5.5*, the maximum GLC+Baseline for NO₂ at the nearest worst case receptor location from the operation of the facility is 125.5 µg/m³ for the maximum 1-hour mean concentration at the 99.79th percentile. When combined predicted and baseline conditions are compared to the limit values stated in TABLE 5.1, this is less than or equal to 62.75% of the impact criterion for cumulative emissions from all sources. An annual average was also generated to allow comparison with the limit values contained in TABLE 5.1. The maximum predicted annual average + baseline ground level concentration at the nearest worst case receptor location was 13.75µg/m³. When compared the annual average NO₂ air quality impact criterion is less than or equal to 34.38% of the impact criterion for cumulative emissions from all emission points.
4. With regard to Hydrogen sulphide, the maximum GLC+Baseline for H₂S at the nearest worst case receptor location from the operation of the facility is 1.50 µg/m³ for the maximum 1-hour mean concentration at the 100th percentile. When combined

predicted and baseline conditions are compared to the limit values stated in *Table 5.1*, this is less than or equal to 1.07% of the impact criterion for cumulative emissions from all sources.

5. An annual average was also generated to allow comparison with the limit values contained in TABLE 5.1. The maximum predicted annual average + baseline ground level concentration at the nearest worst case receptor location was $0.01\mu\text{g}/\text{m}^3$. When compared the annual average H_2S air quality impact criterion is less than or equal to 0.10% of the impact criterion for cumulative emissions from all emission points.
6. With regard to Ammonia, the maximum GLC+Baseline for NH_3 at the nearest worst case receptor location from the operation of the facility is $350\mu\text{g}/\text{m}^3$ for the maximum 1-hour mean concentration at the 100th percentile. When combined predicted and baseline conditions are compared to the limit values stated in TABLE 5.1, this is less than or equal to 10.61% of the impact criterion for cumulative emissions from all sources. An annual average was also generated to allow comparison with the limit values contained in TABLE 5.1. The maximum predicted annual average + baseline ground level concentration at the nearest worst case receptor location was $1.0\mu\text{g}/\text{m}^3$. When compared the annual average NH_3 air quality impact criterion is less than or equal to 33.34% of the impact criterion for cumulative emissions from all emission points.
7. With regard to Total Particulates (PM_{10}), the maximum GLC+Baseline for PM_{10} at the nearest worst case receptor location from the operation of the facility is $16\mu\text{g}/\text{m}^3$ for the maximum 24-hour mean concentration at the 90.40th percentile. When combined predicted and baseline conditions are compared to the limit values contained in TABLE 5.1, this is less than or equal to 32% of the impact criterion for cumulative emissions from all sources. An annual average was also generated to allow comparison with the limit values. The maximum predicted annual average + baseline ground level concentration at the nearest worst case receptor location was $12.5\mu\text{g}/\text{m}^3$. When compared, the annual average PM_{10} air quality impact is less than or equal to 31.25% of the impact criterion for cumulative emissions from all sources. For $\text{PM}_{2.5}$, the maximum predicted annual average + baseline ground level concentration at the

nearest worst case receptor location was $11.5 \mu\text{g}/\text{m}^3$. When compared, the annual average $\text{PM}_{2.5}$ air quality impact is less than or equal to 46% of the impact criterion for cumulative emissions from all sources.

8. With regard to Arsenic, Lead, Cadmium and Zinc, an annual average predicted max GLC value was generated for emissions from emission point A2-4 for Arsenic, Lead, Cadmium and Zinc to allow comparison with limit values contained in TABLE 5.1. The maximum predicted annual average + baseline ground level concentration at the nearest worst case receptor location for Arsenic, Lead, Cadmium and Zinc was 0.0030, 0.00638, 0.00029 and $0.004 \mu\text{g}/\text{m}^3$. When compared the annual average air quality impact criterion, all parameters are well within the limit value with predicted values ranging from 0.02 to 5.8% of the impact criteria.
9. The overall modeling indicates that the emissions from the combined RAR's and Mill emission point operation will not result in any significant impact on worst case sensitive receptors in the surrounding area with all ground level concentrations of pollutants within their respective ground level concentration limit values for the protection of human health.

Appendix 5.1 - Air dispersion Modeling Contour Plots⁶

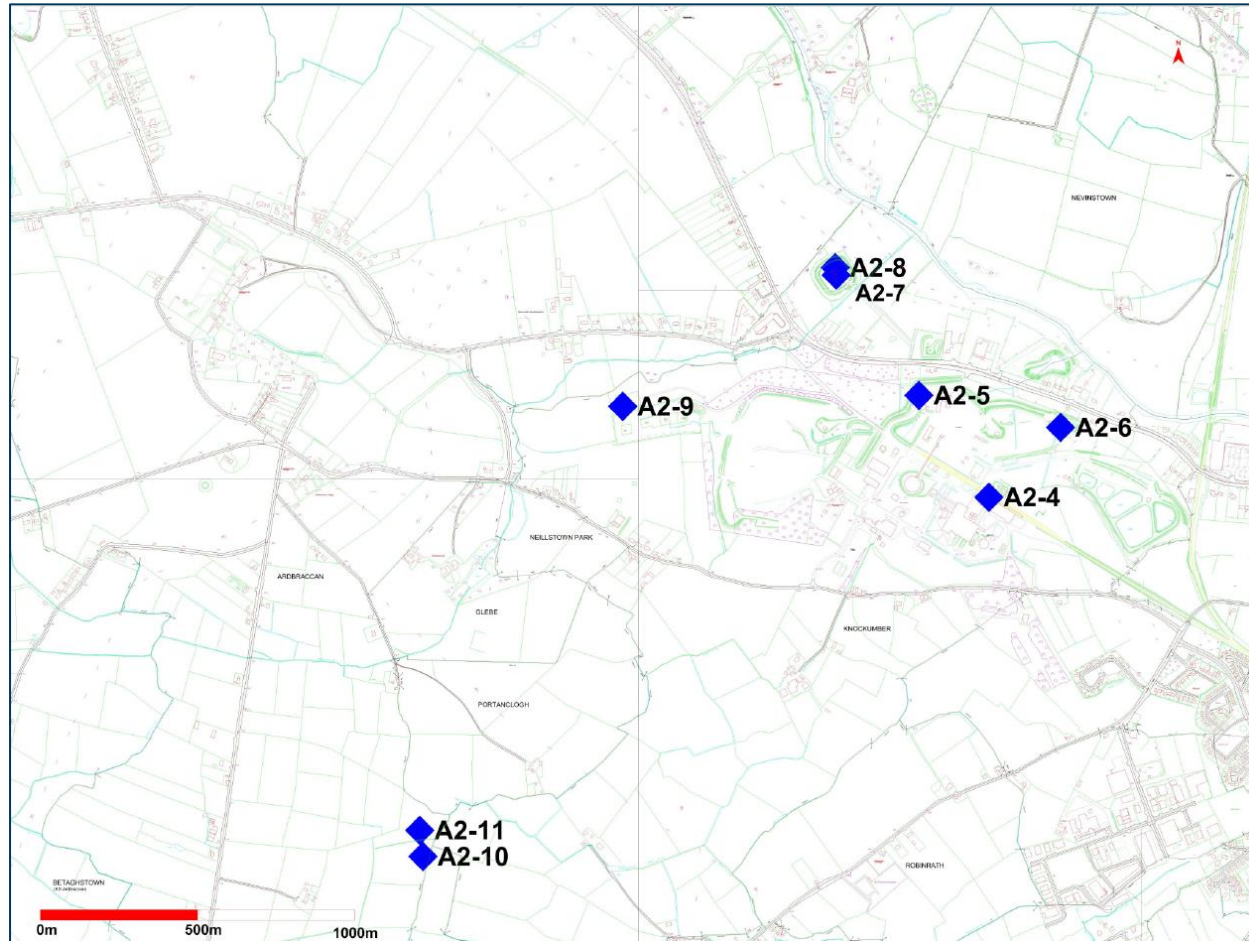


FIGURE 5.1 Plan view drawings showing relative location of emission points A2-4 to A2-11.

⁶ These contour plots are for illustrative purposes only.

The pollutant contour values were selected for illustrative purposes only to allow for graphical representation of dispersion from the identified source.

Oxides of nitrogen contours:

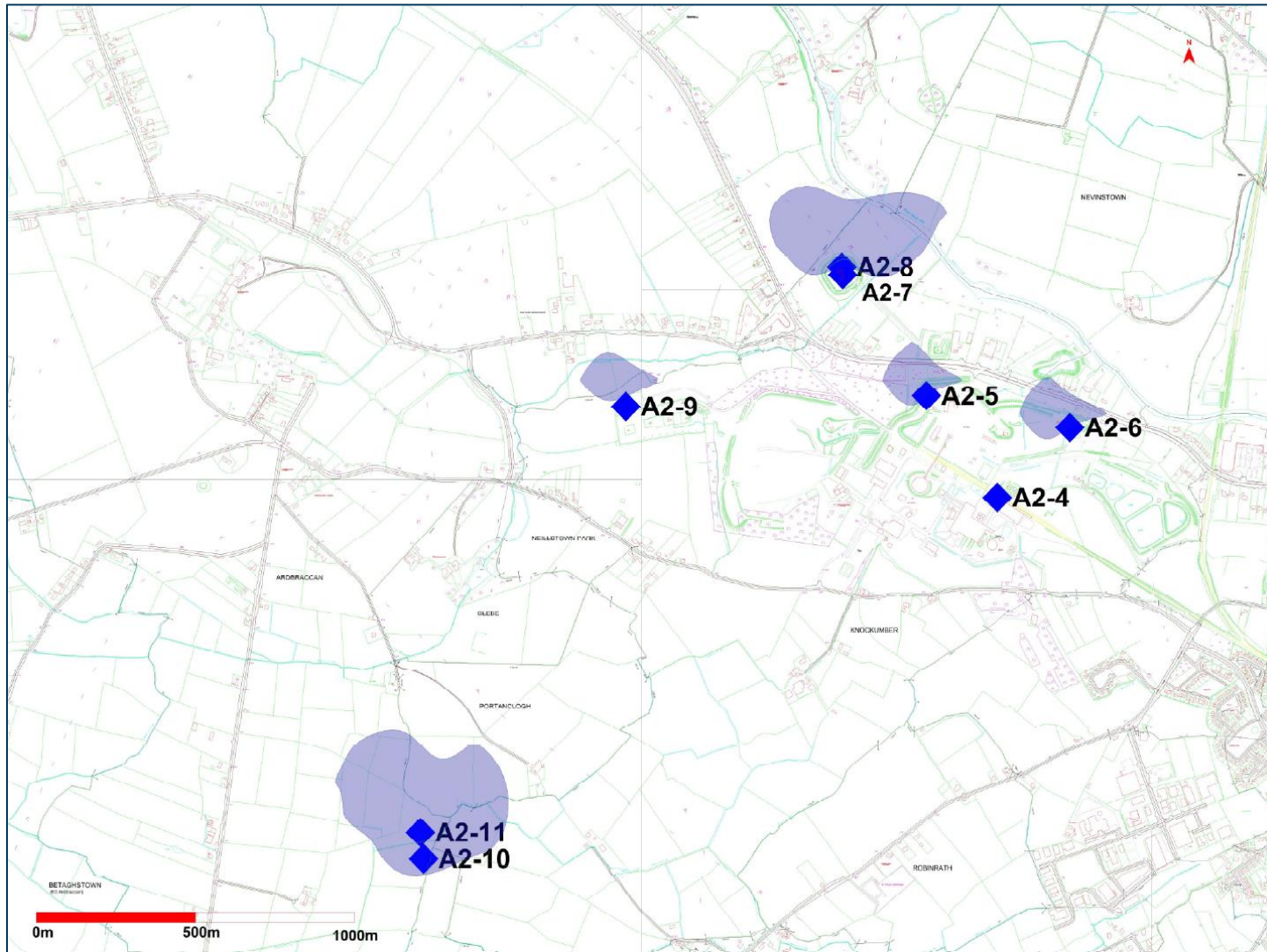


FIGURE 5.2 Predicted NOx as NO2 ground level concentration impact contribution of cumulative emissions from A2-5 to A2-11 for the 99.79th %ile ground level concentration of $\leq 105 \mu\text{g}/\text{m}^3$ (—).

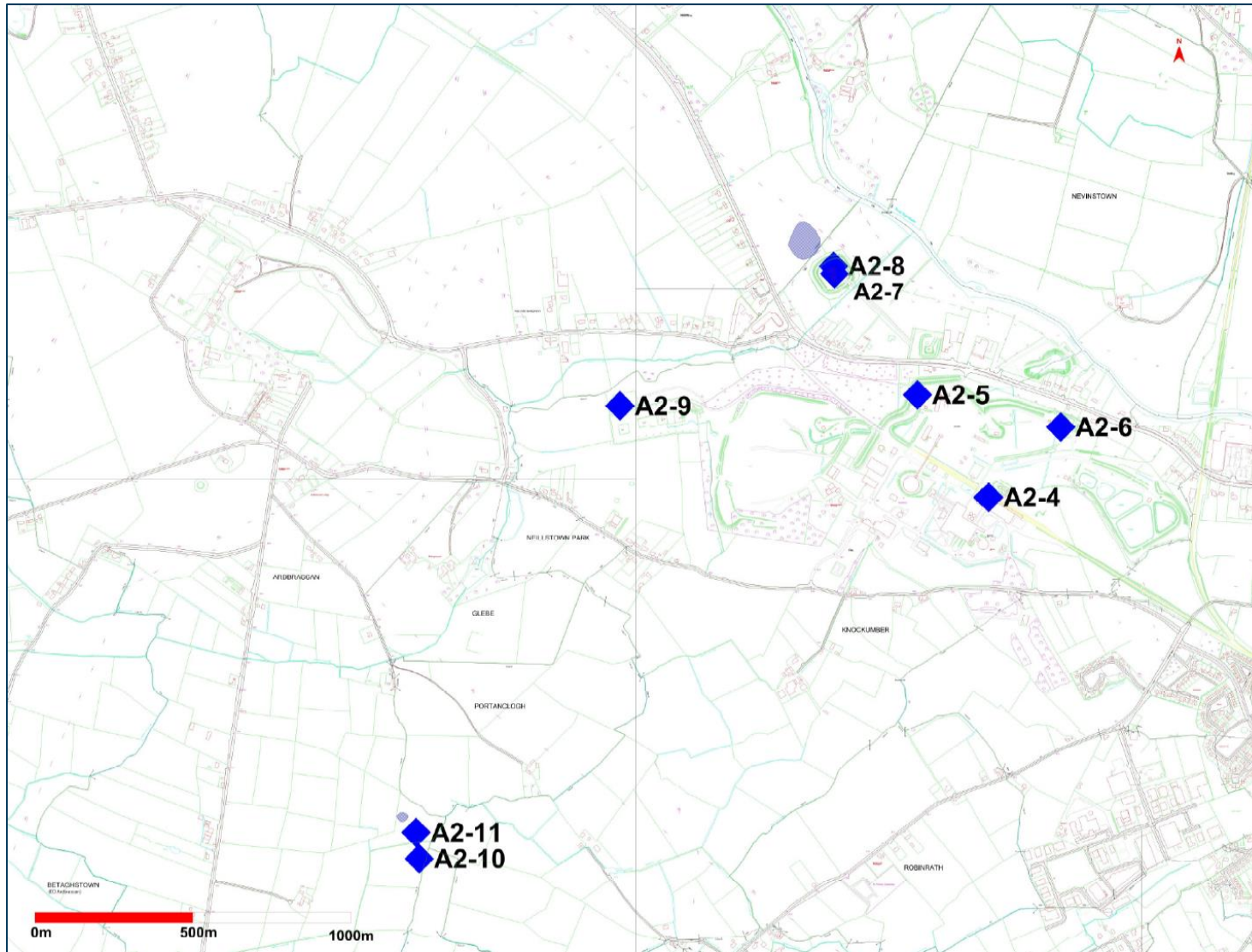


FIGURE 5.3 Predicted NO_x as NO₂ ground level concentration impact contribution of cumulative emissions from A2-5 to A2-11 for the annual average ground level concentration of $\le 10.5 \mu\text{g}/\text{m}^3$ (—).

Ammonia contours;

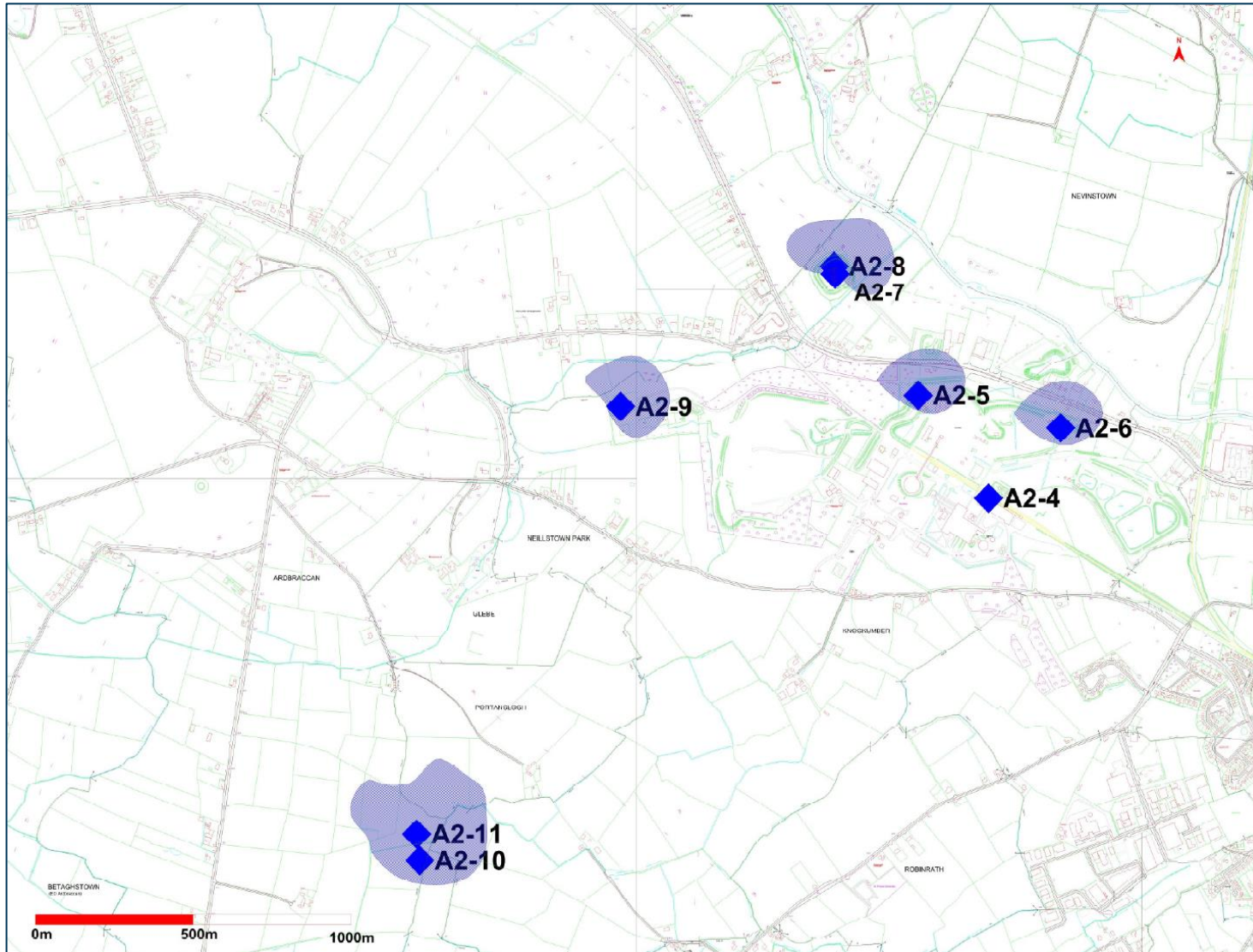


FIGURE 5.4 Predicted 1 hour NH3 ground level concentration impact contribution of cumulative emissions from A2-5 to A2-11 for the 100th %ile ground level concentration of $\leq 300 \mu\text{g}/\text{m}^3$ (—).

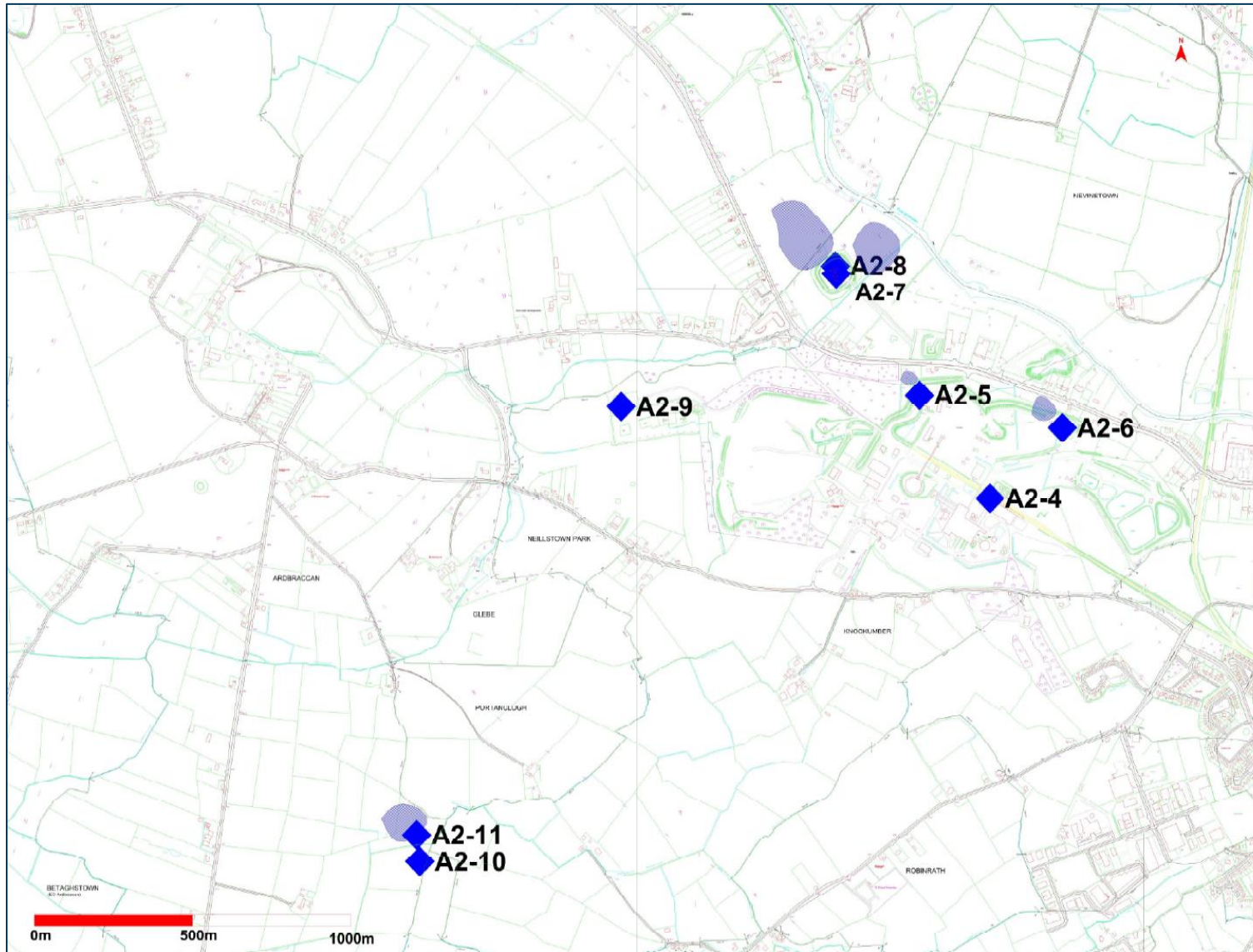
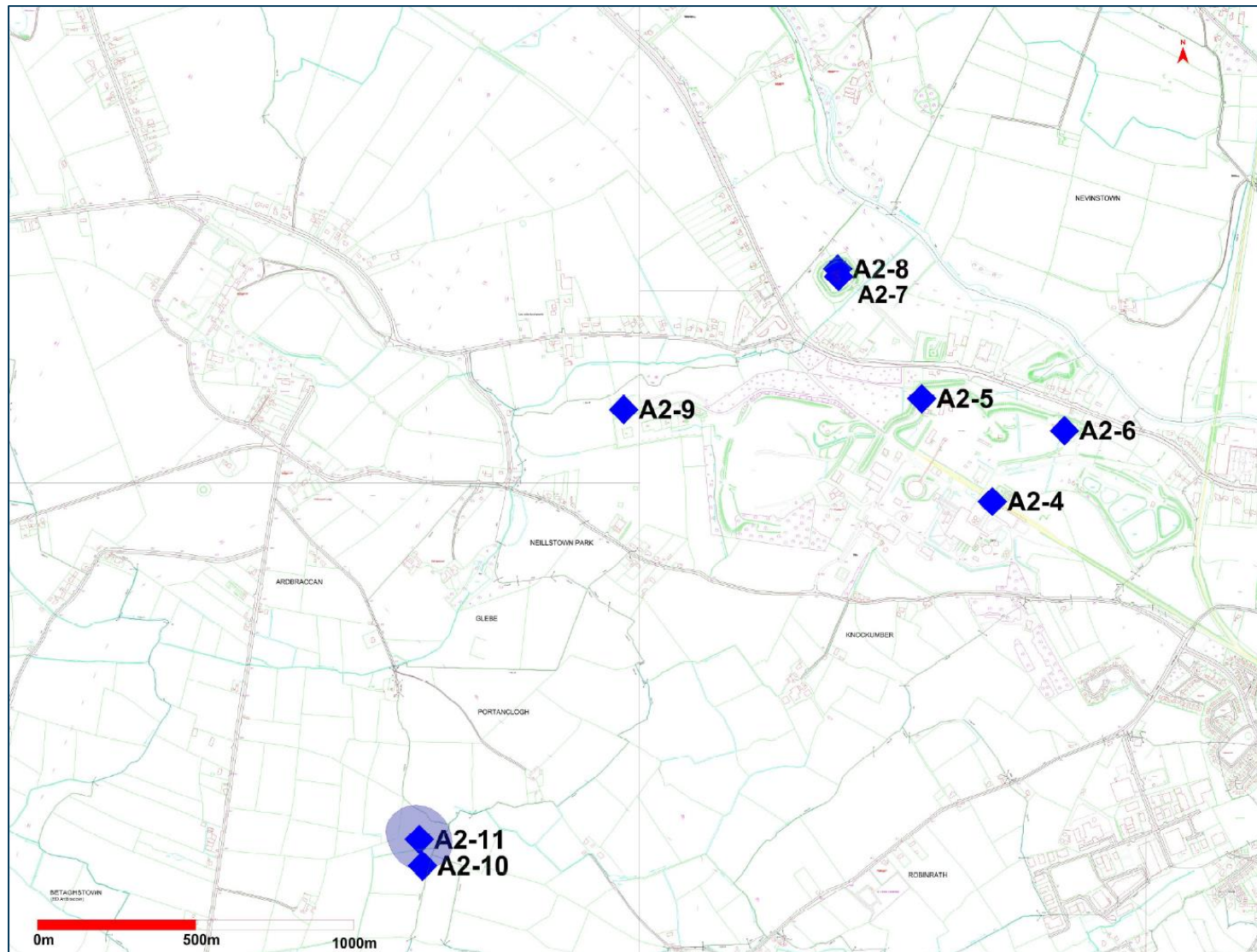


FIGURE 5.5 Predicted NH3 ground level concentration impact contribution of cumulative emissions from A2-5 to A2-11 for the annual average ground level concentration of $\leq 3.0 \mu\text{g}/\text{m}^3$ (—).



Hydrogen sulphide contours:

FIGURE 5.6 Predicted 1 hour H₂S ground level concentration impact contribution of cumulative emissions from A2-5 to A2-11 for the 100th %ile ground level concentration of $\leq 2.0 \mu\text{g}/\text{m}^3$ (—).

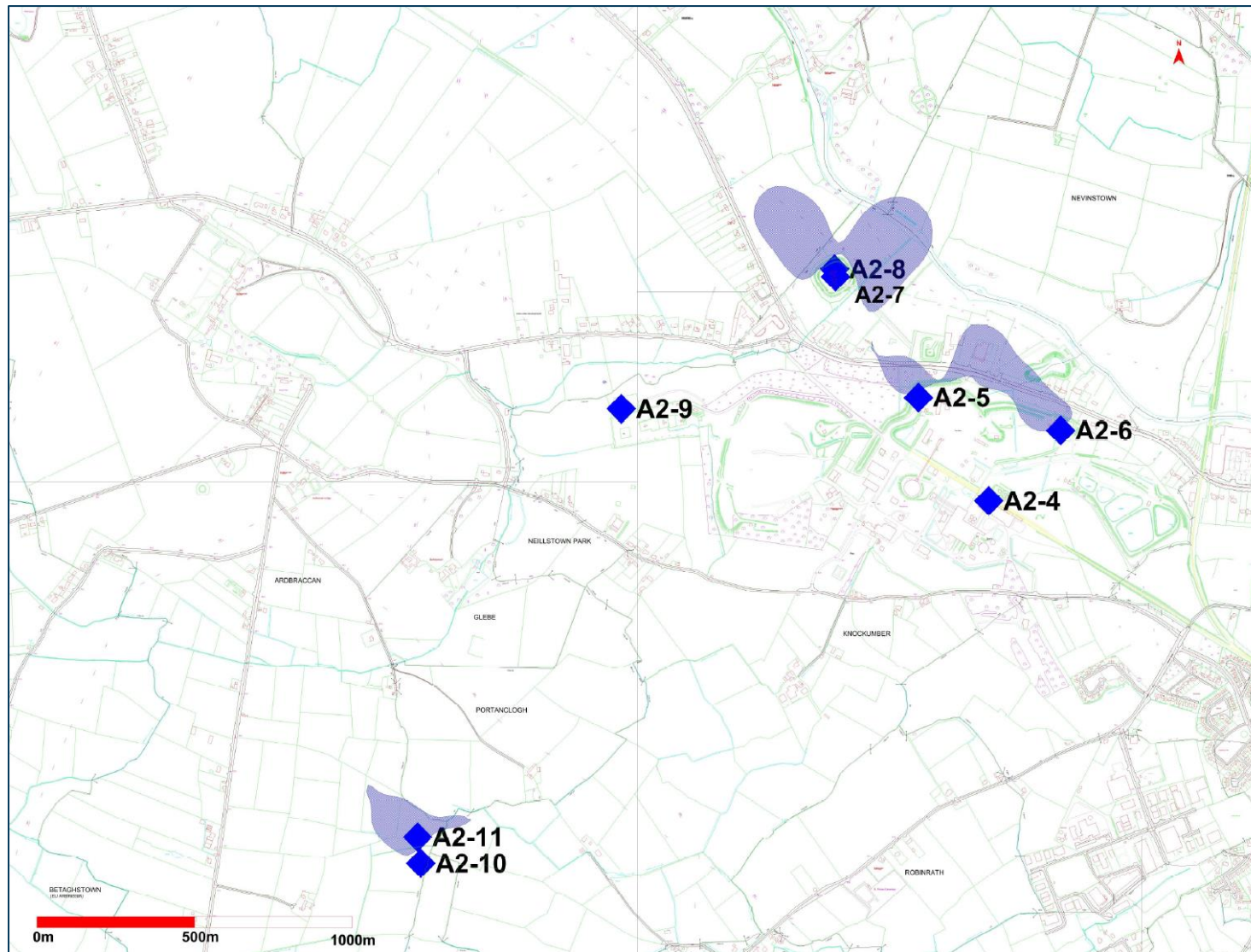


FIGURE 5.7 Predicted H2S ground level concentration impact contribution of cumulative emissions from A2-5 to A2-11 for the annual average ground level concentration of $\leq 0.005 \mu\text{g}/\text{m}^3$ (—).

Total particulates Contours:

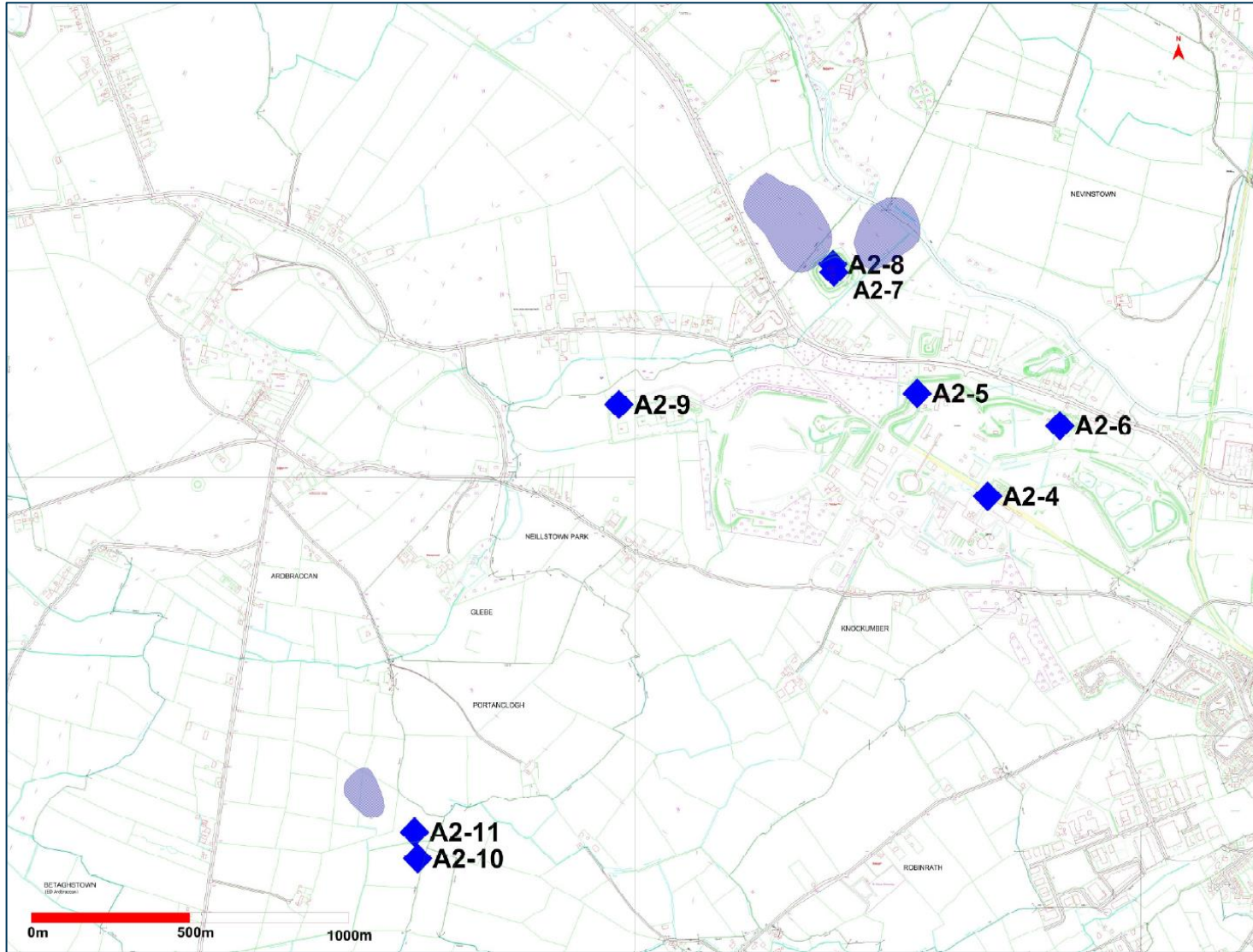


FIGURE 5.8 Predicted total particulates as PM10 ground level concentration impact contribution of cumulative emissions from A2-5 to A2-11 for the 90.40th %ile ground level concentration of $\le 6.0 \mu\text{g}/\text{m}^3$ (—).

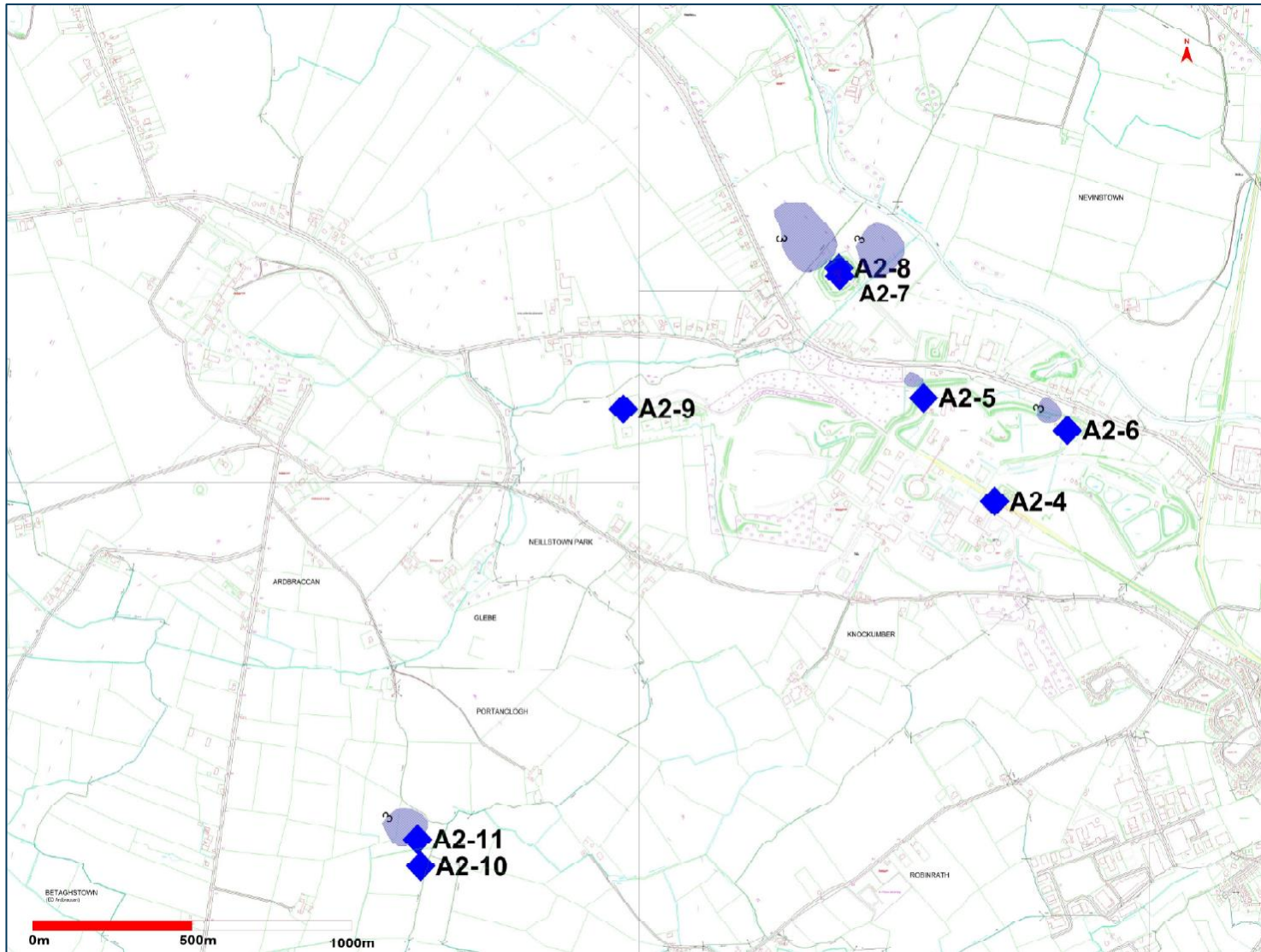


FIGURE 5.9 Predicted Total particulates as PM10 ground level conc. impact contribution of cumulative emissions from A2-5 to A2-11 for the Annual average ground level concentration of $\leq 3.0 \mu\text{g}/\text{m}^3$ (—).

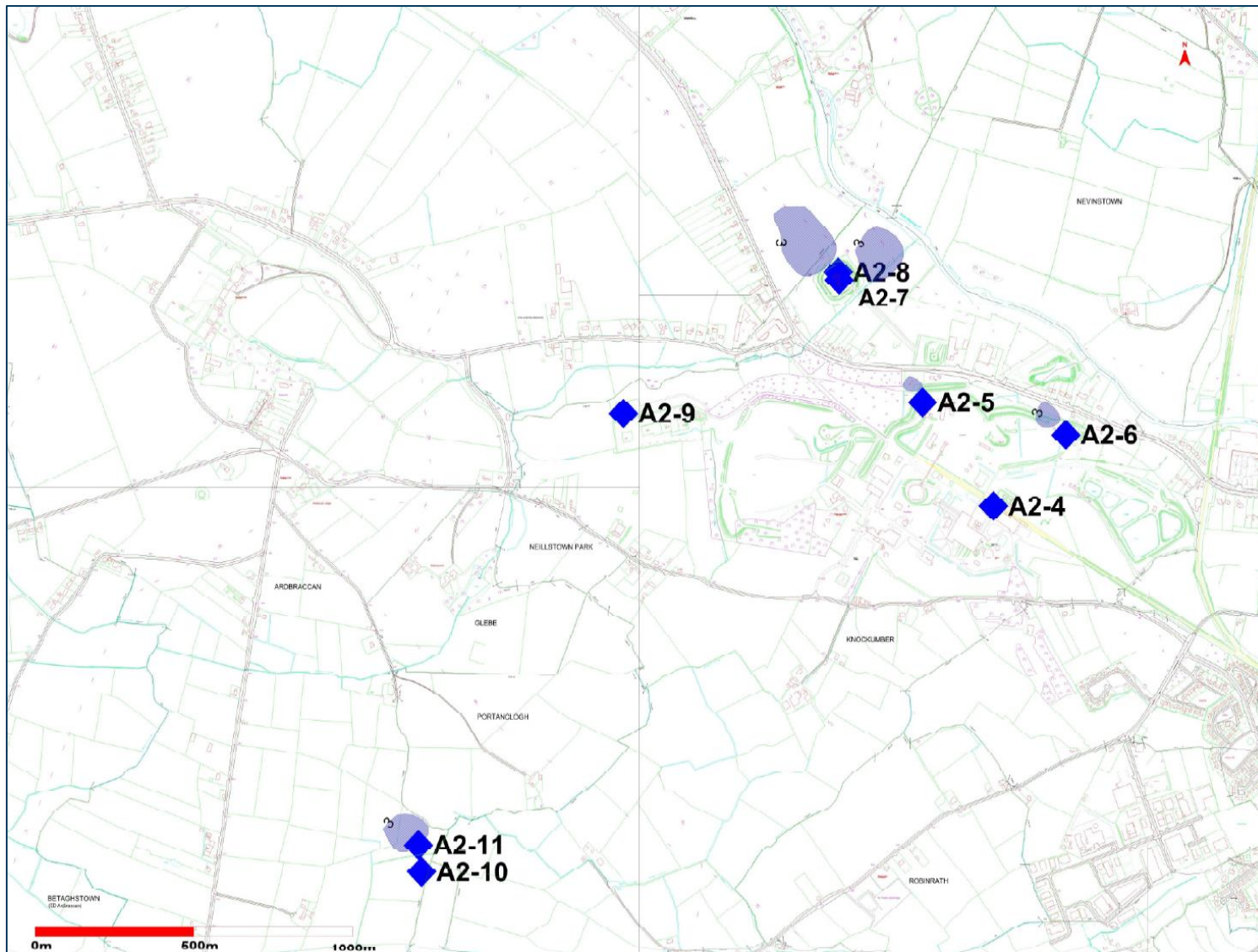
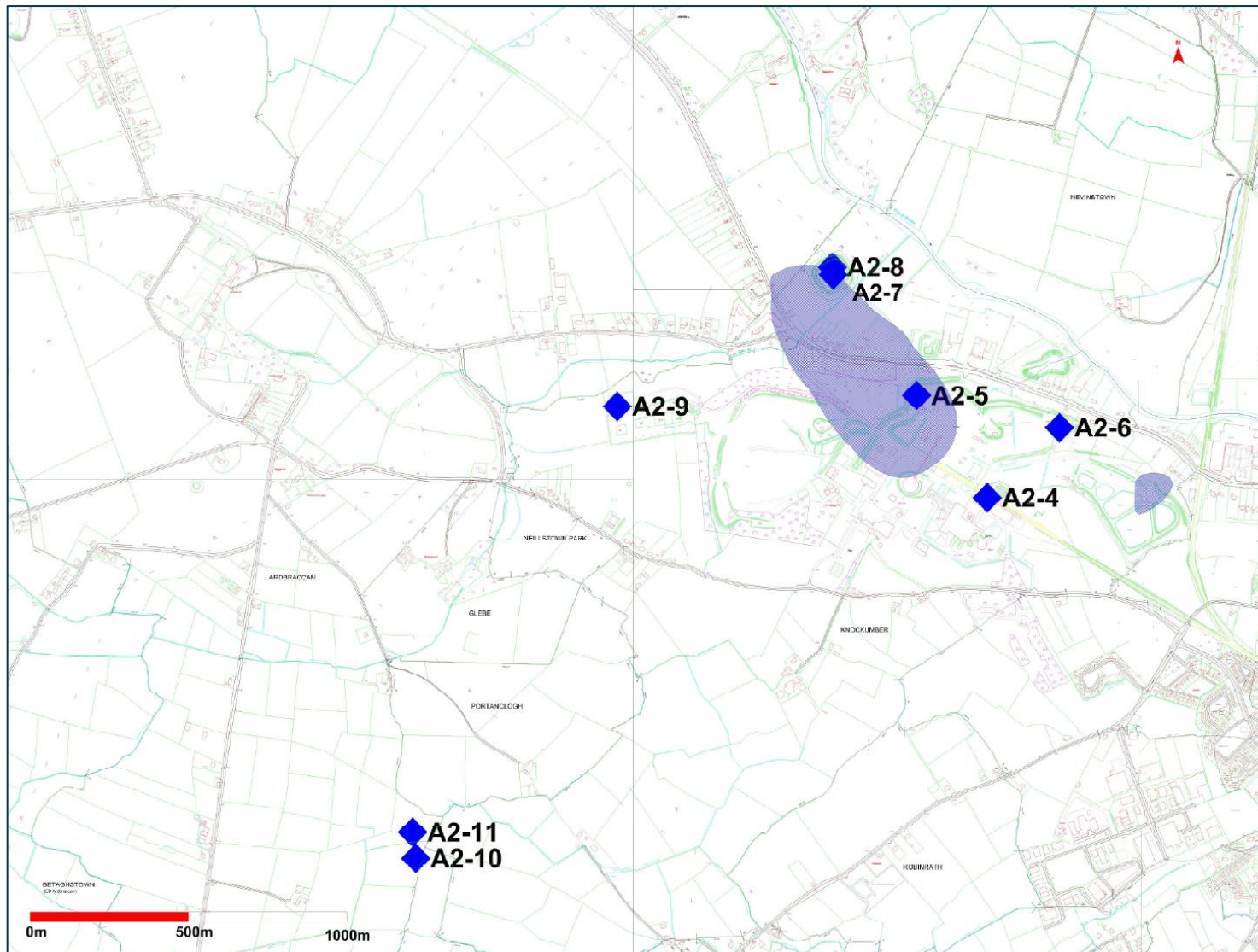
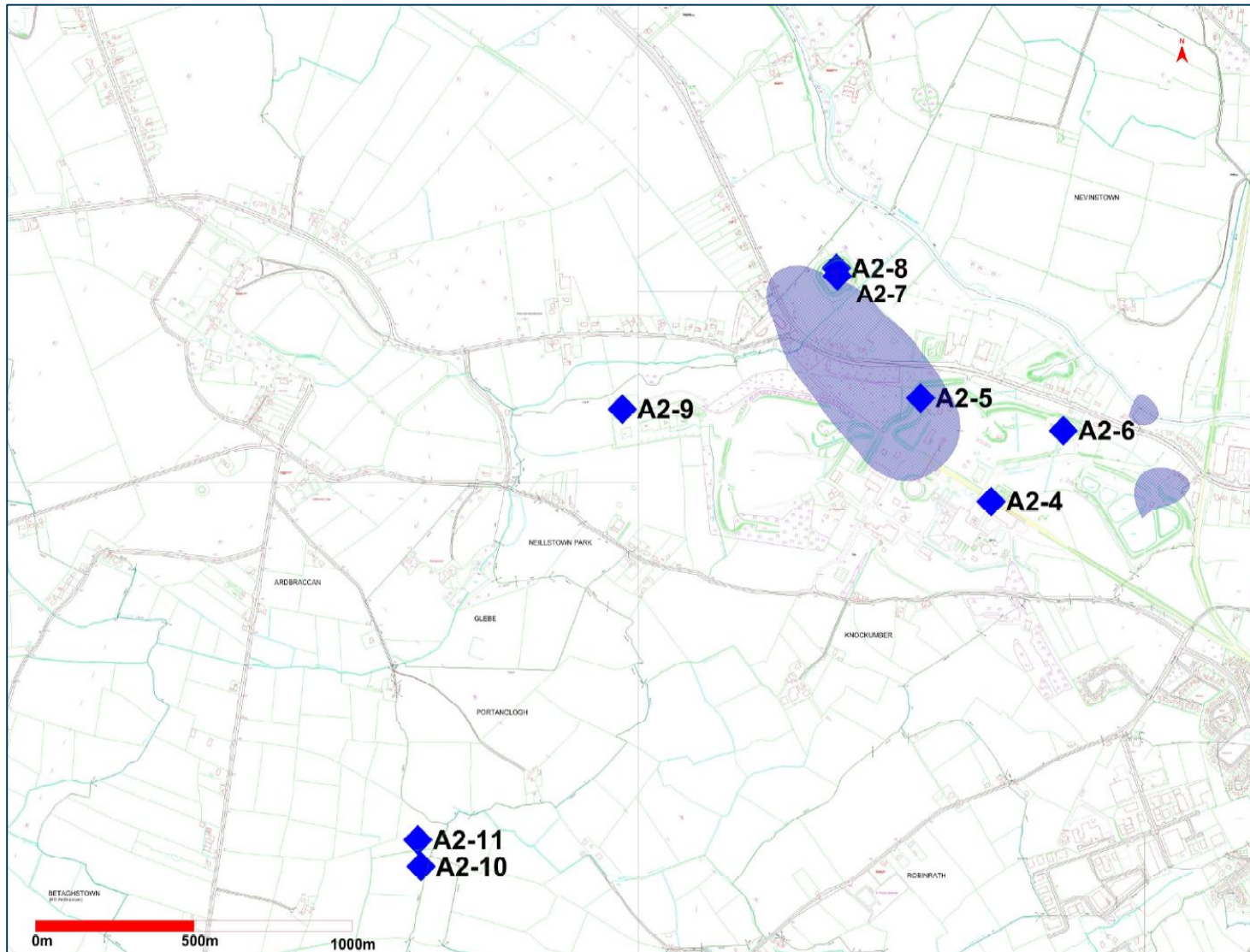


FIGURE 5.10 Predicted Total particulates as PM2.5 ground level conc. impact contribution of cumulative emissions from A2-5 to A2-11 for the Annual average ground level concentration of $\leq 3.0 \mu\text{g}/\text{m}^3$ (—).



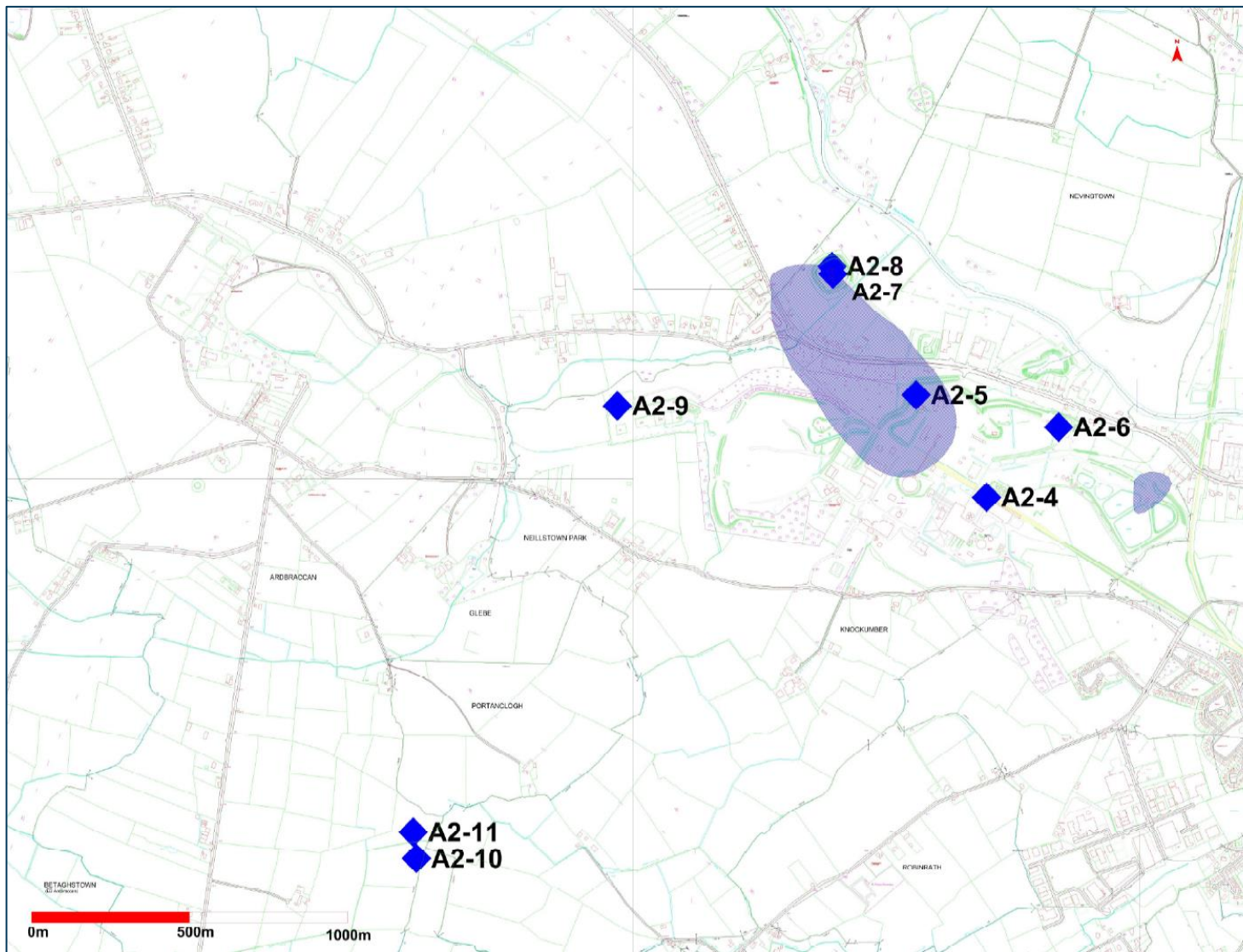
Arsenic:

FIGURE 5.11 Predicted Arsenic ground level concentration impact contribution of cumulative emissions from A2-4 for the annual average ground level concentration of $\leq 0.00010 \mu\text{g}/\text{m}^3$ (—).



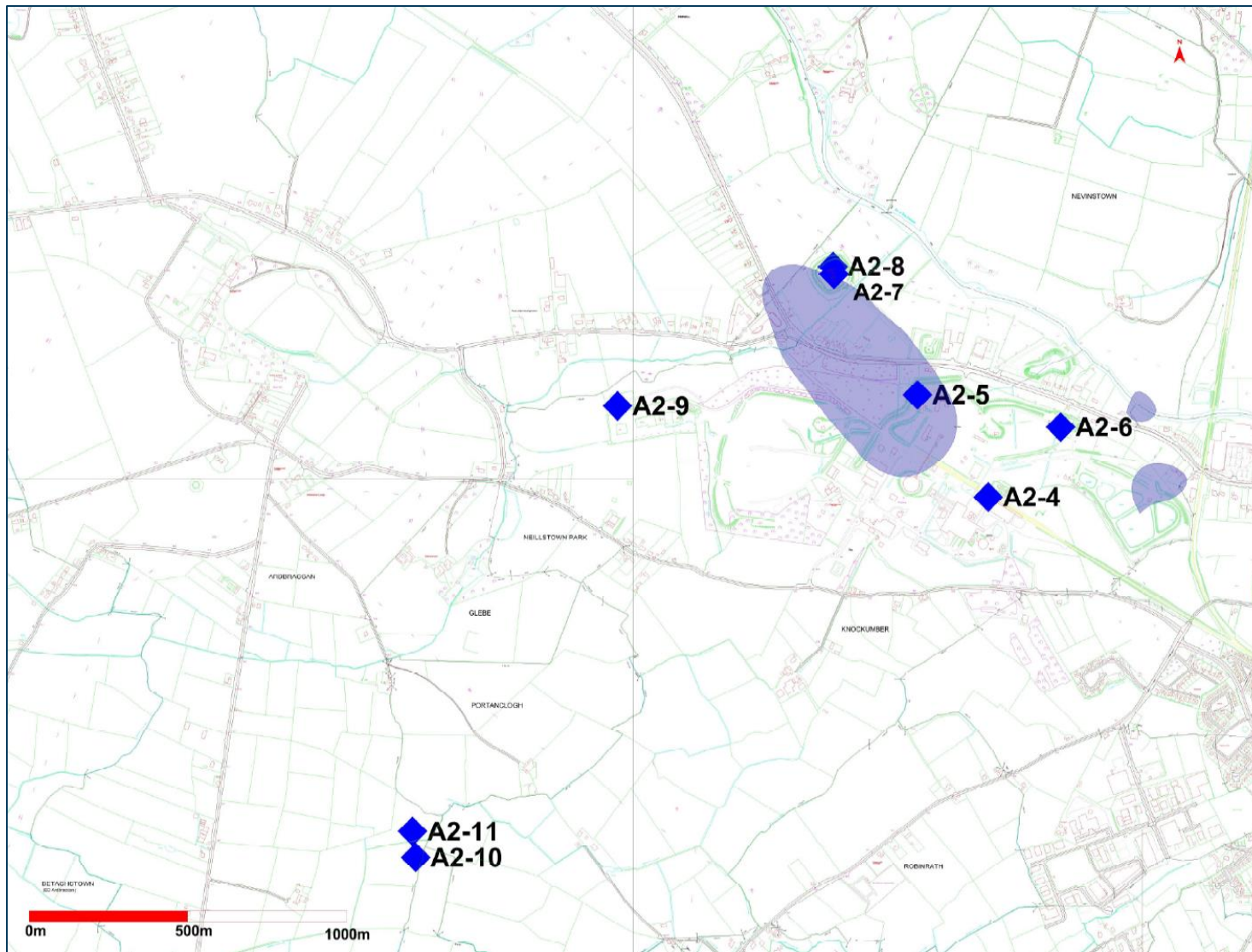
Zinc:

FIGURE 5.12 Predicted Zinc ground level concentration impact contribution of cumulative emissions from A2-4 for the annual average ground level concentration of $\leq 0.0010 \mu\text{g}/\text{m}^3$ (—).



Cadmium:

FIGURE 5.13 Predicted Cadmium ground level concentration impact contribution of cumulative emissions from A2-4 for the annual average ground level concentration of $\leq 0.00010 \mu\text{g}/\text{m}^3$ (—).



Lead:

FIGURE 5.14 Predicted Lead ground level concentration impact contribution of cumulative emissions from A2-4 for the annual average ground level concentration of $\leq 0.0010 \mu\text{g}/\text{m}^3$ (—).

Appendix 5.2 - Meteorological Data used within the Dispersion Modeling Study

Meteorological file Dublin 2011 to 2015 inclusive

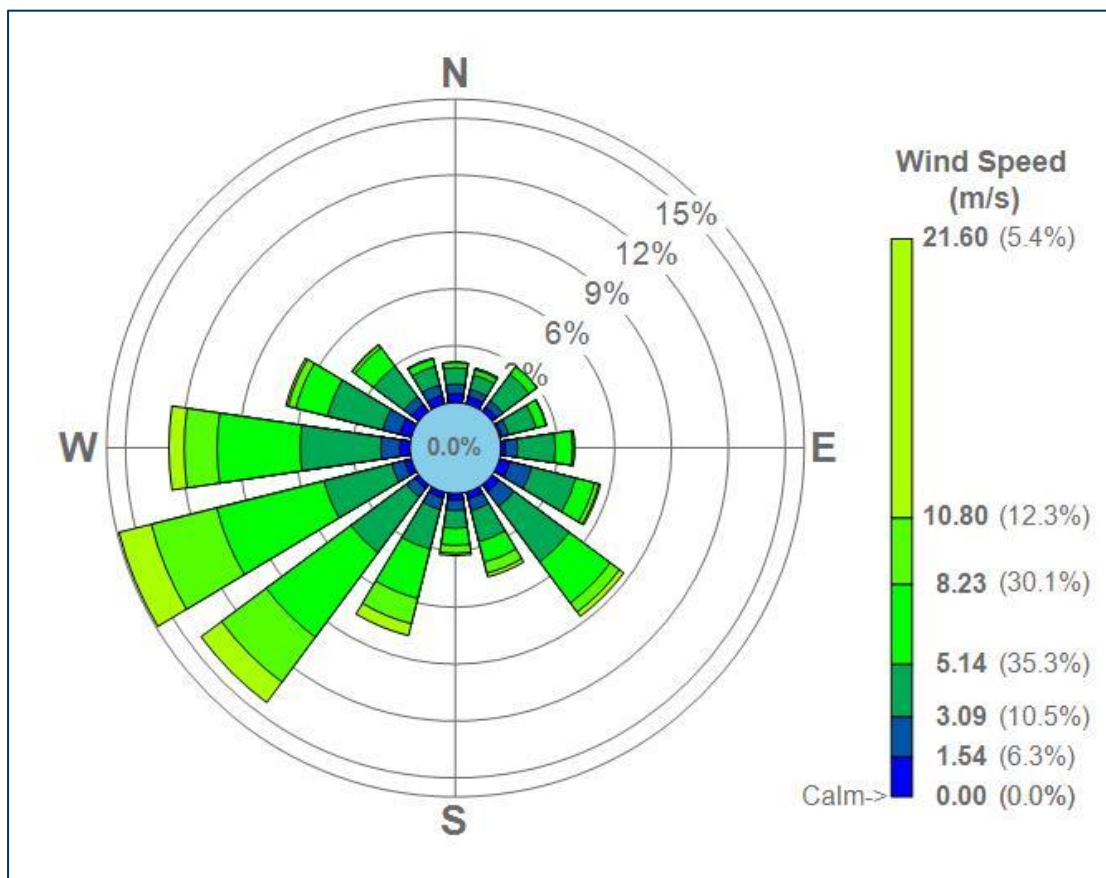


Figure 5.15 SCHEMATIC ILLUSTRATING WINDROSE FOR METEOROLOGICAL DATA USED FOR ATMOSPHERIC DISPERSION MODELING - DUBLIN 2011 TO 2015 INCLUSIVE.

TABLE 5.6 CUMULATIVE WIND SPEED AND DIRECTION FOR METEOROLOGICAL DATA USED FOR ATMOSPHERIC DISPERSION MODELING DUBLIN 2011 TO 2015 INCLUSIVE.

Cumulative Wind Speed Categories							
Relative Direction	> 1.54	>3.09	>5.14	>8.23	> 10.80	< 10.80	Total
0	0.47	0.51	0.86	0.29	0.01	0.00	2.13
22.5	0.40	0.40	0.77	0.30	0.07	0.00	1.94
45	0.30	0.41	1.74	0.50	0.02	0.00	2.96
67.5	0.13	0.37	1.49	0.54	0.03	0.00	2.56
90	0.22	0.65	2.00	0.91	0.10	0.00	3.88
112.5	0.57	1.18	2.39	1.03	0.23	0.09	5.49
135	0.47	0.96	3.64	2.69	0.60	0.29	8.65
157.5	0.37	0.63	1.68	1.12	0.59	0.21	4.61
180	0.35	0.53	0.94	0.91	0.42	0.12	3.28
202.5	0.31	0.63	2.16	2.68	1.38	0.65	7.80
225	0.25	0.57	3.65	5.56	2.95	1.35	14.32
247.5	0.36	0.70	3.69	5.83	3.56	1.76	15.90
270	0.54	1.00	4.25	4.38	1.74	0.81	12.72
292.5	0.62	0.94	3.00	1.72	0.42	0.13	6.82
315	0.47	0.50	2.00	1.22	0.19	0.03	4.41
337.5	0.46	0.56	1.02	0.42	0.04	0.00	2.49
Total	6.28	10.54	35.26	30.11	12.33	5.43	99.95
Calms	--	-	-	-	-	-	0.05
Missing	-	-	-	-	-	-	0.00
Total	-	-	-	-	-	-	100.00

Appendix 5.3

Checklist for EPA Requirements for Air Dispersion Modeling Reporting

TABLE 5.7 EPA CHECKLIST AS TAKEN FROM THEIR AIR DISPERSION MODELING REQUIREMENTS REPORT.

ITEM	YES/NO	REASON FOR OMISSION/NOTES
Location map	Yes	-
Site plan	Yes	-
List of pollutants modeled and relevant air quality guidelines	Yes	-
Details of modeled scenarios	Yes	-
Model description and justification	Yes	-
Special model treatments used	Yes	-
Table of emission parameters used	Yes	-
Details of modeled domain and receptors	Yes	-
Details of meteorological data used (including origin) and justification	Yes	-
Details of terrain treatment	Yes	-
Details of building treatment	Yes	-
Details of modeled wet/dry deposition	N/A	-
Sensitivity analysis	N/A	Five years of hourly sequential data used from nearest valid met station-Dublin 2011 to 2015. Worst case year was Year 2015.
Assessment of impacts	Yes	Pollutant emissions assessment from process identified.
Model input files	No	DVD can be sent upon request. Files are a total of 4.60 GB in size.

6 GROUNDWATER

6.1 EXISTING ENVIRONMENT

The underground workings are made up of a number of distinct but integrated mining sub-areas: (Figure 6.1).

- The Main Mine,
- Liscartan/Rathaldron,
- The Southwest Extension (SWEX), and
- Nevinstown

The Nevinstown Extension is located immediately northeast of the Main Mine, the original area of mining at Tara. Working of the Main Mine commenced in 1977, and mining of the Nevinstown Extension commenced in 2004 (ceasing in 2015).

A detailed surface water and groundwater monitoring program has been in place since the start of mining and is on-going. The monitoring program includes meteorological data, detailed geology including geological logs and completion details of all holes drilled, a groundwater monitoring network including water levels and hydrochemical samples taken from monitoring wells, and monitoring of underground groundwater discharge rates and water quality. An annual water balance for the mine is prepared.

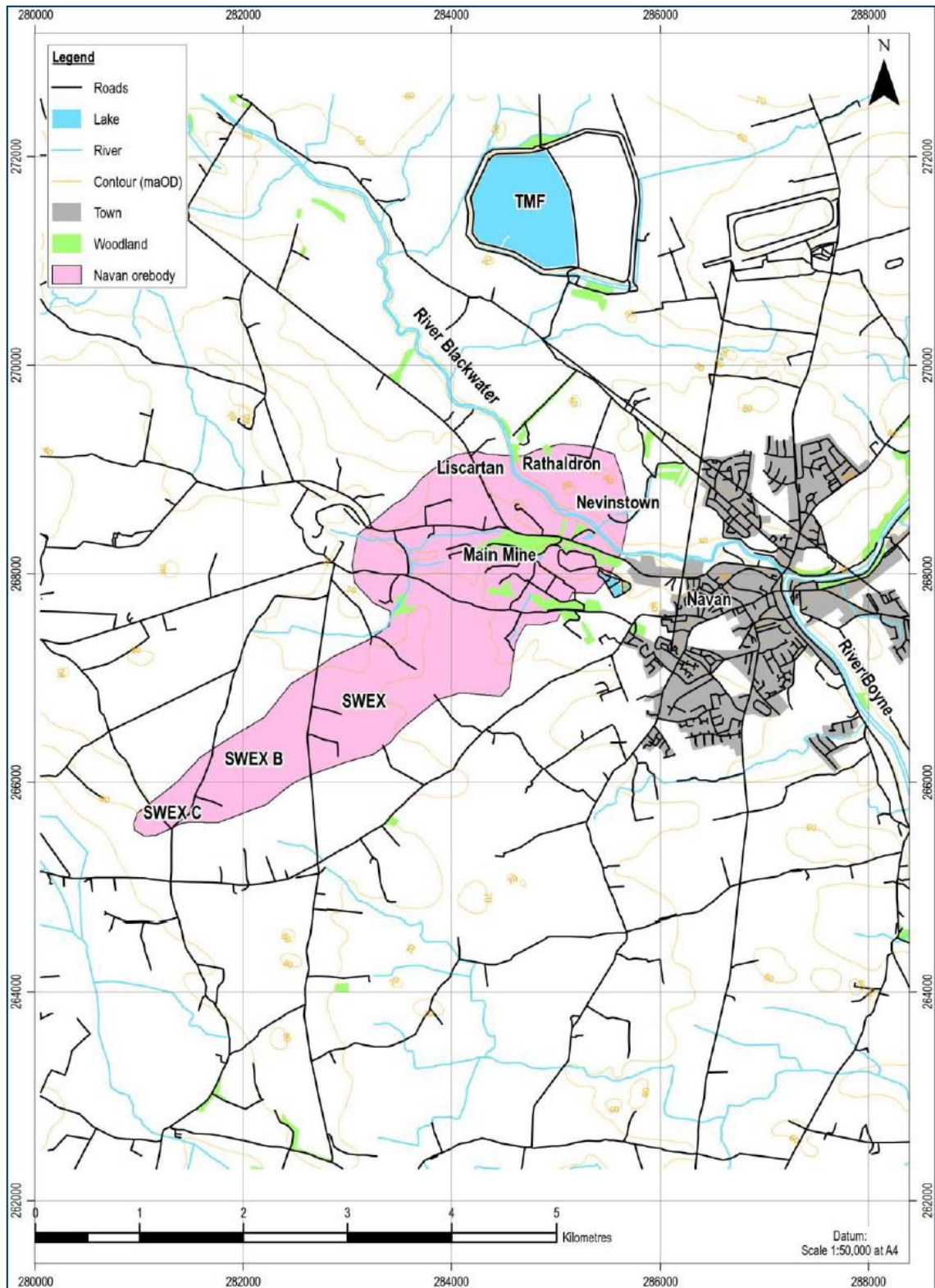


FIGURE 6.1 UNDERGROUND WORKINGS

6.1.1 GEOLOGY

The geology of Tara Mines has been characterized by the many geological exploration holes that have been drilled over a 40-year period.

The main stratigraphic units are as follows:

- **Superficial deposits**, consisting mainly of dense boulder clay, but with occasional silt and discontinuous sand and gravel lenses that usually occur in areas where the glacial deposits are thicker. Thicker alluvial deposits may occur beneath the flood plain of the River Blackwater
- **Weathered Upper Dark Limestone (UDL)** that directly underlies the alluvium and may extend to several hundred meters depth where weathering has occurred along the principal geological structures, such as the P-fault above the SWEX area
- **Competent Upper Dark Limestone (UDL)** which forms a thick layered sequence of limestones, shaley limestones and shales that is strongly bedded
- **Boulder Conglomerate**, which comprises a relatively thin sequence of conglomerate and mudstone layers
- **Shaley Pales**, which mostly consist of shaley limestone above the main ore sequence
- **Pale Beds Limestone (PB)**, which hosts the main orebody and is also the main bedrock groundwater unit in the area of Tara Mines. The Pale Beds occurs beneath the UDL throughout most of the Tara Mines area. It outcrops over an area of about 13 km² to the northwest of the mining area, partly above the Nevinstown and Liscatan/Rathaldron sub-areas (Figure 6.2).

Palaeozoic rocks occur to the east of the Nevinstown area and are in fault contact with the UDL and Pale beds. The bedrock beneath the River Blackwater is currently being dewatered and there is an unsaturated zone between the saturated river flood plain sediments and the water level in the underlying bedrock. Currently, the Pale Beds below the river in this area are dewatered to about 20-30 m above the mining horizon (elevation -120 to -170 maOD). The degree of leakage from the river is limited by the thickness and low permeability of the flood plain sediments and the weathered nature of the bedrock surface. It is estimated that inflows derived from the river and flood plain deposits currently account for less than 2% of the total mine inflows.

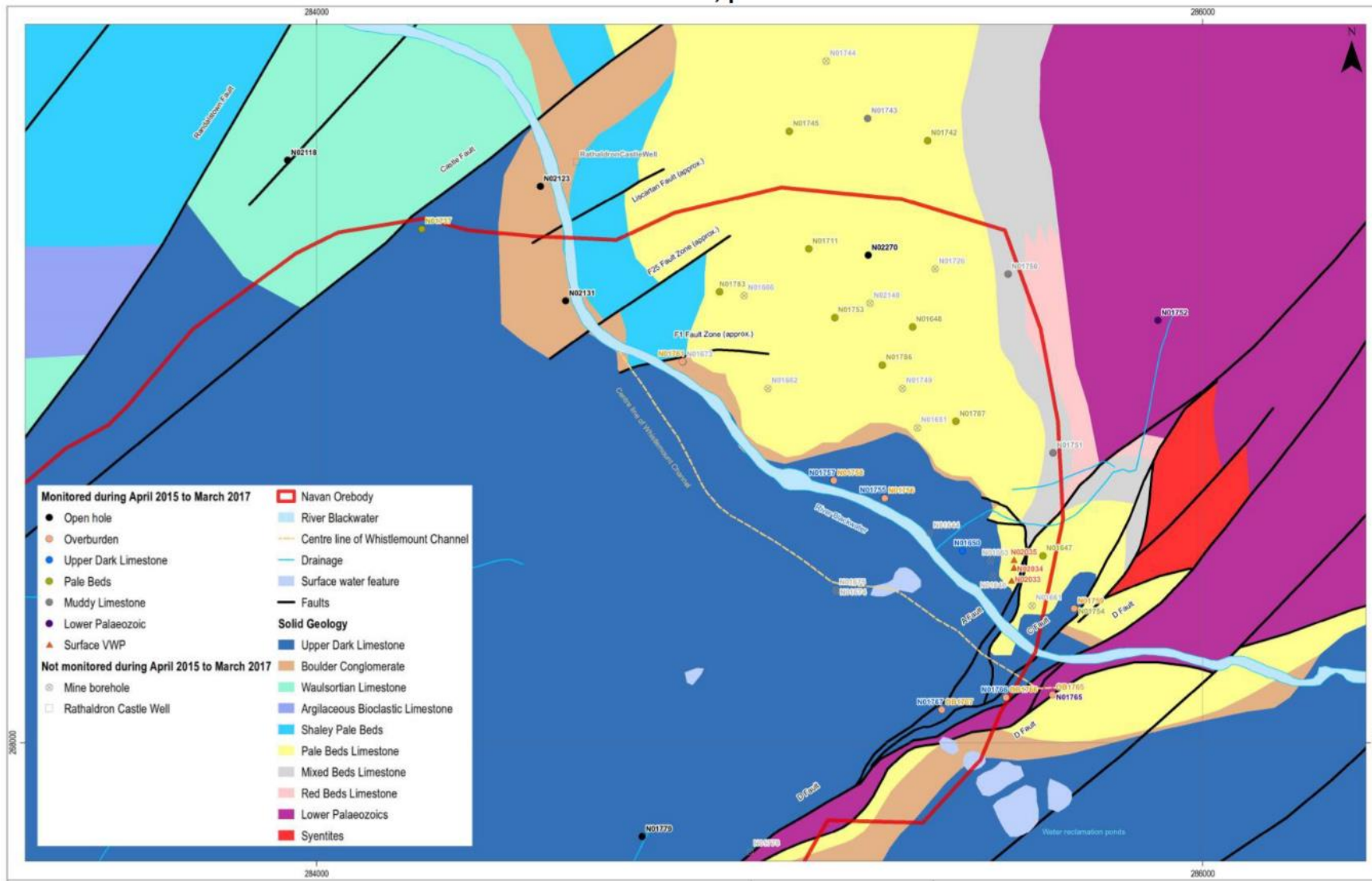


FIGURE 6.2 BEDROCK GEOLOGY MAP OF THE TARA MINES ARE SHOWING THE SUBCROP OF PALE BEDS (YELLOW) IN NEVINSTOWN AND TO THE NORTHWEST

6.1.2 RAINFALL

The average annual rainfall in the Navan area is about 900 mm (TABLE 6.2). A meteorological station has been in place at Tara Mines site since the early 1970s. The station is located adjacent to the main Knockumber mine site at National Grid Reference 284808, 268441. It reports daily rainfall, maximum and minimum air and soil temperatures. Rainfall has been reported daily since 1987.

TABLE 6.2 RAINFALL STATISTICS AT TARA MINES

Month	Apr 2015 to Dec 2015 (mm)	Jan 2016 to Dec 2016 (mm)	Jan 2017 to Feb 2017 (mm)	Long Term Average (mm)
January	64.1	111.7	35.3	86.4
February	31.1	90.3	52.9	69.4
March	64.3	55.8	92.2	60.1
April	43.0	86.7	14.5	62.5
May	123.2	69.2	66.9	61.6
June	38.3	72.2	97.9	76.1
July	76.8	69.6	72.3	72.3
August	86.9	58.3	61.1	79.2
September	42.4	76.8	102.2	67.7
October	28.3	44.3	39.4	93.6
November	166.4	38.3		86.5
December	308.6	53.5		89.0
Total	1073.3	826.6		904.4
Notes: Long term average based on period 1 January 1987 to 31 December 2016.				

Periods of abnormal rainfall have been reported throughout Ireland in recent years. Rainfall in 2015 was 19% higher than the long-term average, and rainfall in 2016 was 9% lower. High rainfall totals were reported for November and December 2015, with 475 mm recorded for the combined months. This is the equivalent of 48% of average annual rainfall. The monthly rainfall total in December 2015 (308.6 mm) was the second highest monthly rainfall recorded since the start of monitoring in 1987. November 2015 was the seventh wettest month on record.

Excluding May 2015, the period January 2015 through to October 2015 experienced lower than average rainfall; 475 mm rainfall was recorded compared to the long-term average 667 mm for the same period. In contrast, May 2015 experienced 100% more rainfall (123.2 mm) than the long-term average (61.6 mm). In early 2016, the trend from the end of 2015 continued, with higher than average rainfall during the first five months of the year. Total rainfall between January 2016 and May 2016 was 22% higher than the long-term average (413.6 mm compared to 340.1 mm). In contrast, total rainfall from October 2016 to February 2017 was nearly 50% lower than the long-term average (224.3 mm compared to 424.9 mm).

6.1.3 MINE DEWATERING

Inflows of groundwater (water-makes) to the mine workings occur where natural groundwater-filled structures (faults, fractures, joints or cavities within the Carboniferous sequence) or water-filled drill holes are intercepted by the mining advance or by underground mine water control or ore delineation drill holes. The locations of the water-makes are shown on FIGURE 6.3. The water-makes are colour coded by the year in which they were first recorded as flowing.

The Nevinstown mining area is hydraulically connected to the Main Mine, which has been in operation since the 1977. Dewatering of the Main Mine is carried out using a series of sumps to collect the mine inflows. Water from the sumps is routed to the main pumping stations and pumped to the surface. Significant groundwater (water-make) inflow rates are estimated by the Tara Mine Geology Department on a weekly basis. When practical, the flow rate is estimated by measuring the time that the water-make takes to fill a container of known volume.

On-going recharge to the mine are occurs over a subcrop area of Pale Beds around 13 km² immediately to the northwest of the mining area which includes parts of both Nevinstown and Liscartan/Rathaldron orebodies.

The zone of active groundwater circulation in the Pale Beds extends to relatively shallow depths within and just down-dip of the Pale Beds outcrop area. As one moves further down-dip within the Pale Beds, beneath the increasing thickness of UDL cover, the residence time of the water in the Pale Beds increases.



FIGURE 6.3 LOCATION OF WATER MAKES RECORDED IN NEVINSTOWN

The Main Mine is stratigraphically down-dip from Nevinstown. As a result, a considerable lowering of groundwater levels had already occurred prior to the start of mining at Nevinstown in 2004. Because most of the on-going recharge to the Tara Mines orebodies is derived from infiltration over the Pale Beds subcrop area, the Nevinstown mining area is close to the recharge source. Consequently, many of the groundwater inflows are now managed in Nevinstown, rather than in the Main Mine.

As a result of the connection between the two mining areas, the mining of Nevinstown has caused an equivalent reduction of the inflow and dewatering rate for the Main Mine. There has been virtually no net increase in the overall groundwater inflow rate to the mine as a result of mining Nevinstown.

The Liscartan and Rathaldron mining areas are located to the west and northwest of Nevinstown. Mining of these areas commenced in 2014. They are also hydraulically connected to the Main Mine and Nevinstown. Consequently, mining of these areas is also occurring without any significant increase in the overall groundwater inflow or mine dewatering rate.

6.1.4 GROUNDWATER INFLOWS

The hydrochemistry of water-make inflows to the Nevinstown workings is of young calcium-bicarbonate groundwater consistent with recent meteoric recharge to the Pale Beds subcrop area. There is no hydrochemical evidence that leakage from the River Blackwater contributes any significant proportion of the inflow. The underground workings of Nevinstown have continued to remain hydraulically isolated from the River Blackwater.

Recharge to the Pale Beds occurs over the subcrop area of about 13 km², and is considered to be around 20-25% of annual precipitation, potentially higher in wet years. Based on this assumption, it is estimated that aerial recharge over the subcrop of the Pale Beds area contributes around 6,400 m³/day to 8,000 m³/day; equivalent to 46% to 57% of the cumulative flow rate to the Main Mine, SWEX and Nevinstown. In 2015, the extreme rainfall recorded in November and December is considered to have contributed additional recharge to the Pale Beds, equivalent to almost 70% of the cumulative inflow rate to the mine.

The balance of the inflow is likely derived from recharge over the UDL subcrop areas and gradual downward leakage through the UDL sequence. Although the footprint area of the UDL above the mine workings is significantly greater than the subcrop area of the Pale Beds, the percentage of surface precipitation that becomes bedrock recharge in the UDL subcrop area is considerably lower.

The number of active water-makes varies over time and their flow rates fluctuate. This variation is due to a number of factors, including changes in mining activity (stopping and advancement of drifts) or exploration drilling in the vicinity, development of other water-makes (capturing flow from existing water-makes), pressure grouting of water-makes, and variations in groundwater recharge associated with rainfall cycles. The uncontrolled inflow from water-makes continues to increase slightly as the mine void increases in volume.

A high proportion of the observed inflow to the Main Mine and Nevinstown occurs close to the F1 fault, particularly where the workings intercept swarms of open joints. Significant inflows in the vicinity of the F1 (and F24) fault zone were observed during and following the high rainfall recorded between November 2015 and February 2016. Underground water-makes associated with the A and B Faults were observed much less frequently.

Appendix 6A Figures 1-6 present water-make discharge hydrographs up to the end of the current monitoring period for the major water-makes recorded at Nevinstown and Liscartan/Rathaldron. Water-makes have been grouped together based on the mine level and approximate geographical location.

To date, 86 water-makes have been recorded since the start of the water-make record in 2003 (excluding the minor water-makes (commonly less than 8.6 m³/day) which collectively have a recorded inflow rate of between 86 and 259 m³/day). Since 2003, 51 water-makes have ceased to discharge, either through exhaustion of the groundwater storage in the fracture system or cavity feeding the water-make, or as a result of plugging, grouting or channelling the water-make for abstraction.

Many of the early water-makes at Nevinstown were at shallower levels in the mine, but these dried up as mining progressed deeper and as the water table was lowered.

A number of water-makes relevant to Nevinstown and Liscartan/Rathaldron are currently grouped with those of the Main Mine in the Tara monitoring database. This is partly for reasons of historical expediency and partly because of the good hydraulic connection between the Main Mine, Nevinstown and Liscartan/Rathaldron. These include the 1450 226N development drift in Nevinstown, the 1230 B17EX extension drift from the Main Mine into Liscartan, and the hanging wall drift of Zone 3 in Nevinstown.

Appendix 6A Table 1 provides a summary of the recorded discharge at the individual water-makes since records began. Each location is assigned a unique name, which is derived from the mine level and a mine location term. Appendix 6A Table 2 summarises the maximum, minimum and mean measured flow rates for water-makes recorded as actively flowing during the current reporting period. The table presents the average percentage contribution of an individual water-make compared to the total Nevinstown water-make discharge.

Average flow rates for eight water-makes have recently shown an increase. These are mainly located in the vicinity of the F1 Fault zone as a result of the period of high rainfall from November 2015 to February 2016, as follows:

- 1395 N303/304DA was first encountered in May 2012, after development of the 1395 N304DA drift from May to July 2012, this water-make also incorporates water from the 304DA drift. The

average flow rate from this water-make has increased from 720 m³/day to 1,750 m³/day since 2012, making it the most significant water-make, contributing almost 30% to the total Nevinstown inflow. Appendix 6A Figure 3 shows that, since December 2015, the flow rate has increased significantly from <300 m³/day to >3,000 m³/day at the end of December 2016. This is considered to be largely due to increased inflows to the mine in the vicinity of the F1 Fault Zone from the high rainfall and recharge to the Pale Beds subcrop area during the period November 2015 to February 2016

- Since February 2011, the groundwater from 1390 N303 water-makes has been pumped to the surface and discharged to the surface water pond. The new system includes a dedicated reservoir, pump and pipe range, with single-stage pumping to surface and discharge into the mine reclaim surface water pond. This water is stored in the surface clear water pond, from where it is periodically discharged (depending on river flow rates), under licence, into the River Boyne. Water-make discharge rates from 1390 N303CA are no longer presented as water-make discharges but are recorded separately as 'Nevinstown controlled inflows' and reported as part of the overall mine water balance as Nevinstown controlled inflows

- Water-make 1315 1NEXDW is considered to be linked to the F-24 fault zone situated between the F1 and F25 fault zones. Discharge to this area is removed via a pipeline to headings 1395 N210CX/1390 N303CA. Approximately 21% of the total inflows to Nevinstown are currently attributed to this water-make, with significant inflows (>4,000 m³/day) recorded in early 2016 following the period of above average rainfall. The average flow rate decreased to <50 m³/day by June 2016 and has remained stable since.

6.1.4.1 INFLOWS FROM THE RIVER BLACKWATER

Three of the water-makes (1450 226N, 1450 226N (CGO) and 1500 NDEX2) are situated either beneath the footprint of, or close to the surface drainage pond to the south of the River Blackwater. It is considered that the flow at these locations is linked to the leakage from the surface water pond facilitated by the bedrock fracture network and old N00173 core hole. The combined average flow rate from these water-makes has decreased to about 77 m³/day, and the contribution is approximately 1.3% of the total mine inflow. There is a direct relationship between flow from the 1450 226N water-makes and rainfall, as shown on Appendix 6A Figure 5.

It is considered that the increase in flow rate is linked to the increased rainfall for the current monitoring period, particularly at the end of 2015/beginning of 2016.

6.1.4.2 SUMMARY OF MINE WATER INFLOWS

The total average inflow from water-makes at Nevinstown has recently increased by around 2,700 m³/day (TABLE 6.3). This is a recent increase of approximately 85% of the total uncontrolled flow. It is directly attributable to the period of high rainfall from November 2015 to February 2016. Peak total mine inflows during this period were in excess of 17,000 m³/day, which is the highest inflow rate recorded since records began. Inflows to the mine in the vicinity of the F1 Fault zone accounted for 75% of the total discharge to Nevinstown, as recorded at water-makes 1395 N303/304DA (30%), 1390 N303CA (23%) and 1315 1NEXDW (21%).

TABLE 6.3 SUMMARY STATISTICS FOR TOTAL MINE WATER-MAKE INFLOWS

Monitoring Period	Average Total Water-make Flow (m ³ /day)	Min Total Water-make Flow (m ³ /day)	Max Total Water-make Flow (m ³ /day)
April 2005 to March 2007	5,053	3,888	7,895
April 2007 to March 2009	4,224	1,650	9,819
April 2009 to March 2011	4,589	3,430	6,094
April 2011 to March 2013	2,733 [#]	1,499	4,432
April 2013 to March 2015	3,233	2,160	5,296
April 2015 to March 2017	5,938	1,506	17,446

Notes:

- The overall reduction in uncontrolled inflow is directly attributable to the channelling and control works on water-make 1390 N303CA which was responsible for over 50% of the uncontrolled inflows at Nevinstown.

6.1.5 MINE WATER BALANCE

Appendix 6A Figure 6 presents a summary mine groundwater inflow, including the contribution of Nevinstown, Liscartan/Rathaldron, the Main Mine and SWEX. Mine water outflow comprises groundwater (originating from the water-makes), service water and backfill drainage water. These flow volumes are measured on a daily basis. Water is continuously pumped from the mine workings by the mine pumping stations to the water reclaim ponds. Water is also removed from the mine workings by the Mars Pump, which discharges to the surface via the tailings line, rather than to the reclaim ponds.

In early February 2011, all water-makes in the 1390 N303CA drift were harnessed for pumping. Pumping of this groundwater began on 16 February 2011 in a single stage, and is pumped to surface via the new dedicated 1390 reservoir, pumping station and pipe range to surface (this water is not routed through the primary mine pumping system). This water is stored in the surface clear water pond from which it is periodically discharged (depending on river flow rates), under licence, into the River Boyne. Discharge rates from 1390 N303CA are no longer recorded as water-make discharges but are recorded and presented separately as part of the overall mine water balance as 'Nevinstown controlled inflows'. This volume has consequently removed from the load on the No.1 Pump Station, thus increasing pumping capacity from elsewhere in the mine.

6.1.5.1 WATER BALANCE CALCULATIONS

The mine water balance is expressed as the following equation:

$$Net_GW_In = MineWater_ExMine - (Service_W + Backfill_W)$$

Where:

- *Net_GW_In* = the net groundwater inflow rate to the mine.
- *MineWater_ExMine* = the rate of pumping of water from the mine. This is the sum of the measured pumping from the sequence of mine pumps (No. 1 Pump Station + Nevinstown 1390 Pump Station + the estimated rate of discharge of water to the tailings line by the Mars Pump).
- *Service_W* = the rate of inflow of service water to the mine void.
- *Backfill_W* = the rate of inflow of water in backfill tailings. The backfill tailings is pumped into the mine workings at a water content of around 40%. A 5,000 tonne pour contains 1,900 tonnes of water and 3,100 tonnes of tailings sand. It is estimated that 10% of the water is retained within the tailings post placement in the workings. This is equivalent to 5.8% of the mass of the sand plus water in the post-placement tailings.

Water-make inflows to Nevinstown (excluding controlled Inflows) increased from 3,130 m³/day (March 2015) to 5,730 m³/day (December 2016). Inflows peaked at over 9,000 m³/day between December 2015 and May 2016, following the period of above average rainfall. The Nevinstown and Liscartan/Rathaldron workings are up-dip from the Main Mine and SWEX, and consequently are more susceptible to periods of increased rainfall.

From April 2015 to December 2016, a total of 1,286,000 m³ of clean water was pumped directly to surface via the 1390 clean water pumping station (Nevinstown controlled inflows). This is less than previous in order to allow pumping of the uncontrolled inflows from the mine, this occurred most notably in December 2015, January 2016 and May 2016, resulting in a lower volume removed via the 1390 clean water pumping station.

Water-make inflows to the Main Mine have remained largely stable, but with a slight increase observed at the end of 2015/early 2016. Average inflows peaked at approximately 3,500 m³/day from December 2015 to April 2016. Average monthly inflows reduced gradually to 3,300 m³/day by the end of December 2016.

Water-make inflows from SWEX show an overall (20%) increase from April 2015 (2,330 m³/day) to end December 2016 (2,800 m³/day). A similar rise of 21% was recorded from the start of April 2013 to end March 2015. Conversely, controlled inflows to SWEX at the 0650 collection point have decreased by over 70% from 685 m³/day (April 2015) to 185 m³/day (December 2016). As a result, the overall combined average SWEX uncontrolled and controlled flow rate remained relatively stable at 2,995 m³/day in December 2016, compared to 3,005 m³/day in April 2015. Inflows to SWEX increased slightly during the period of extreme rainfall (December 2015 to February 2016) but overall remained largely unimpacted compared to Nevinstown, due to the depth and isolation of the workings.

6.1.6 SUMMARY OF WATER BALANCE

The overall mine water balance may be summarized as follows:

- The total volume of groundwater and controlled inflows for the whole mine (Nevinstown + Main Mine + SWEX) has increased to 9,000,000 m³
- The overall average water-make inflow for the whole mine has increased to 14,300 m³/day (December 2016)

- Groundwater inflows to the Main Mine have increased by 6%
- Groundwater inflows (including controlled inflows) to SWEX have decreased by less than 0.5%
- Groundwater inflows to Nevinstown and Liscartan/Rathaldron (including controlled inflows) have increased by 38%.

The relative contribution of each mine area to the overall mine water-make inflow (including controlled inflows) is as follows:

- Nevinstown and Liscartan/Rathaldron: 7,950 m³/day (56% of total groundwater inflow)
- Main Mine: 3,320 m³/day (24% of total groundwater inflow)
- SWEX: 2,800 m³/day (20% of total groundwater inflow)

6.1.7 GROUNDWATER LEVEL MONITORING

A total of 49 observation wells have been monitored for water level within and around the Nevinstown and Liscartan/Rathaldron extensions, of which 36 are purpose-designed monitoring wells with screens in specific hydrostratigraphic units. The remaining holes are open along their full length. The location of the observation wells are shown in Figure 2 in Appendix 6B.

In August 2010, six Vibrating Wire Piezometers (VWPs) were installed in the Nevinstown Crown Pillar. The VWPs were installed in three new dual purpose surface diamond drill holes. These holes, drilled due east at angles of -45°, were targeted to intersect and locate the A Fault zone and associated structures at a high angle. Completion information for the piezometer holes is included in TABLE 6.4.

TABLE 6.4 COMPLETION DETAILS FOR THE VIBRATING WIRE PIEZOMETERS INSTALLED IN THE NEVINSTOWN CROWN PILLAR

N02033			N02034			N02035		
Easting	Northing	Malin	Easting	Northing	Malin	Easting	Northing	Malin
285569.4	268366.0	40.9	285574.2	268395.3	42.4	285573.8	238413.5	42.9
Downhole Depth and Location of Nevinstown VWP's								
N02033			N02034			N02035		
Upper	18.2m	A Fault	Upper	N/A	Open Hole	Upper	24.5m	A Fault
Middle	N/A	N/A	Middle	N/A	Open Hole	Middle	39.5m	A Fault Branch
Lower	132.5m	3-5 Lens HW	Lower	200m	Laminated Beds	Lower	115.0m	3-5 Lens HW

The primary purpose of these VWPs is to continuously monitor groundwater pressures in and around the A Fault zone. Any significant increases in water pressure would provide a warning of groundwater infiltration into the fault zone. This could be due to structural movement in the A Fault zone allowing water ingress. The holes were all drilled down to and beyond the 3-5 lens ore footwall horizon, yielding additional geological information, in addition to pore water pressures. The lower VWP sensor in each holes defines ongoing ambient groundwater pressures at the 3-5 ore hangingwall zone.

6.1.8 SURFICIAL GROUNDWATER LEVELS

Appendix 6 B Figure 1 shows groundwater level hydrographs for overburden (superficial deposits) wells for the period April 2004 to March 2017. The hydrographs include rainfall as a monthly total as well as the calculated long term monthly average since records began in 1987. There are seven monitoring wells screened in the overburden; they range from 2.3 m to 10.0 m in depth. N01756, N01758, N01759 and N01761 are close to the northern bank of the River Blackwater. N01756 and N01758 overlie the Nevinstown workings. OB1765, OB1766 and OB1767 are situated to the south of the River Blackwater, located in the Whistlemount Channel.

There is a correlation between rainfall and groundwater level fluctuations within the overburden. Increases in groundwater levels correspond to the periods of higher rainfall in May 2015, November to December 2015, and April 2016. Decreases in groundwater levels were observed following the peak levels recorded during the November 2015 to February 2016 period. The greatest fluctuation is observed in N01761, with groundwater levels ranging by 4.5 m throughout the reporting period. N01761 is 10 m deep and screened over a 7.5 m length in the overburden deposits, compared to the other shallow wells which are about 3 m deep and screened over intervals between 1 and 1.5 m. The smallest fluctuation is observed in N01758, which only varies by 0.5 m throughout the monitoring period.

Sustained or non-seasonal decreases in water level are not discernible in the hydrographs of the overburden wells. This indicates that the dewatering and mining operations at Tara Mines continue to have no discernible impact on groundwater levels in the superficial deposits.

OB1765, OB1766 and OB1767 in the Whistlemount Channel, demonstrate the highest groundwater levels of all the overburden monitoring wells. This area is hydraulically connected to the river. The shallower monitoring wells do not show any response to mining. They are separated from the deeper, basal sand and gravel unit by a thickness of approximately 15 m of clay and silt (glacial till). The basal sand and gravels of the Whistlemount Channel have become drained as a result of the mine dewatering without impacting the shallow deposits, which remain saturated. Downward percolation within the Whistlemount Channel is low because of the low permeability of the clayey till. Thus, the near-surface groundwater system in the Whistlemount Channel remains unaffected by the underlying mining operations.

6.1.9 GROUNDWATER LEVELS IN THE UDL

Appendix 6 B Figure 2 shows hydrographs for the UDL monitoring wells. Monitoring ceased in wells N01644 and N01674 due to blockages in December 2004 and March 2005, respectively. These wells are not shown on the figure.

N01650, N01755, N01757 are situated to the north of the River Blackwater. N01755 and N01757 are within 20 m of the river, N01650 is around 45 m NE of the river. N01766 and N01767 are situated to the south of the River Blackwater. N01766 is within 60 m of the centreline of the Whistlemount Channel. N01767 is around 150 m southwest of the centreline of the channel. N01766 is situated

between the D and C Faults, here separated by less than 30 m. The D Fault brings Palaeozoic rocks to the surface to the east of the UDL outcrop. N01767 is situated between the A and C Faults, around 35 m apart at that location.

Long term groundwater levels have remained relatively stable after a period of general increasing groundwater levels which commenced in mid-2006, correlating with an increase in cumulative rainfall. No long-term decline in groundwater levels is discernible in any of the UDL hydrographs.

The recent monitoring results do show a correlation with rainfall. Groundwater level peaks coincide with periods of high rainfall. Responses are similar in N01757 and N01766; all with relatively low fluctuations in groundwater level (1.5 m in N01757 and 1.0 m in N01766). Groundwater level responses are similar between N01755 and N01650 where they are observed to range by 8.3 m and 9.5 m, respectively.

Groundwater levels in N01767 generally show small (less than 1 m) changes apart from between May and December 2015, where a decrease and recovery of nearly 6 m was observed. A decrease of 5.1 m for N01755 was recorded over the same period. It has been previously proposed this could be linked to a change in storage with depth in the UDL. Groundwater levels were observed to sharply recover back to May 2015 levels in November 2015. These periods of groundwater level decline have been observed on multiple occasions since April 2004 and have been found to coincide with seasonal variations in rainfall, as previous lows in N01767 were observed in August 2004, 2005, 2006, 2008 and in September 2011 and 2013.

6.1.10 PALE BEDS GROUNDWATER LEVELS

Since the mine void is mostly located in the Pale Beds unit, the hydrographs of wells screened in the Pale Beds are more strongly influenced by mining-related events than those wells screened in the overlying formations. Appendix 6B Figures 3 and 4 show the groundwater level hydrographs for the monitoring wells screened in the Pale Beds. Monitoring in well N01673 ceased in April 2007, N01749 ceased in October 2007, and N01661 ceased in December 2012 because the falling groundwater levels at the level of the mining horizon.

With the exception of N01754, all the Pale Beds monitoring well hydrographs demonstrate a significant drop in groundwater levels from late summer 2007 until almost the end of 2007, when Nevinstown dewatering was being ramped up. Groundwater levels have shown a stable trend in many of the monitoring wells since early 2008, however a recent declining trend is observed in some wells (N01711, N01742, N01743, N01745, N01737 and N01783) from mid-2015 as a result of mining the Liscartan and Rathaldron sectors of the mine, which are hydraulically connected to Nevinstown (Appendix 6B Figure 3).

N01754 is screened in the Pale Beds and underlying Red Beds. The hydrograph for this well shows a stable long-term trend with groundwater levels fluctuating due to rainfall patterns (Appendix 6B Figure 4). Groundwater levels followed a rising trend at the start of monitoring in 2004 to 2011 before stabilising. It is noted that this well is located within a faulted block in between the A Fault and the C Fault and screened within highly fractured Pale Beds close to the C Fault. N01754 consistently has the highest groundwater levels of all monitoring wells in the Pale Beds.

Similar to N01754, borehole N01647 is located between the A Fault and the C Fault and has shown little recent change due to the on-going dewatering, with post-2009 groundwater levels observed to be slightly higher than early 2004 levels (Appendix 6B Figure 4). Recent groundwater levels have shown a correlation with rainfall, with an increase of over 19 m in response to the period of high rainfall at the end of 2015.

N01711, N01737, N01745, N01753, N01787 are screened in the Pale Beds and the underlying Muddy Limestone. Water levels in N01787 have followed an almost identical pattern to N01647 through the current monitoring period (Appendix 6B Figure 4). Groundwater levels remain around 30 m lower than pre-mining levels. Hydrographs from N01711, N01742, N01743 and N01745 all show very similar trends and ranges in groundwater level fluctuations in response to rainfall and on-going mine dewatering effects (Appendix 6B Figure 3). The hydrographs for these wells have shown a long-term decreasing trend in peak groundwater levels, since February 2011. Groundwater levels have followed a declining trend since the peaks recorded in February 2016, despite average or above average rainfall occurring in the period to October 2016.

N01742, N01783 and N01786 are screened solely within the Pale Beds. N01647 and N01648 are predominantly open in the Pale Beds. The hydrograph of N01786 has shown a continuing long-term stable trend in groundwater levels from January 2008 to March 2017 (Appendix 6B Figure 4). Groundwater levels are approximately 25 m lower than pre-mining levels although now appear to be stable at around -39 maOD. Groundwater levels continue to fluctuate by around 5 m due to rainfall patterns and on-going mine dewatering.

N01743 is screened from the Muddy Limestone Transition (MLT) at the base of the Pale Beds through the Muddy Limestone and into the Laminated Beds. Water level data are considered representative of the Pale Beds.

Groundwater levels in N01648 and N01753 have been stable since early 2008 and fluctuate by between 5 and 7 m (Appendix 6B Figure 4). The levels follow opposite trends from April 2016, with a decrease of approximately 10 m observed in N01648, and an increase of over 10 m in N01753. Groundwater levels in N01753 are analogous to levels observed pre-2008. A similar rise (10m) in groundwater level is observed in N01783, located 260 m west of N01753, over the same period. Other boreholes located to the east (N01648) and southeast (N01786) of N01753 display a decrease in groundwater levels. It is considered that the rise in groundwater level is likely due to the sealing of underground water-makes at the mining horizon which has locally caused a rebound in water levels.

The hydrograph of N01737 shows the widest fluctuations of all the monitoring wells, with fluctuations in excess of 50 m observed (Appendix 6B Figure 4). Recent groundwater levels were observed to decrease from +33.1 maOD in May 2016 to -45.2 maOD in September 2016. It is noted that this well has one of the longest screen intervals (48 m) and is screened across a significant fracture zone associated with faulting at a depth of 300 m below ground level.

Groundwater levels in N01783 decreased by over 60 m, from -41 mAOD in May 2015, to -105.9 mAOD in May 2016, despite the period of high rainfall at the end of 2015. Groundwater levels have since recovered to -57.3 mAOD. This well is located close to the 1390 level Nevinstown clean water pumping station and the pumping activities (started in February 2011) have had a notable effect on local groundwater levels in the Pale Beds. The recovery in groundwater level from May 2016 is considered to be a result of sealing of underground water-makes at the mining horizon.

6.1.11 GROUNDWATER LEVELS IN UNITS UNDERLYING THE PALE BEDS

The Pale Beds are underlain by less permeable formations: the Muddy Limestones, Laminated Beds, Red Beds. The Muddy Limestones and Laminated Beds can be referred to collectively as the Mixed Beds. In view of their low permeability, the formations are considered as a single hydrostratigraphic unit (formations underlying the Pale Beds). There are currently four monitoring wells screened in these formations. Monitoring ceased at N01640 in December 2008. Groundwater level hydrographs are presented in Appendix 6B Figure 5.

N01750 and N01751 are screened in the Muddy Limestone and underlying Laminated Beds (i.e., Mixed Beds). As shown on Figure 6.2, they are drilled on the outcrop of the Mixed Beds, up dip of the Pale Beds. They are situated to the northeast of the River Blackwater and to the north of the A Fault.

Hydrographs of monitoring wells in the formations underlying the Pale Beds show a correlation with rainfall patterns. Groundwater level peaks in N01750 are observed between February to May 2015 and February to April 2016. Two distinct periods of low groundwater levels are recorded from August to November 2015 and from July 2016, during and following periods of low rainfall. Historically, this borehole has been influenced by the on-going dewatering program; however, there is no discernible long-term rise or decline in groundwater levels.

Groundwater levels in N01751 show a correlation with rainfall. The magnitude of peak groundwater levels is higher than the previously observed due to the high rainfall at the end of 2015, resulting in an increase in groundwater level of approximately 1.5 m. There is a stable long-term trend in groundwater levels at this well, with levels commonly fluctuating by less than 1 m.

6.1.12 GROUNDWATER LEVELS IN THE LOWER PALAEOZOICS

N01752 and N01765 are both screened in the Lower Palaeozoics and have very similar hydrographs. They are located adjacent to the Pale Beds and show a stable long-term trend in groundwater levels, with fluctuations of around 2 m, which correlate with rainfall patterns. N01752 is situated on the outcrop of the Lower Palaeozoics, around 380 m northeast of N01751. N01765 is situated about 875 m to the

south southwest of N01752, around 80 m southwest of the River Blackwater, on the fault-bounded outcrop of the Lower Palaeozoics within the D Fault zone.

There is minimal to no impact on groundwater levels in the Lower Palaeozoics due to mining, which helps to illustrate that the drawdown area surrounding Tara Mines is strongly bounded and is limited in extent. Because of their lower permeability, no discernible sustained drawdown is observed at any significant lateral distance into the Palaeozoic rocks. The Palaeozoic rocks form a hydraulic barrier to the lateral propagation of drawdown.

6.1.13 OPEN HOLE WATER LEVEL RECORDS

Appendix 6B Figure 6 shows the groundwater level hydrographs for the screened open cored boreholes. The data obtained are considered to be indicative of groundwater levels in the most permeable unit penetrated by the hole, which is typically the Pale Beds. Monthly monitoring of groundwater levels has been undertaken in 5 wells during this reporting period. The remaining open holes have become blocked over time.

Only holes N01779, N02118, N02123, N02131 and N02270 have recent data available. N01779 is situated to the south of the Nevinstown extension and is located on the outcrop of UDL, some 800 m south of the River Blackwater. N02118 is located in the northwest of the Liscartan extension, and is considered to be open from the Waulsortian Limestone to the Pale Beds. N02123 and N02131 are situated to the west of the River Blackwater in close proximity (less than 25 m) to the river, on an outcrop of Boulder Conglomerate in the Liscartan extension. The boreholes are open from the Boulder Conglomerate through to the Pale Beds. N02270 is located some 500 m north of the River Blackwater on the Pale Beds outcrop.

N01779 was covered and therefore not monitored between June 2007 and September 2012. Groundwater levels in the borehole have since been recorded at depths greater than 200m bgl (limit of dip meter tape) in the current monitoring period. N02118 and N02123 have shown a general declining trend in groundwater levels since early 2012, with seasonal fluctuations in line with the monthly rainfall record. Peaks in groundwater level in N02123 occur at similar times to N02118, and have historically been of a lower magnitude.

N02131 has followed a broadly stable slightly increasing trend since the hole was cleaned in March/April 2012. Groundwater levels have continued to follow an increasing trend since November 2015, which can be primarily attributed to the late 2015 high rainfall, resulting in a groundwater level increase of nearly 15 m between October 2015 and April 2016. N02270 shows a declining trend in groundwater levels since monitoring commenced in March 2015. Groundwater levels have decreased by approximately 10 m from -3.1 maOD to -13.3 as a result of on-going mine dewatering. No data are available after April 2016.

6.1.14 PORE PRESSURES

A VWP measures fluid and pore pressure acting upon it. The pressure may be converted to an equivalent head water. There are six VWPs, which have recorded pore water pressure on a 6-hourly basis since October 2010. The hydrographs for the VWPs are presented in Appendix 6B Figure 6). The lithostratigraphic positioning of the VWPs is as follows:

- N02033 A-Fault – the VWP is positioned at an elevation of 22.72 maOD within a 1.7 m thick zone of fractured UDL which is interpreted as the A Fault zone.
- N02033 Lower – this VWP is positioned at an elevation of -91.58 maOD within a 3.5 m thick microconglomerate within the Pale Beds.
- N02034 Open – the VWP has been placed in an open hole at an elevation of -157.57 maOD. The VWP is positioned adjacent to the Laminated Beds. However, the position of the VWP is not crucial given that it is not grouted in place and is measuring the water pressure in an open bore. This borehole encountered both the A Fault and the B Fault.
- N02035 A Fault – the VWP is positioned at an elevation of 18.39 maOD within a 4 m thick zone of highly fractured bedrock interpreted as the A Fault.
- N02035 Middle – the VWP is positioned at an elevation of 3.39 maOD within a 3 m thick unit of a boulder conglomerate, which is sandwiched between 0.75 m thick fractured zones of bedrock.
- N02035 Lower – the VWP is positioned at an elevation of -72.11 maOD within a 30m+ thick unit of Pale Beds.

Following their initial stabilization prior to June 2011, N02033 A Fault, N02035 A Fault and N02035 Middle show a similar slightly increasing trend with no fluctuations in pressure throughout the entire record. Since June 2011, the reported pressure has increased by 3.8 m in N02033 A Fault, 1.7 m in N02035 A Fault, and by 1.2 m in N02035 Middle to March 2017. These VWP's are installed above the current water table.

N02033 Lower and N02034 Open show similar increases and decreases in groundwater level that correlate well with the rainfall record. The amplitude of fluctuations in level are significantly greater in N02034 Open than in N02033 Lower, which exhibits a more rapid response. An increase in groundwater level of 33 m was recorded in N02034 Open between November 2015 and January 2016, compared to an increase of 18.5 m in N02033 Lower. Recent total heads are between -47.9 maOD and -14.7 maOD which are consistent with water levels observed at the nearby monitoring well N01647 (from -39.4 maOD to -20.3 maOD).

N02035 Lower shows total head values that are generally higher than N02033 Lower and N02034 Open, by at least 5 m since early 2011. Recent groundwater levels in N02034 Open were seen to be higher than in N02035 between December 2015 and March 2016. This is likely due to N02034 Open being more responsive to rainfall events resulting in peak levels after the high rainfall at the end of 2015. Overall, the total head measurements in N02035 Lower show similar correlation to the rainfall record as N02034 Open and N02033 Lower, however, the magnitude of fluctuations is reduced in comparison. Borehole N02035 is located around 75m from the A Fault/B Fault zone, compared to boreholes N02033 and N02034, which are both located on or within 20 m of the trajectory of this fault zone.

6.1.15 HYDROCHEMISTRY AND SOURCE ANALYSIS

6.1.15.1 WATER SAMPLING SCHEDULE

The water-makes which are sampled in the Nevinstown workings are listed in Table 6.5. Field parameters pH, electrical conductivity (EC) and temperature are measured monthly. A sample from each water-make is taken annually for analysis at an independent laboratory. The first sampling round was undertaken on in 2009.

TABLE 6.5 MAJOR NEVINSTOWN WATER-MAKES FOR ANNUAL HYDROCHEMICAL SAMPLING

Water-Make	Average Flow (April 2014 to March 2017) (m³/day)	Average Contribution to Total Nevinstown Discharge (% of total)
1315 1NEX	104	1.8
1315 1NEXDW	1,234	20.8
1390 N303CA	1,358	22.9
1330 N208EX	56	0.9
1390 N3CHLG	99	1.7
1395 N303/304DA	1,751	29.5
<i>1395 N210CA</i>	<i>143</i>	<i>2.4</i>
1435 N317EA	107	1.8
1480 NDECDN	30	0.5
Notes:		
<ul style="list-style-type: none"> • Bold text indicates new additions to the major Nevinstown water-make annual hydrochemical sampling. • Grey italic text indicates water-make is no longer sampled annually due to low flow rate. • Water-make 1395 N210CA has been removed from the annual sampling round. 		

Of note, the 1315 1NEXDW water-make was first encountered in March 2014 and is thought to be associated with the F-24 fault zone situated between the F1 and F25 fault zones. Discharge to this area is removed via a pipeline to headings 1395 N210CX/1390 N303CA and accounts for around 21% of the total discharge to Nevinstown.

In addition to the annual samples, a synoptic water chemistry survey is carried out by Minerex twice per year. Minerex staff travel underground, independently sampling the main water-makes, as well as other water-makes that they consider will usefully augment the hydrochemical dataset for the mine. EC and pH values are also determined by the laboratory at the time of the sample analysis. The samples are unfiltered and unacidified. The laboratory determines total major ions and selected total trace metals (Pb, Zn, Fe, Mn). These samples are denoted by a 'Q' prefix Lab ID.

6.1.15.2 FIELD PARAMETERS

Appendix 6C Figure 1 presents the time series EC data for the water-makes which have more than 2 recent readings. Appendix 6C Figure 2 shows the time series for pH data. Appendix 6C Figure 3 shows the data for temperature. Water-makes have been grouped together based on the mine level and approximate geographical location.

6.1.15.3 FIELD ELECTRICAL CONDUCTIVITY

Groundwater from the majority of the water-makes has fairly stable electrical conductivity (EC) levels of between 700 and 900 $\mu\text{S}/\text{cm}$. Most of the original (minor) groundwater storage in the Nevinstown area was removed in the very early stages of mining, and most of the inflow water is now derived from recent and on-going recharge over the Pale Beds subcrop area. EC is correlated with temperature, with warmer higher EC groundwater measured at the deeper mine horizons and cooler lower EC groundwater is found in the upper mine levels.

EC levels in groundwater at 1500 NDEX2 is consistently lower than groundwater from any other water-makes, ranging from 490 $\mu\text{S}/\text{cm}$ to 680 $\mu\text{S}/\text{cm}$ during the current reporting period. This is consistent with the groundwater being influenced by infiltrating surface water from the Tara surface drainage pond.

6.1.15.4 FIELD PH

pH values are also broadly stable, mostly with slightly alkaline pH, which is consistent with the young calcium-bicarbonate type of groundwater present in the area. Relatively low pH readings were recorded at all water-makes in October 2016. The lowest pH readings were observed at water-makes 1315 1NEXDW (pH 6.8) and 1395 N303/304DA (pH 6.9). It is considered that the infiltration of low pH meteoric water to the mine in the vicinity of the F1 Fault zone may have caused the relatively low pH during this period.

6.1.15.5 FIELD TEMPERATURE

The temperature of water-make discharge at Nevinstown generally lies in the range 11.5°C to 13.5°C. The data show a seasonal trend with lower temperatures (around 11.5 to 12.5°C) during the winter months and higher temperatures (around 12.5 to 13.5°C) during the summer months, typical of a groundwater system with low (fracture) porosity, high diffusivity and a rapid response to rainfall events.

In general, temperatures increase with depth, with the highest temperatures are consistently recorded at water-make 1230 B17EX2 in the drift which extends from the Main Mine into Liscartan. Temperatures in this part of the mine range between 15.3 and 16.9 C and represent the deepest waters in the Nevinstown part of the mine. The lowest temperatures are seen in the shallower water-makes such as those from mine levels 1500, 1435 and 1420. Water-make 1500 NDEX2 exhibits a widely fluctuating temperature, ranging between 8.5°C in winter and 13.2°C in summer/autumn, associated with the Tara surface drainage pond.

6.1.15.6 ANALYTICAL RESULTS

The Nevinstown groundwater shows a fairly uniform hydrochemistry, as would be expected close to the recharge area of the Pale Beds subcrop. Table 6.6 summarises the results. Appendix 6C Figure 4 illustrates the major ion hydrochemistry on Shoeller plots. The water is a calcium bicarbonate type. In addition to the dominant calcium and bicarbonate, the water-make analyses generally show elevated magnesium and sulphate⁻, with relatively low sodium, strontium⁺, chloride⁻ and fluoride. This is consistent with an active groundwater circulation; the young water having had limited time for hydrochemical interaction with the formation rock. There are no significant temporal trends in the hydrochemistry data.

All analytical results are presented as total species (unfiltered samples). The contribution of the particulate phase (the amount of suspended sediment included in the water sample) will have a strong bearing on the analytical results. The variations in results for “totals” analyses over time generally demonstrate considerably higher variability than those for dissolved components of a filtered water sample. It is noted that many of the higher reported values of trace metals are associated with high reported values of iron, indicating that the metals are present in total recoverable (settleable) form.

Samples from water-make 1500 NDEX2 (Q952 and Q971) typically exhibit the lowest EC (<600 uS/cm) and lowest concentrations of strontium (<0.27 mg/l), sodium (<12 mg/l), manganese (<0.005 mg/l). This water-make is situated beneath the footprint of the surface drainage pond to the south of the River Blackwater.

TABLE 6.6 SUMMARY STATISTICS OF WATER-MAKE HYDROCHEMISTRY DATA

Parameter	Count	Minimum	Average	Maximum
Aluminum (mg/L)	14	<0.1	<0.1	<0.1
Ammonium as NH ₄ (mg/L)	8	<0.08	<0.08	<0.08
Arsenic (mg/L)	14	<0.001	0.003	0.010
Bicarbonate as CaCO ₃ (mg/l)	37	145	321	531
Cadmium (mg/L)	14	<0.0006	<0.0006	<0.0006
Calcium (mg/l)	29	58.9	140	185
Chloride (mg/l)	37	10.3	22	62.2
Chromium (mg/L)	14	<0.002	<0.002	<0.002
Cobalt (mg/L)	14	<0.002	0.002	0.003
Copper (mg/L)	14	<0.009	<0.009	<0.009
Cyanide (mg/L)	14	<0.009	0.03	0.298
Electrical Conductivity Field (uS/cm)	23	370	791	980
Electrical Conductivity Laboratory (uS/cm)	37	353	706	954
Fluoride (mg/l)	23	<0.5	<0.5	<0.5
Iron (mg/l)	37	0.024	0.71	6.3
Lead (mg/l)	37	<0.0005	0.017	0.17
Magnesium (mg/l)	37	6.17	20	30.5
Manganese (mg/l)	37	0.0027	0.98	1.77
Mercury (mg/L)	14	<0.00010	0.0001	0.00067
Nickel (mg/L)	14	0.005	0.011	0.042
Nitrate (mg/L)	6	<3.1	<3.1	<3.1
Nitrite (mg/L)	14	<0.28	<0.28	<0.28
pH Field (pH Units)	23	6.77	7.44	8.23
pH Laboratory (pH Units)	37	7.28	7.75	8.3
Phosphorus (mg/L)	14	<0.12	0.21	1.26
Potassium (mg/l)	37	<1	2.14	11.5
Selenium (mg/L)	14	<0.0008	<0.0008	<0.0008
Silver (mg/L)	14	<0.0007	<0.0007	<0.0007
Sodium (mg/l)	37	5.96	16	42.8
Strontium (mg/l)	23	0.217	0.86	3.35
Sulphate (mg/l)	37	34.5	120	275
Tellurium (mg/L)	14	<0.00038	<0.00038	<0.00038
Temperature (°C)	23	9.7	13.1	16.9
Thallium (mg/L)	14	<0.012	<0.012	<0.012
Tin (mg/L)	14	<0.007	<0.007	<0.007
Titanium (mg/L)	14	<0.002	0.002	0.004
Total Alkalinity as CaCO ₃ (mg/l)	23	145	310	340
Total Hardness as CaCO ₃ (mg/L)	14	243	366.5	603
Zinc (mg/l)	29	0.022	0.36	0.74
Notes:				
<ul style="list-style-type: none"> • Full dataset presented in Appendix 6 C1 and C2. • All results reported as unfiltered (total) results unless otherwise stated. 				

The lowest chloride (10.3 mg/l), sulphate (<40 mg/l) and magnesium (<15 mg/l) concentrations are measured at water-make 1480 NDECDN. Temperatures at this water-make have also historically displayed wide seasonal fluctuations. This water-make is one of the shallowest and is located within an offshoot of the A-Fault zone, which is likely to have a very rapid flow path.

In general, the groundwater sampled from Nevinstown typically exhibits low sodium to calcium ratios compared to samples from deeper parts of the mine. This suggests that the degree of ion exchange of calcium for sodium is generally less for Nevinstown water samples than for SWEX. This is consistent with a shorter residence time for the relatively shallower (up-dip) groundwater at Nevinstown compared to deeper parts of the mine.

6.2 CONCEPTUAL HYDROGEOLOGICAL MODEL

6.2.1 Recharge

Recharge to the Tara Mines groundwater system comes from three sources:

- **Recharge to the sub-crop area of the Pale Beds** which is around 13 km² in extent, located immediately to the northwest of the mining area (and including parts of both Nevinstown and Liscartan/Rathaldron). This water moves progressively downdip within the Pale Beds into Nevinstown, Liscartan/Rathaldron, the Main Mine, and SWEX.
- **Groundwater recharge from the surrounding district** which may occur as a result of lateral flow through the faults that bound the orebody, and downward leakage from the overlying Pale Beds.
- **Recharge from the River Blackwater** which flows across the Nevinstown mining area. The bedrock beneath the River Blackwater is already dewatered and there is an unsaturated zone between the saturated river flood plain sediments and the water level in the underlying bedrock. Currently, the Pale Beds below the river in this area are dewatered to about 20-30 m above the mining horizon (elevation -120 to -170 maOD).
-

The degree of leakage from the river is limited by the thickness and low permeability of the flood plain sediments and the weathered nature of the bedrock surface. It is estimated that inflows derived from the river and flood plain deposits are less than 1 l/s, which is less than 1% of the total mine inflows.

6.2.2 Hydrogeological units

6.2.2.1 *Pale beds*

The Pale Beds constitutes the main hydrogeological unit at Tara Mines. The Pale Beds unit also hosts the bulk of the economic ore mineralisation, so most of the mine voids occur in the Pale Beds.

All groundwater movement in the Pale Beds occurs by fracture flow. The permeability is of a secondary nature, dominated by discrete groundwater flow paths associated with faulting, joint sets and bedding planes. Within the immediate mine area, groundwater in the Pale Beds flows preferentially along prominent northwest-trending joint sets. The density of fissures is likely to be greater close to the main fault zones.

6.2.2.2 *UDL*

The overlying UDL sequence is strongly layered, comprising massive calcirudites/calcarenites with dark, locally carbonaceous mudstones and siltstones. This layering results in a low vertical hydraulic conductivity (restricting vertical flow) and a relatively higher horizontal permeability.

Jointing and karst development are less well developed in the UDL than in the Pale Beds. Although there are some discrete stratigraphic horizons within the UDL sequence that exhibit fracturing and some groundwater flow potential, these tend to be localised. Permeability perpendicular to the bedding planes is much lower than permeability along bedding.

The thickness of the UDL sequence overlying the Pale Beds increases towards the southwest. The UDL is absent over much of Nevinstown, north of the River Blackwater.

Above the SWEX area, the P-fault dips to the southeast across the top of the orebody (Figure 4). The P-fault is the only mapped regional that extends through the UDL sequence. Many of the inflows to SWEX are associated with the P-fault.

6.2.2.3 Palaeozoics

Palaeozoic rocks occur immediately to the east and northeast of the Nevinstown area. The Palaeozoics in this area are in fault-contact with the Pale Beds.

Because of their lower permeability, no discernible sustained drawdown is observed at any significant lateral distance into the Palaeozoic rocks. The Palaeozoic rocks form a hydraulic barrier to the lateral propagation of drawdown away from the immediate mine area.

6.2.2.4 Whistlemount Channel

The Whistlemount Channel occurs adjacent to the River Blackwater along its southwestern side. It is a sediment-filled palaeochannel about 30 m in depth. The basal sand and gravels of the Whistlemount Channel have become drained and dewatered in response to mining at Nevinstown. However, the basal unit is hydraulically disconnected from the upper shallow beds which remain saturated with a perched groundwater system. Downward leakage within the Whistlemount Channel is low because of the low permeability of the clayey silt deposits that overlie the basal unit.

The shallow groundwater system in the Whistlemount Channel remains unaffected by the mining operations. The monitoring data and chemistry typing of the waters also demonstrate that leakage from the River Blackwater and the flood plain alluvial deposits has been very low.

6.2.3 Groundwater Flow Regime

6.2.3.1 Water level zones

There are three distinct water tables in the immediate mine area. These are shown in Figures 6.4 and 6.5, and are summarised as follows:

1. **A shallow (superficial) groundwater table, which occurs within the alluvium and glacial till deposits.** This is often underlain by unsaturated UDL. There has been no discernible drawdown within this near-surface zone as a result of mining or dewatering activities at Nevinstown. Where the alluvium and glacial deposits are thin (less than about 3 m), such as in the planned area of crown pillar mining, there may be no near-surface water table.
2. **A second (deeper) groundwater table, which occurs within the UDL.** This is frequently underlain by unsaturated Pale Beds. However, because the UDL is absent over much of the

Nevinstown area to the north of the river, the UDL groundwater table does not occur in that area. It does not occur in the planned area of crown pillar mining

3. **A third (deepest) groundwater table, which occurs within the Pale Beds.** Continuous saturation occurs below this zone, except where open mine voids occur below the water table. Pale Beds groundwater levels were originally drawn down because of operations in the Main Mine. They have been further drawn down as new mining areas in Nevinstown and Liscartan/Rathaldron have been opened up.

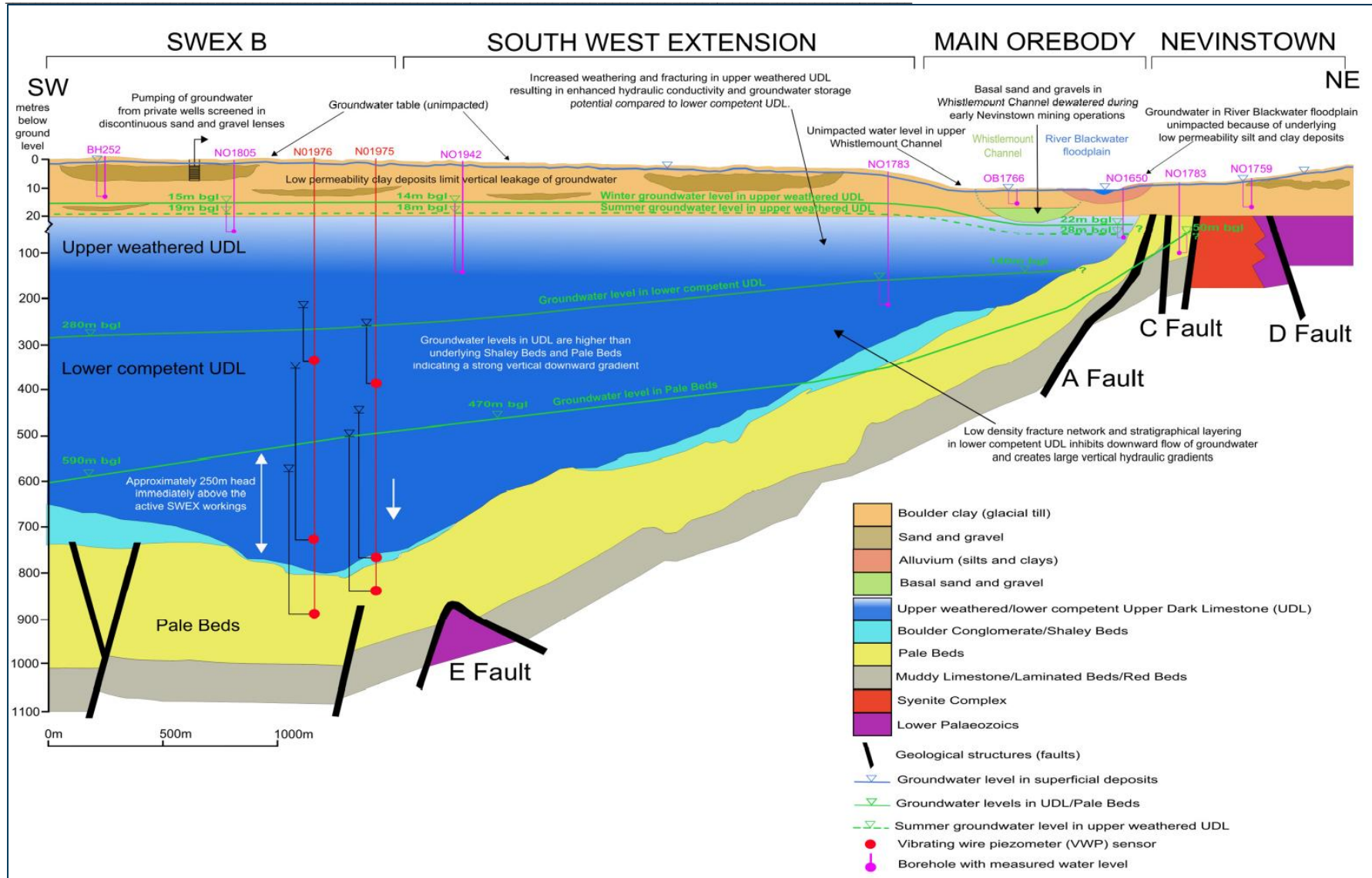


FIGURE 6.4 NE-SW HYDROGEOLOGICAL SECTION THROUGH THE TARA MINING AREAS

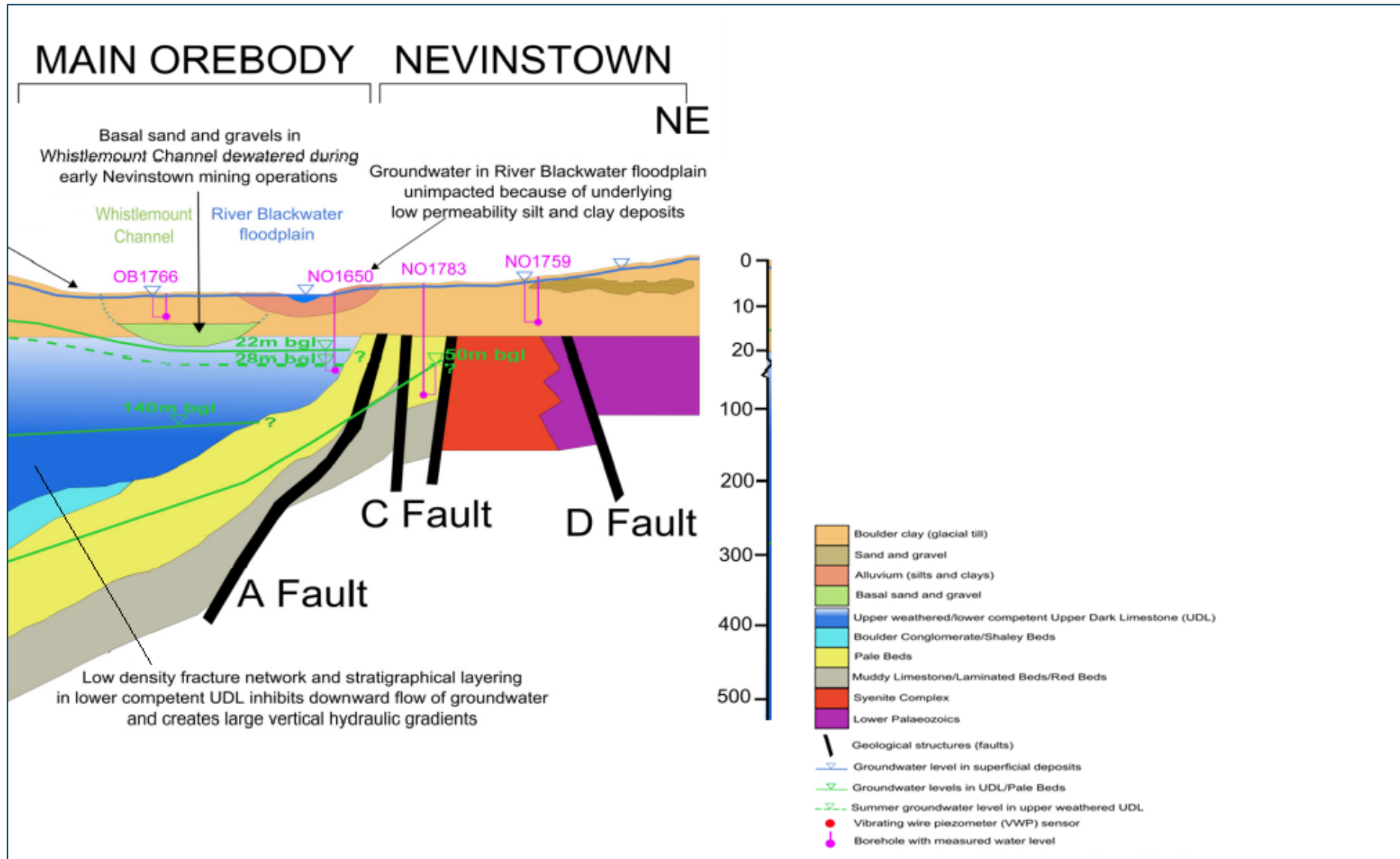


FIGURE 6.5 NEVINSTOWN HYDROGEOLOGICAL SECTION

6.2.3.2 Groundwater levels in the Pale Beds

Groundwater level monitoring data indicate that the majority of mine-related drawdown is restricted to the Pale Beds (and the underlying interconnected Muddy Limestone). The data show there is a large amount of lateral hydraulic connectivity along the strike and dip of the Pale Beds unit. There is a good general hydraulic connection within the Pale Beds between the Nevinstown, Liscartan/Rathaldron and Main Mine areas. There is slightly lesser hydraulic connection within the Pale Beds between the Main Mine and SWEX (to the southwest), although the presence of mine voids and tunnels causes continuity of flow.

The regional groundwater flow system within the Pale Beds is fault-bounded. Many of the faults cause offsets to the stratigraphy. The area of significant drawdown associated with the mine is limited to the local area. The localised drawdown is constrained by:

- The D fault zone (to the south and southeast)
- The presence of the Palaeozoic rocks (to the north and northeast)
- The Randalstown fault and other northeast trending structural zones (to the northwest)
- The increasing depth (towards the southwest) of the Pale Beds below the UDL.

6.2.3.3 Nevinstown groundwater levels

Overall, groundwater conditions in the Nevinstown area have remained relatively stable. As the mining area is progressively extended, so the local drawdown in the Pale Beds continues to show a slow propagation to the north and northeast, parallel to the major water-bearing features, and within the confines of the bounding structures (Figure 6.6). The 0 maOD head contour has moved between 180 m and 450 m to the north/northeast between April 2004 and February 2017. Open borehole N01779 located to the south of Nevinstown continues to record drawdown of at least 250 m.

The Pale Beds within the Nevinstown area has an unsaturated zone, with an overlying perched water table where the UDL is present. Where present, the UDL also has an unsaturated zone above it, with a perched water table in the overburden. An example of this occurs at paired boreholes N01755 (UDL) and N01756 (overburden); both wells are located within about a metre of each other at ground surface.

In February 2017, the groundwater level in the UDL was 26.2 maOD (10.3 m bgl); the rockhead elevation of the UDL at this location is 33.5 maOD (3.0 m bgl). The unsaturated zone above the water table in the UDL in March 2015 is therefore around 7 m in thickness. In contrast, the groundwater level in the overburden at this time was 36.0 maOD (0.6 m bgl).

The proposed crown pillar mining area is considerably above any of the water tables in the Pale Beds or the UDL. As a result, it is not expected that mining of the crown pillar will create any additional impacts to the bedrock groundwater system.

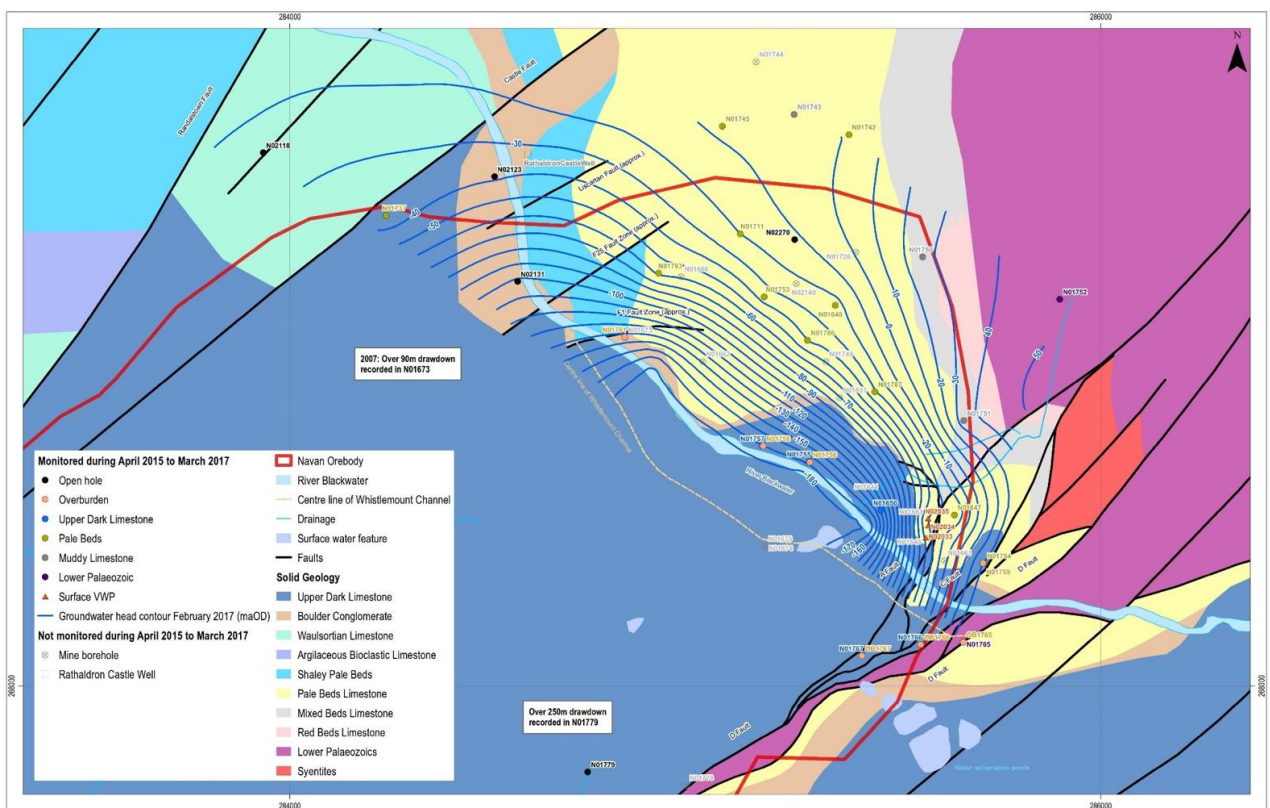


FIGURE 6.6 WATER LEVEL CONTOURS IN THE PALE BEDS IN THE NEVINSTOWN AREA (2017)

6.2.4 Superficial groundwater

In most areas where till and/or other glacial alluvial deposits are present directly above the dewatered Pale Beds or UDL, there is an underlying unsaturated zone within the rock. Because of this, when incremental drawdown occurs within the Pale Beds as a result of mining, there is no decline in groundwater levels observed in the wells screened in the overburden. The groundwater systems have become decoupled. Consequently, it is expected that the moisture content of the alluvial and other

near-surface deposits will continue to remain unchanged, regardless of any future mining at Nevinstown.

6.2.5 Groundwater discharge

Virtually all groundwater in the Tara area discharges to the mine dewatering system. There are minor groundwater losses to evaporation along the lower parts of the River Blackwater flood plain.

6.3 POTENTIAL IMPACTS ASSESSMENT

The proposed plan to resume mining in the Nevinstown orebody including the Crown Pillar mining could potentially impact the surface and groundwater system in the following ways:

- Creation of incremental drawdown in the bedrock
- Creation of drawdown in the superficial deposits
- Additional leakage from the River Blackwater
- Increased groundwater inflow to the mine workings
- Changes in groundwater chemistry to the mine inflow waters

6.3.1 IMPACTS ON THE GROUNDWATER FLOW REGIME

There are three distinct water tables in the immediate mine area, as follows:

- A shallow (superficial) groundwater table which occurs within the alluvium and glacial till deposits. This is underlain by unsaturated UDL. There has been no discernible drawdown within this near-surface zone as a result of dewatering activities at Nevinstown. Where the alluvium and glacial deposits are thin (less than about 3 m), such as in the planned area of Crown Pillar mining, there may be no near-surface water table.
- **A second (deeper) groundwater table, which occurs within the UDL.** This is frequently underlain by unsaturated Pale Beds. However, because the UDL is absent over much of the Nevinstown area to the north of the river, the UDL groundwater table does not occur. It does not occur in the planned area of Crown Pillar mining.
- **A third (deepest) groundwater table which occurs within the Pale Beds.** Continuous saturation occurs below this zone, except where open mine voids occur below the water table. Pale Beds groundwater levels were originally drawn down because of operations in the Main Mine. They have been further drawn down as new mining areas in Nevinstown and Liscartan/Rathaldron have been opened up.

Groundwater level monitoring data indicate that the majority of mine-related drawdown is restricted to the Pale Beds (and the underlying Muddy Limestone). The data show there is a large amount of lateral hydraulic connectivity along the strike and dip of the Pale Beds unit. There is a good general hydraulic connection within the Pale Beds between the Nevinstown, Liscartan/Rathaldron and Main Mine areas. There is slightly lesser hydraulic connection within the Pale Beds between the Main Mine and SWEX (to the southwest), although the presence of mine voids and tunnels causes continuity of flow.

The regional groundwater flow system within the Pale Beds is fault-bounded. The area of significant drawdown associated with the mine is limited to the local area. The localised drawdown is constrained by the D fault zone (to the south and southeast), the presence of the Palaeozoic rocks (to the north and northeast), the Randalstown fault and other NE trending structural zones (to the northwest) and the increasing depth (towards the southwest) of the Pale Beds below the UDL.

Within the Nevinstown area, the Pale Beds has an unsaturated zone with an overlying perched water table in the UDL. The UDL also has an unsaturated zone above it, with a perched water table in the overburden. An example of this occurs at paired boreholes N01755 (UDL) and N01756 (overburden); both wells are located within about a metre of each other at ground surface. In February 2017, the groundwater level in the UDL was 26.2 maOD (10.3 m bgl); the rockhead elevation of the UDL at this location is at 33.5 maOD (3.0 m bgl). The unsaturated zone above the water table in the UDL in March 2015 is therefore around 7 m in thickness. In contrast, the groundwater level in the overburden at this time was 36.0 maOD (0.6 m bgl).

6.3.2 IMPACTS ON THE WHISTLEMOUNT CHANNEL

The Whistlemount Channel occurs adjacent to the River Blackwater along its southwestern side. It is a sediment filled palaeochannel about 30 m in depth. The basal sand and gravels of the Whistlemount Channel have become drained and dewatered in response to mining at Nevinstown. However, the basal unit is hydraulically disconnected from the upper shallow beds which remain saturated with a perched groundwater system. Downward leakage within the Whistlemount Channel is low limited because of the low permeability of the clayey silt deposits that overlie the basal unit.

The shallow groundwater system in the Whistlemount Channel remains unaffected by the mining operations. The monitoring data and chemistry typing of the waters also demonstrate that leakage from the River Blackwater and the flood plain alluvial deposits has been very low.

6.3.3 POTENTIAL IMPACTS ON GROUNDWATER LEVELS

Recent groundwater levels in the overburden at Nevinstown are approximately 32 to 46 maOD, whereas those in the UDL are at approximately 10 maOD (N01650) to 45 maOD (N01767). Recent groundwater levels in the Pale Beds are approximately 0 maOD (N01742) to -30 maOD (N01647), around 50 to 75 m lower than the levels in the UDL.

The available monitoring data demonstrate that mine-related drawdown in groundwater levels is restricted mainly to monitoring wells in the Pale Beds and the Muddy Limestone. This indicates a significant degree of hydraulic connectivity between the Pale Beds and the Muddy Limestone, which directly underlies the Pale Beds. The monitoring wells in the overburden outside the Whistlemount Channel, the UDL and the Lower Palaeozoics continue to show virtually no discernible drawdown attributable to mining activities.

The presence of the unsaturated zones in both the UDL and the Pale Beds indicates that, regardless of any future dewatering activities at Tara Mines, the influence of the mine dewatering on the shallow groundwater system will continue to be negligible.

Appendix 6D Figure 1 shows water level contour maps of groundwater heads in the Pale Beds in April 2004. Appendix 6D Figure 2 shows water level contour maps of groundwater heads in the Pale Beds in February 2017. Appendix 6 D Figure 3 shows the net drawdown between April 2004 and February 2017. The most discernible feature of the contours is the apparent influence of the faults. The groundwater system around Tara Mines shows strong lateral boundaries which act to minimise the spread of drawdown away from the mine area. The A Fault/C Fault complexes to the east of Nevinstown, and the Randalstown Fault to the west of Liscartan create a strong influence on the groundwater flow regime. The Randalstown Fault is considered to be a zone of tight shear in the UDL acting as a barrier to groundwater flow perpendicular to strike along most of its length. Drawdown to the west of the Randalstown Fault is thought to be limited. Groundwater levels in the Lower Palaeozoics to the east of the C Fault complex suggest no significant drawdown from mine activities (borehole N01752).

The F1 Fault zone is considered to be the principal structure influencing district scale groundwater flow in the Pale Beds towards the Main Mine and Nevinstown. Inflows related to F1 contributed around 75% of the recent total discharge to Nevinstown, at water-makes 1395 N303/304DA, 1390 N303CA and 1315 1NEXDW. The period of high rainfall (November 2015 to February 2016; 677 mm) resulted in a substantial increase in the vicinity of F1. The average inflow from water-makes has increased by over 80% (2,700 m³/day) to 5,940 m³/day.

Historically, a net drawdown of around 90 m was observed between April 2004 and May 2007 in the vicinity of borehole N01673 (now decommissioned) which was located within the F1 Fault zone. Drawdown in excess of 70 m is observed in the boreholes to the north of the F1 Fault zone and the River Blackwater. Drawdown in the Pale Beds has continued to propagate to the north and northwest as a result of mining into Liscartan and Rathaldron, and the Liscartan/Rathaldron workings continue to be opened up towards the northwest. The most northerly wells in the Pale Beds (N01742 and N01745) show drawdown of between 35 m and 40 m since 2004, demonstrating the expansion of mine-related dewatering to the north in the Pale Beds. An estimated 45 m of drawdown is observed to the north and west of the Liscartan Fault in Pale Beds borehole N01737 since 2004.

Overall, groundwater conditions in the Nevinstown area have remained relatively stable. Drawdown in the Pale Beds continues to show propagation to the north and northeast, parallel to the major water-bearing features, and within the confines of the bounding structures. The 0 maOD head contour has moved between 180 m and 450 m to the north/northeast between April 2004 and February 2017. Open borehole N01779 located to the south of Nevinstown continues to record drawdown of at least 250 m.

The proposed Crown Pillar mining area is considerably above any of the water tables in the Pale Beds or the UDL. As a result, it is not expected that mining of the Crown Pillar will create any additional impacts to the bedrock groundwater system.

6.3.4 POTENTIAL IMPCATS ON THE OVERLYING ALLUVIAL DEPOSITS

In most areas where till and/or other glacial alluvial deposits are present directly above the dewatered Pale Beds or UDL, there is an underlying unsaturated zone within the rock. Because of this, when incremental drawdown occurs within the Pale Beds as a result of mining, there is no decline in groundwater levels observed in the wells screened in the overburden. The groundwater systems have

become decoupled. Consequently, it is expected that the moisture content of the alluvial and other near-surface deposits will continue to remain unchanged, regardless of any future mining at Nevinstown.

There are isolated locations where natural near-surface cavities within the Pale Beds transmit local near-surface groundwater from superficial deposits downwards towards the workings. These are discrete and relatively minor, and occur in areas of extensive jointing and cavity development that have been previously mapped by Tara geologists. Generally, once the initial storage in a cavity is depleted, the flow rate from the water-make will tail off as equilibrium is reached between recharge inflow to the cavity and discharge to the mine workings at the water-make where the workings intersected the cavity.

Figure 6.7 shows that the overburden thickness in the proposed area of Crown Pillar mining is typically less than 3 m depth. Where the overburden thickness is less than about 3 m, and a vadose zone occurs beneath the overburden, a surficial (perched) groundwater table may not be present. However, isolated zones of thicker alluvium have been identified within the proposed mining area, and these may show some degree of saturation.

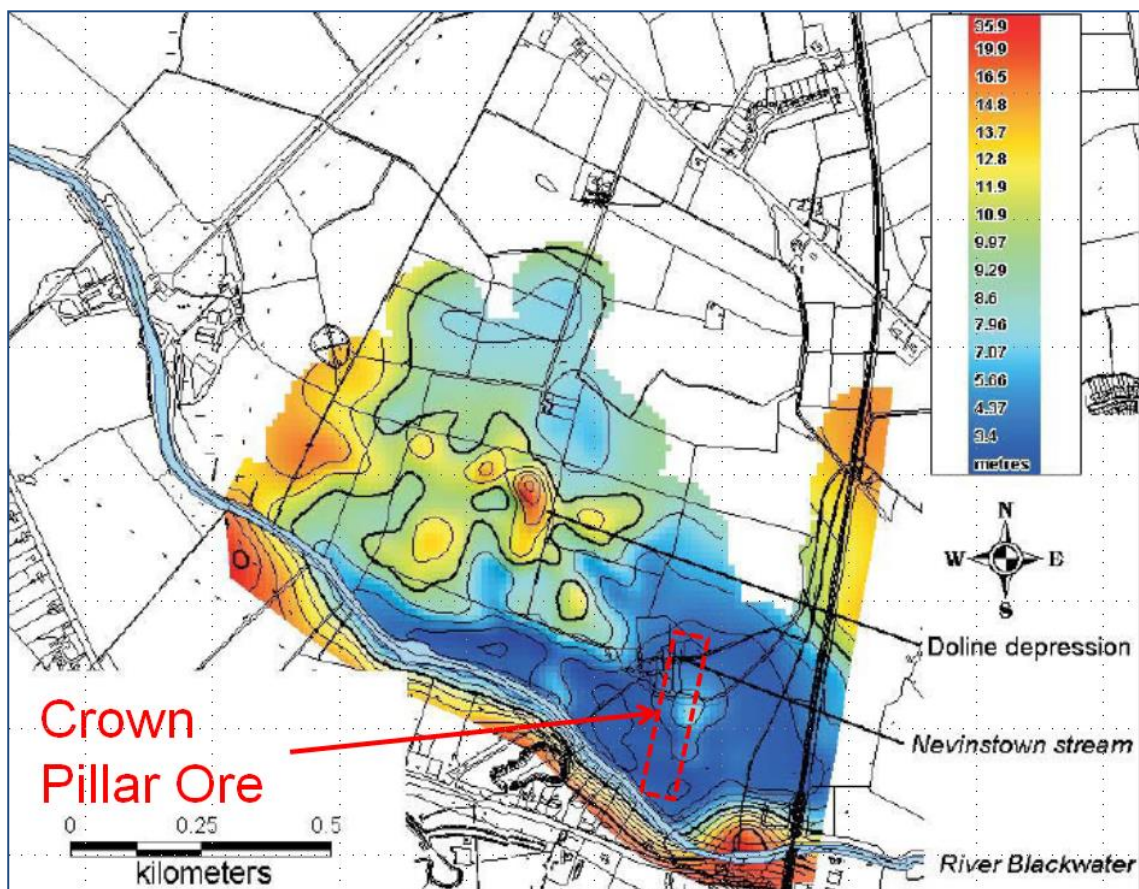


FIGURE 6.7: ALLUVIAL THICKNESS IN THE PLANNED AREA OF CROWN PILLAR MINING (RED)

6.3.5 INCREMENTAL DRAWDOWN IN THE BEDROCK

The proposed Nevinstown mining area is already fully dewatered. Therefore, no additional impacts are anticipated.

No mitigation is required apart from on-going monitoring of the bedrock groundwater levels and mine inflow water chemistry.

Mine-related drawdown in groundwater levels is mostly restricted to the Pale Beds unit, extending into the underlying Muddy Limestone. The groundwater system around Tara shows strong lateral boundaries which act to minimize the spread of drawdown away from the immediate mine area.

6.3.6 DRAWDOWN IN THE SUPERFICIAL DEPOSITS

In the planned area of Crown Pillar mining, the alluvium is generally thin, and mostly consists of silts and glacial deposits. It is not known whether the alluvium in the area is sufficiently well developed to include a superficial water table.

If some superficial groundwater exists, there is potential for localized drainage of this water into the workings if the disturbance resulting from the planned mining propagates to the surface. However, due to the low permeability of the glacial tills and silts in the area, any drawdown in the superficial deposits is not expected to propagate away from the localized area. No hydraulic connection to the river is anticipated. There is no connection to the Whistlemount Channel.

If a superficial groundwater system does exist, there will be a vadose zone developed in the underlying dewatered Pale Beds. The groundwater systems have become decoupled so any drainage of the superficial deposits would have no effect on the underlying bedrock groundwater system. Similar conditions have previously occurred because of mining into and draining shallow cavities.

Monitoring of conditions within the alluvium in the planned area of Crown Pillar mining will be carried out using a series of up to four test trenches installed prior to the start of proposed mining. These will be dug to the base of the alluvium (or as deep as possible) to investigate the nature of the soils and the potential for saturated conditions. If saturation soils are encountered in any of the test pits, alluvial

piezometers will be installed to about 3 m depth (above the surface of the bedrock). Depending on conditions, the piezometers are anticipated to be screened standpipes which will be installed as the test pits are backfilled.

Other than monitoring, no further mitigation controls are necessary.

6.3.7 ADDITIONAL LEAKAGE FROM THE RIVER BLACKWATER

The current monitoring data show that leakage losses from the River Blackwater to the mine workings are minor. The current water balance shows that leakage losses from the river and interconnected flood plain alluvium currently account for less than 2% of the total mine inflow rate. The monitoring wells in the overburden outside the Whistlemount Channel, the UDL and the Lower Palaeozoics demonstrate no significant drawdown attributable to mining activities. There are no discernible impacts on shallow groundwater levels in the superficial alluvial or till deposits.

The only significant inflow event occurred during a period when the flood plain to the north of the river was inundated and flood waters entered an old exploration drill hole that was connected to the mine workings. This was a single isolated event that occurred to the west of the planned Crown Pillar mining area, where the flood plain is wider. Subsequently all drill holes beneath the flood plain area have been identified and investigated.

The proposed mining for the Crown Pillar includes a mitigation plan to prevent the possibility of flood waters from reaching the mining area. Much of the surface topography in the planned area is above 130 mAOD, which is above the level of the flood plain

A monitoring plan has been prepared to assess the potential for on-going surface settlement and consolidation. This is included in a separate geotechnical report. The requirement for additional surface water protection will be assessed on an on-going basis using the geotechnical monitoring results.

6.3.8 INCREASED INFLOW TO THE MINE WORKINGS

An increase in inflow to the mine workings may potentially occur as a result of four processes: (i) increased groundwater inflow from the bedrock, (ii) increased groundwater inflow from the alluvium, (iii)

increased surface water inflow through the area above the proposed Crown Pillar, and (iv) additional leakage losses from the river or from alluvium that is hydraulically connected to the river.

As noted the bedrock groundwater system is already below the planned area of Crown Pillar mining, so no additional bedrock inflows are anticipated.

Drainage of a perched surficial alluvial groundwater in the Crown Pillar area would be minor and short lived and would not materially affect the groundwater inflow rate to the mine workings. Should deformation reach the ground surface above the area of planned Crown Pillar mining, there may be a minor increase in infiltration of incident rainfall on the Crown Pillar area, but this would amount to no more than about 800 m³/day during an extreme rainfall event, with runoff contribution from the surrounding area.

A mitigation plan is being put in place to protect against the possibility of additional surface water flows entering the Crown Pillar mining area during high flow events in the River Blackwater. The mitigation plan will be evaluated on an on-going basis using the results of the geotechnical monitoring program.

A vadose zone (unsaturated zone) exists between the river (and alluvium that is hydraulically connected to the river) and the underlying bedrock groundwater system. Consequently, the leakage rate from the river is independent of groundwater levels in the underlying bedrock. This has been demonstrated by over 10 years of monitoring. As bedrock groundwater levels in the Nevinstown area have continued to fall, so there has been no observed increase in the leakage rate from the river. Therefore, should any further bedrock drawdown occur in the Nevinstown area, a future increase in the leakage rate from the river would not be anticipated.

The only possibility of an increased leakage rate from the river would occur if a significant amount of subsidence occurred, sufficient to create new groundwater pathways through the fractured rock. A 30 m exclusion zone is planned between the area of Crown Pillar mining and the river to prevent and surface settlement from effecting the river flows. Therefore, the only potential for opening up new groundwater pathways would be if significant shear displacement occurred along any of the geological structures, and particularly the A fault. A geotechnical study and monitoring plan is being prepared to assess this. Currently, there are a series of extensometers and vibrating wire piezometers installed

across the A fault. As part of the Crown Pillar monitoring plan, two additional extensometer and piezometer holes are planned. The exact location of these is being determined by the geotechnical study.

6.3.9 CHANGES IN GROUNDWATER CHEMISTRY TO THE MINE INFLOW WATERS

To date, there have been no sustained trends in the hydrochemistry of the water-makes in the Nevinstown area, and the groundwater quality remains generally stable. This is consistent with a lack of influence of the mining activity on global water quality in the groundwater units around Tara Mines. Since no additional major bedrock or alluvial groundwater inflows are anticipated to result from the proposed Crown Pillar mining plan, no changes in the groundwater chemistry of the mine inflow waters are expected. This will be confirmed by the on-going monitoring and sampling program.

6.4 MITIGATION MEASURES

6.4.1 INCREMENTAL DRAWDOWN IN THE BEDROCK

The proposed Crown Pillar mining area is already fully dewatered. Therefore, no additional impacts are anticipated.

No mitigation is required apart from on-going monitoring of the bedrock groundwater levels and mine inflow water chemistry.

Mine-related drawdown in groundwater levels is mostly restricted to the Pale Beds unit, extending into the underlying Muddy Limestone. The groundwater system around Tara shows strong lateral boundaries which act to minimize the spread of drawdown away from the immediate mine area.

6.4.2 DRAWDOWN IN THE SUPERFICIAL DEPOSITS

Monitoring of conditions within the alluvium in the planned area of Crown Pillar mining will be carried out using a series of up to four test trenches installed prior to the start of proposed mining. These will be dug to the base of the alluvium (or as deep as possible) to investigate the nature of the soils and the potential for saturated conditions. If saturation soils are encountered in any of the test pits, alluvial piezometers will be installed to about 3 m depth (above the surface of the bedrock). Depending on conditions, the piezometers are anticipated to be screened standpipes which will be installed as the test pits are backfilled.

Other than monitoring, no further mitigation controls are necessary.

6.4.3 ADDITIONAL LEAKAGE FROM THE RIVER BLACKWATER

To minimise the risk, mining will not be undertaken within the area of the surface Blackwater flood plane. A monitoring plan has been prepared to assess the potential for on-going surface settlement and consolidation. This is included in the Section 8 Geotechnical section of this EIAR. The requirement for

additional surface water protection will be assessed on an on-going basis using the geotechnical monitoring results.

6.4.4 INCREASED INFLOW TO THE MINE WORKINGS

A mitigation plan is being put in place to protect against the possibility of additional surface water flows entering the Crown Pillar mining area during high flow events in the River Blackwater (Section 6.3.3). The mitigation plan will be evaluated on an on-going basis using the results of the geotechnical monitoring program.

The only possibility of an increased leakage rate from the river would occur if a significant amount of subsidence occurred, sufficient to create new groundwater pathways through the fractured rock. A 30 m exclusion zone is planned between the area of Crown Pillar mining and the river to prevent and surface settlement from effecting the river flows. Therefore, the only potential for opening up new groundwater pathways would be if significant shear displacement occurred along any of the geological structures, and particularly the A fault.

6.4.5 CHANGES IN GROUNDWATER CHEMISTRY TO THE MINE INFLOW WATERS

Since no additional major bedrock or alluvial groundwater inflows are anticipated to result from the proposed Crown Pillar mining plan, no changes in the groundwater chemistry of the mine inflow waters are expected. This will be confirmed by the on-going monitoring and sampling program.

7 SURFACE WATER

7.1 PROPOSED DEVELOPMENT

There are no new emissions to surface water associated with the proposed development. However all groundwater encountered in the mining process will continue to be pumped from the mine workings to the surface (Ref. Section 6 Groundwater). Despite the fact that the Nevinstown orebody is currently not being worked it must remain dewatered.

This section assesses the potential surface water impacts associated with the ongoing operation of BTM and assesses potential impacts associated with the proposed resumption of mining activity in the Nevinstown orebody.

All emissions to surfacewater are controlled, operated, and emissions take place as set out in the Company's current IE Licence. Mass emissions to water are reported to the Agency in Annual Environmental Report (AER) and through PRTR reporting.

7.2 EXISTING ENVIRONMENT

The BTM facilities, including the mine site at Knockumber and the Tailings facility site at Randalstown are situated within the Boyne catchment, which lies within Ireland's Eastern River Basin District (ERBD), as designated under the European WFD. The ERBD incorporates the majority of County Meath and all or part of 12 other counties, covering approximately 6,300 km² and equal to a tenth of Ireland's land mass.

The Boyne catchment area constitutes Hydrological Area 07 within the ERBD and is made up of 89% agricultural land use, with the majority as pasture.

The local surface water network is made up of the Rivers Blackwater and Boyne and associated tributaries.

The mine site is located to the south of the River Blackwater, although underground workings extended under the River Blackwater and into the Nevinstown orebody.

The location of the site is shown on Figure 7.1 in relation to its surrounding geographic environment.

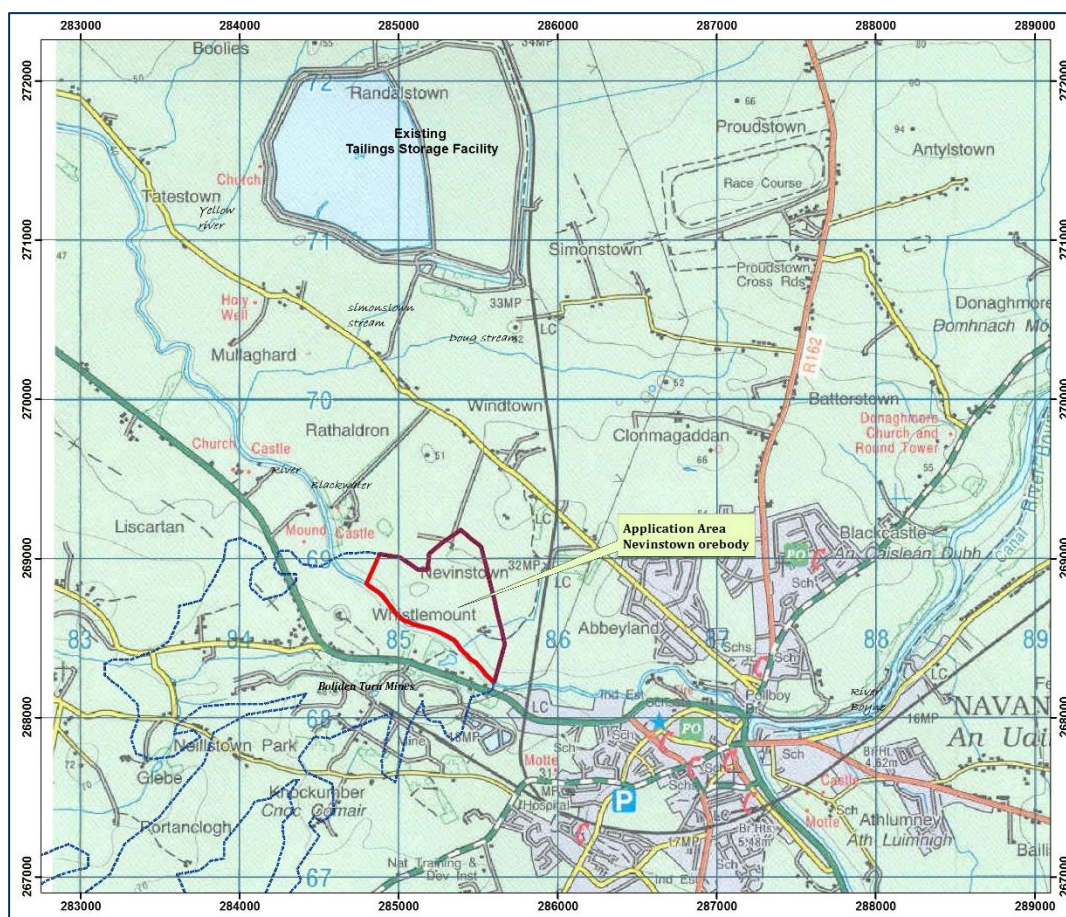


FIGURE 7.1 SITE LOCATION WITH SURFACE WATER FEATURES

The River Boyne and the River Blackwater are classified as “At Risk” water bodies due to the potential for diffuse agricultural pollution and because the River Boyne has been extensively drained in the 1970s and 1980s. The ERDB has not fully assessed the ecological effect of the drainage works, with respect to the aim of achieving “good ecological status”.

7.2.1 RIVER BLACKWATER

The River Blackwater is designated as a Special Area of Conservation (Site Code 002299). The river channel is designated for species listed under Annex II of the EU Habitats Directive 92/43/EEC, namely Atlantic Salmon, Otter and River Lamprey. The riverine floodplains are designated under the EU Habitats Directive for alkaline fen and alluvial woodlands.

The river Blackwater is used for abstraction of water used to supply potable water to the town of Navan. The abstraction point is approximately 2km upstream from the Nevinstown area.

The EPA water monitoring data indicates that the biotic index of the River Boyne is consistent at Q3-4 both upstream and downstream of the Navan urban area. This indicates that the quality is of moderate

status. The Yellow River joins the River Blackwater approximately 3km upstream of Navan town centre and the EPA classified the status of water quality at this location as “Poor” in 2009.

7.2.1.1 WATER QUALITY

7.2.1.1.1 WATER CHEMISTRY

TABLE 7.1 below present the annual average data from two locations on the river Blackwater; T7 Upstream of the Tara Mines facilities T4 downstream of all working operations.

TABLE 7.1 BLACKWATER RIVER MONITORING DATA

Parameter		Unit	T7	T4
pH	pH	pH	8.2	8.3
Conductivity	SpEC@25C	uS/cm	392.3	439.6
Temperature	Temp	degree C	11.1	10.7
Dissolved Oxygen	DO	mg/l	9.2	9.2
Zinc Tara Lab Input	Zn	mg/l	0.002	0.004
Lead	Pb	mg/l	0.002	0.002
Sulphate	SO4	mg/l	20.3	27.5
Suspended Solids	SS	mg/l	7.2	5.3
Antimony	Sb	mg/l	0.002	0.002
Iron	Fe	mg/l	0.11	0.09
Copper	Cu	mg/l	0.002	0.002
Chromium	Cr	mg/l	0.002	0.002
Cadmium	Cd	mg/l	0.001	0.001
Arsenic	As	mg/l	0.005	0.005
Mercury	Hg	mg/l	0.000	0.000
Cyanide	Cn	mg/l	0.020	0.020
Manganese	Mn	mg/l	0.025	0.028
Aluminium	Al	mg/l	0.100	0.105
Hardness	CaCo3	mg/l	158.6	173.9
Nitrate as NO3	NO3	mg/l	7.0	6.8
Ammonium	NH4	mg/l	0.11	0.10
Ortho Phosphate	PO4	mg/l	0.18	0.18
Chlorine	Cl	mg/l	17.4	18.5
Cobalt	Co	mg/l	0.002	0.002
Magnesium	Mg	mg/l	8.6	9.0
Nickel	Ni	mg/l	0.004	0.004
Sodium	Na	mg/l	10.4	10.7

The chemistry and quality of the River Blackwater is consistent upstream and downstream of the BTM facilities. The physico-chemical quality of the water is quite good.

- The surface water is slightly alkaline, with the pH recorded generally within the range for Salmonid Water and Drinking Water.
- The hardness of the surface water is not excessive and considered normal for a surface water flowing through a catchment of predominant limestone provenance.
- Dissolved Oxygen concentration exceeds 9mg/l over 50%, which is in accordance with the Salmonid Regulations. The average DO is 9.5mg/l.
- The suspended solid loading in the surface water is generally low and below the threshold indicated in the Salmonid Regulations.
- The concentration of Ammonia is generally low and well within the threshold of the Salmonid regulations.
- The concentration of Nitrate is also not excessive, albeit the impact of nutrient leaching is evident (average Nitrate concentration of approximately 10mg/l).
- The Phosphorous concentration is also slightly elevated and again indicative of nutrient leaching from within the catchment.
- The concentration of Chloride and Sulphate are considered normal for Irish surface waters. The sulphate concentration is significantly lower than the sulphate concentration of the deep groundwater and there is no indication of mineralisation in the surface water.
- The Sodium:Potassium ratio is generally 0.3-0.4, which suggests that agricultural effluent within the catchment is entering the watercourse.
- Iron, Manganese, Copper and Zinc concentrations are generally low and often below the detection limit of the laboratory.
- Isolated elevated concentrations of Aluminium are recorded in the surface water. The source of this aluminium is not determined, but it may be attributable to mobilisation of clay platelets in the water column.
- The concentration of all trace metals is very low and generally below the detection limit of the laboratory.

In summary, the *River Blackwater* is generally of a high physico-chemical quality. Apart from isolated deviations, the quality is generally consistent with a low but determinable impact of agricultural activity within the catchment. The River Blackwater is of sufficient quality to adhere to the Quality for Salmonid Rivers.

7.2.1.1.2 ECOLOGICAL STATUS

The biological status of the River Blackwater in the Nevinstown has been established after undertaking aquatic surveys. The objective of the study was to assess the status of the aquatic faunal community.

Based on the findings, the River Blackwater at Nevinstown is assigned a Q rating of 3-4, which is considered indicative of slight organic pollution from upstream of the Nevinstown. The findings of this study are consistent with both the EPA data and the ERBD findings that diffuse agricultural contamination impacts the water quality. The report concludes that the aquatic microinvertebrate fauna in the River Blackwater has remained stable over a 25-30 year timeframe. The only apparent aquatic damage is from more intensive agricultural practices leading to increased leaching of phosphorus and nitrate to the water channels.

7.2.2 RIVER BOYNE

The characterisation of the River Boyne, under the Eastern River Basin District (ERBD) Project, indicates that the primary environmental driving force in the Boyne Catchment is considered to be agricultural production. The water quality information suggests that the lengths of unpolluted (Class A) and moderately polluted (Class C) channels have declined, while there is a slight increase in channels classified as slightly polluted (Class B). Impacted river channels were typically located in areas with pasture, arable land, peat bogs and downstream of MWWTP outfalls.

7.2.2.1 WATER QUALITY

7.2.2.1.1 Water Chemistry

TABLE 7.2 below present the annual average data from two locations on the river Boyne, T6 Upstream of the Tara Mines facilities (including discharges) T5 downstream of all working.

TABLE 7.2 BOYNE RIVER MONITORING DATA

Parameter		Unit	T6	T5
pH	pH	pH	8.2	8.3
Conductivity	SpEC@25C	uS/cm	675.2	632.5
Temperature	Temp	degree C	10.9	11.0
Dissolved Oxygen	DO	mg/l	9.3	9.3
Zinc Tara Lab Input	Zn	mg/l	0.004	0.003
Lead	Pb	mg/l	0.002	0.002
Sulphate	SO4	mg/l	32.6	41.8
Suspended Solids	SS	mg/l	3.8	4.4
Antimony	Sb	mg/l	0.002	0.003
Iron	Fe	mg/l	0.06	0.06
Copper	Cu	mg/l	0.002	0.002
Chromium	Cr	mg/l	0.002	0.002
Cadmium	Cd	mg/l	0.001	0.001
Arsenic	As	mg/l	0.005	0.005
Mercury	Hg	mg/l	0.000	0.000
Cyanide	Cn	mg/l	0.020	0.020
Manganese	Mn	mg/l	0.028	0.025
Aluminium	Al	mg/l	0.100	0.100
Hardness	CaCo3	mg/l	353.9	314.1
Nitrate as NO3	NO3 Ind	mg/l	8.7	9.0
Ammonium	NH4	mg/l	0.12	0.10
Ortho Phosphate	PO4 Ind	mg/l	0.19	0.17
Chlorine	Cl	mg/l	20.0	20.1
Cobalt	Co	mg/l	0.002	0.002
Magnesium	Mg	mg/l	8.5	8.6
Nickel	Ni	mg/l	0.005	0.004
Sodium	Na	mg/l	9.2	10.2

Some of the main parameters tested as part of the monthly monitoring suite include Conductivity, pH, Suspended Solids, Sulphate, Total Hardness, Ammonium, Lead and Zinc. Additional monitoring is undertaken for a range of other parameters, on a quarterly monitoring frequency:

parameters tested as part of the additional quarterly testing suite include Cyanide, Chloride, Phosphorus, Potassium, Sodium, Aluminium, Manganese, Copper, Arsenic, Cadmium and Nickel.

The duration of the historic monitoring and the monitoring frequency provide an ample dataset for assessment and comparison of the surface water quality upstream and downstream of the discharge point. The Statutory Instruments that have been used for assessment of the surface water quality are The Salmonid Waters Regulations (S.I. 293 of 1988) and The Surface Water Regulations (S.I. 272 of 2009). The data from the monitoring period shows that the surface water quality of the River Boyne is consistent upstream and downstream of the diffuser discharge point.

Mean values from the monitoring data have been averaged over the period.

- The mean pH recorded upstream is the same as that downstream (mean pH 7.94) and is within the range for Salmonid Waters.
- The mean Total hardness is also of the same range upstream (mean Hardness 369 mg/l as CaCO₃) as that downstream (mean Hardness 377 mg/l as CaCO₃).
- The suspended solid loading in the surface water is consistent upstream and downstream (mean Suspended Solids value of 8 mg/l) and meets the 25mg/l requirement in the Salmonid Regulations.
- The mean concentration of Sulphate is similar both upstream (47mg/l) and downstream (50mg/l) of the discharge location.
- Chloride concentrations upstream (mean 17mg/l Chloride) and downstream (mean 18mg/l Chloride) are also consistent. Both parameters are normal for Irish surface waters.
- Cyanide concentration was below the laboratory detection value of < 0.02 mg/l upstream and downstream.
- Total hardness range for this surface water is > 100mg/l (i.e. downstream mean Hardness 377 mg/l as CaCO₃).
- The downstream concentrations of Zinc (mean 0.01mg/l Zinc), Lead (mean 0.003mg/l Lead) and Copper (mean 0.004mg/l Copper) are acceptable in relation to the respective Annual Average Quality Standards for Surface Water - S.I. 272 of 2009, as set relative to the hardness

range (Annual Average <0.1mg/l Zinc; Annual Average <0.0072mg/l Lead; Annual Average <0.03mg/l Copper).

- The concentrations downstream of Arsenic (mean <0.01mg/l Arsenic) and Nickel (mean 0.01mg/l Nickel) are acceptable in relation to the respective Annual Average Quality Standards for Surface Water (S.I. 272 of 2009).
- Cadmium concentration was below the laboratory detection concentration provided (<0.002mg/l Cadmium).
- The concentrations of Ammoniacal Nitrogen (upstream mean 0.10mg/l Ammonia as N and downstream mean 0.09mg/l Ammonia as N) are within the threshold of the Salmonid regulations (<1mg/l Ammonia as NH₄; < 0.78 mg/l Ammonia as N).

In summary, data shows that the surface water quality of the *River Boyne* is consistent upstream and downstream of the SW1 discharge point. Apart from isolated deviations, the quality is generally consistent with a low but determinable impact of agricultural activity within the catchment. The surface water quality at the monitoring locations is sufficient to adhere to the Quality for Salmonid Rivers.

7.2.2.1.2 ECOLOGICAL STATUS

Since the early 1970's BTM has conducted biological assessments of the water channels in the environs of the site. With reference to the River Boyne, the biological quality rating is consistent upstream and downstream of the BTM discharge point, with Q-rating varying over time between Q4-5 and Q3-4. The results strongly suggest that the Tara Mines discharge does not alter the Biological Quality of the River Boyne. The lower quality rating on the River Boyne downstream of Navan is attributable to discharge of domestic effluent from the town.

7.3 WATER MANAGEMENT / TREATMENT SYSTEM

The function of the water management system is to maintain the water balance to ensure that there is sufficient water to service the mine operations (ore mining and processing) while at the same time ensuring that excess water is discharged back to the receiving environment without have detrimental impact.

Water inputs to the system:

- Groundwater pumped from the mine
- Precipitation (all surface water runoff is collected in either the tailings facility or mine site drainage network)
- Abstraction from the Boyne (small %)

Water outputs from the system

- Discharge to the River Boyne (SW1)
- Discharge to the River Blackwater (SW2)
- Evaporation

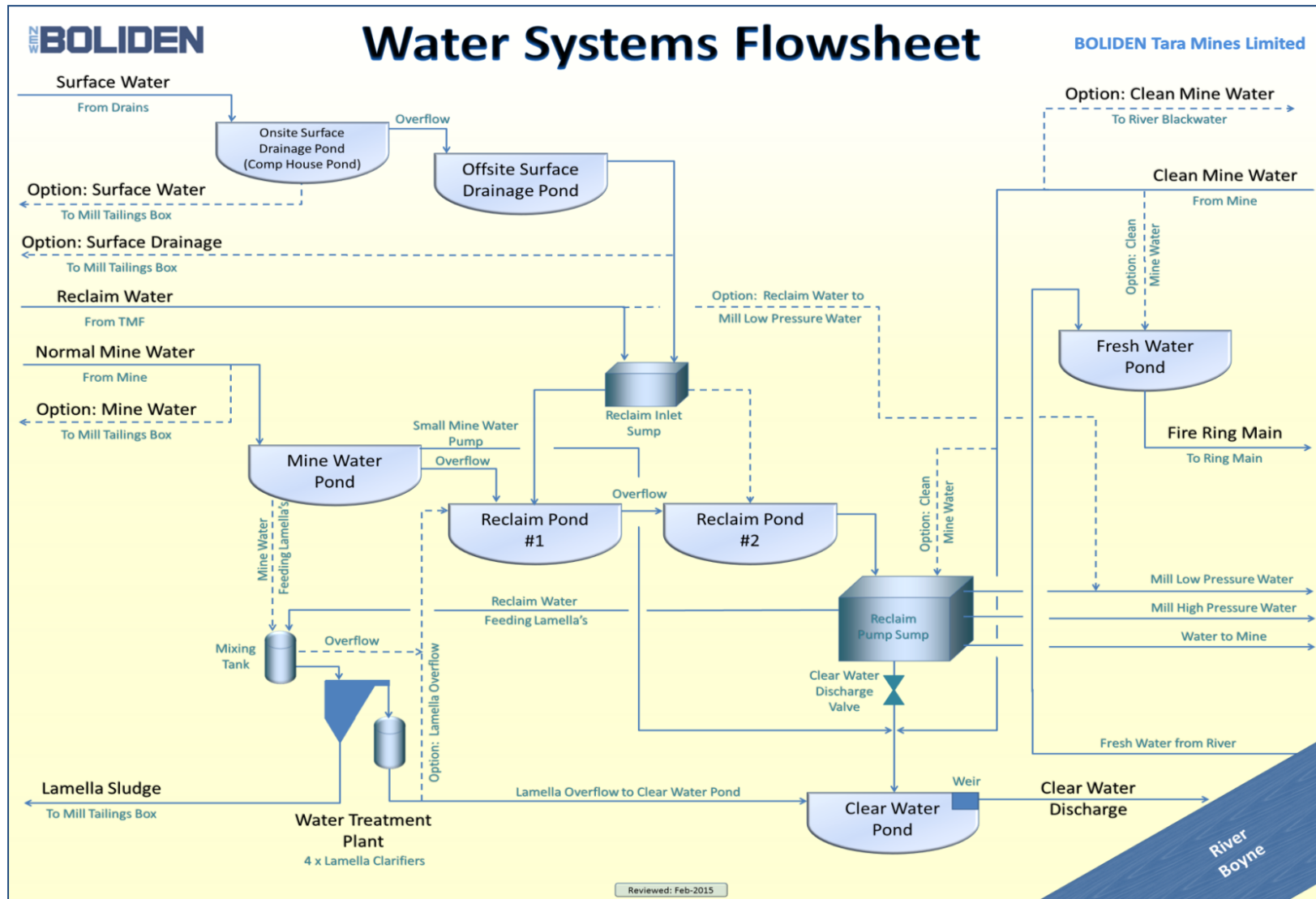


FIGURE 7.2 WATER SYSTEM FLOW DIAGRAM

7.3.1 MINE DEWATERING

The underground working must be dewatered to facilitate the mining process.

Water enters the mine in three ways:

- as natural ground water,
- as service water for the mining operations,
- as transport for the backfill.

The lowest pump station is fully automated, where variable speed slurry pumps operate to remove the dirty water. This water is pumped directly to the main pump station located in the shaft pillar where it is screened, clarified and pumped to the surface. The water entering the clarification system is screened to remove the >3mm material, and clarified with the use of a lamella thickener. An organic polymer is added to induce rapid settlement.

Clean water overflow collects in two holding sumps, where clean water pumps then lift it 416m to the surface pond where it can be reused. The total pumping capacity of the mine is 21,600 m³/d while the current total inflow to the mine is c. 14,300 m³ / day.

Water from these three sources is collected, pumped and treated prior to discharge to the River Boyne.

The pumped water is directed from underground outfalls to a minewater pond, acting as a primary settlement pond. Overflow from this minewater pond decants by controlled overflow to a secondary stage of settlement/clarification in the Reclaim Water Ponds. Water from the Reclaim Water Pond decants, via a controlled overflow, to a Clear Water Pond (Discharge pond).

Once on surface water will be treated and either reused in the process or discharged under licence to the Boyne, Ref SW1. The water treatment system comprises three stages of clarification in sediment-aeration ponds prior to discharge to the River Boyne.

The discharge from the Clear Water Pond to the River Boyne is via a weir structure, which measures and controls the discharge. The rate of discharge from the Clear Water Pond is dictated by the flow in the River Boyne, as a minimum dilution rate of 100:1 is required under licence conditions.

An automatic hydrometric gauging station has been installed on the River Boyne. This gauging station provides a real time record of water levels and flow in the River Boyne. Discharge from the site is controlled based on River Boyne flows.

7.3.2 NEVINSTOWN DEWATERING

Like the main mine the Nevinstown water balance is made up of three sources, natural groundwater, backfill water and service water.

However unlike the main mine area not all ground water inflows are collected centrally.

Within the Nevinstown area, a groundwater inflow was encountered during original mine development works at 200m bgl in the 1390 N3CHLG development drift. This inflow is considered to be discrete and localised.

Potential groundwater inflow at Nevinstown represents 45% of the total water make for the entire mine.

The single inflow from 1390 N303CA represents 31% of the total water make.

The 1390N303Ca inflow of clean ground water is pumped to the surface through a dedicated pipeline and is discharged under licence to the river Blackwater, Ref SW2.

7.3.3 POTENTIAL IMPACTS

Potential impacts on surface water are limited to those associated with the two point source discharges from the system.

No other water leaves the system, all water falling within the BTM catchment is handled within the internal water management and treatment system.

7.3.3.1 WATER TREATMENT AND DISCHARGE

There are three sources of water that are considered process water. These are as follows:

- Water ingress to the mine that is pumped out to maintain a suitable dry working environment
- Surface run-off
- Water from processing plant.

Water from these three sources is collected, pumped and treated prior to discharge to the River Boyne at Emission Point Reference SW1.

Tailings are pumped to the tailings facility as an aqueous slurry (85% water). Within the tailings facility water is retained for primary treatment/sedimentation before water is recycled to the mine site water treatment system.

Minewater and surface run-off, representing a low risk effluent are treated in the onsite water treatment system.

The water treatment system comprises three stages of clarification in sediment-aeration ponds prior to discharge to the River Boyne.

The majority of the minewater is collected at a central underground pumping station. The water enters a large settling sump where suspended solids settle out. The water is pumped to the surface via rising pipework infrastructure within the production shaft to the 'surface minewater pond' which acts as a primary settlement pond. Overflow from this minewater pond decants by controlled overflow to a secondary stage of settlement/clarification in the Reclaim Water Ponds. Water from the Reclaim Water Pond decants, via a controlled overflow, to a Clear Water Pond (Discharge pond).

Water is discharged from the 'Clear Water Pond' to the River Boyne via a weir structure, which measures and controls the discharge. The rate of discharge is dictated by the flow in the River Boyne, as a minimum dilution rate of >100:1 is required under licence conditions.

An automatic hydrometric gauging station has been installed on the River Boyne. This gauging station provides a real time record of water levels and flow in the River Boyne.

Discharge at SW2 is clean groundwater, derived from the Nevinstown mine area which has minimal or no contact with the orebody. This groundwater is collected in a dedicated reservoir and pumped directly to surface for discharge to the River Blackwater. Discharge is recorded and controlled from the Processing Departments automated ABB system.

7.3.4 DISCHARGES TO SURFACE WATER RECEIVING SYSTEMS

7.3.4.1 DISCHARGE TO THE RIVER BLACKWATER _ SW2

TABLE 7.3 BLACKWATER DISCHARGE DATA

Parameter	Unit	Value	Guidance value
pH	pH	8.2	-
Temp	°C	7.8	-
SS	mg/l	3.8	25
Zn	mg/l	0.26	0.8
Pb	mg/l	0.003	0.007
SO ₄	mg/l	162.5	200
DO	mg/l	8.9	-
BOD	mg/l	1.0	2.6
COD	mg/l	5.3	10
Phosphate, ortho as P	mg/l	0.18	0.075
Total Ammonia as N	mg/l	0.19	-
Antimony	ug/l	2.5	-

Note: Mean of 12 months data up to September 2017

7.3.4.2 DISCHARGE TO THE RIVER BOYNE _ SW1

Parameter	Unit	Value	Guidance value ⁷
pH	pH	7.9	6 - 9
Dilution.	Ratio	259	100:1
Suspended Solids	(mg/l)	9.0	30
COD	(mg/l)	22.4	100
Zinc	(mg/l)	0.13	2
Lead	(mg/l)	<0.002	0.1
Copper	(mg/l)	<0.002	0.5
Iron	(mg/l)	0.012	1.0
Antimony	(mg/l)	0.38	0.8
Cyanide	(mg/l)	<0.05	0.2
Cadmium ALS	(mg/l)	<0.0005	0.1
Arsenic	(mg/l)	0.016	0.5
Chromium	(mg/l)	0.002	0.1
Mercury	(mg/l)	0.00001	0.005
Mineral Oils	(mg/l)	0.039	1
Total N Concentration	(mg/l)	15.2	50
Ammonical N	(mg/l)	3.2	5.0
Total P	(mg/l)	<0.12	2
Ortho Phosphate	(mg/l)	0.03	0.5
Chloride as Cl	(mg/l)	86.7	
Sulphate	(mg/l)	555.6	1500
BOD	(mg/l)	2.0	20

7.4 DISCUSSION

The activities associated with the on-going mining activity and tailings storage are having no discernable impact on the water quality of the River Blackwater. All emissions to surfacewater are controlled, operated, and emissions take place as set out in the Company's current IE Licence. Mass emissions to water are reported to the Agency in Annual Environmental Report (AER) and through PRTR reporting.

There are no additional impacts to surface water from the resumption of mining operations in Nevinstown

Monitoring of surface water will continue as per IEL Conditions.

⁷ Industrial Emissions Licence Limits

REFERENCES

The following references have been used in the preparation of this report:

- Schlumberger Water Services (UK) Ltd, March 2016. *April 2014 to March 2015 Hydrogeology monitoring report for Nevinstown*. Fifth biennial monitoring report prepared for Boliden Tara Mines Ltd. covering the period April 2014 to March 2015. Report ref.: 50765/R9.
- Schlumberger Water Services (UK) Ltd, November 2014. *April 2011 to March 2013 Hydrogeology monitoring report for Nevinstown*. Fourth biennial monitoring report prepared for Boliden Tara Mines Ltd. covering the period April 2011 to March 2013. Report ref.: 50765/R7.
- Schlumberger Water Services (UK) Ltd, May 2012. *An Investigation into Cavity Distribution in the Host Limestones at Liscartan and Rathaldron*. Report ref.: 50765/R4.
- Schlumberger Water Services (UK) Ltd, March 2012. *April 2009 to March 2011 hydrology monitoring report for the Nevinstown extension*. Third biennial monitoring report prepared for Boliden Tara Mines Ltd. covering the period April 2009 to March 2011. Report ref.: 50765/R1.
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- Water Management Consultants, February 2009. *April 2005 to March 2007 monitoring report for the Nevinstown extension*. First biennial monitoring report prepared for Boliden Tara Mines Ltd covering the period April 2005 to March 2007. Report ref.: 1785/R6.
- Water Management Consultants, May 2005. *Annual Monitoring Report – Nevinstown*. Initial annual monitoring report prepared for Boliden Tara Mines Ltd covering the period April 2004 to March 2005. WMC ref 1785/R1.
- Australian Mining Consultants, April 2003. *Nevinstown Geotechnical Study*. Report Produced for Tara Mines Limited.

8 CULTURAL HERITAGE

8.1 ARCHAEOLOGY

The Nevinstown orebody is almost wholly contained within the boundaries of the townland of Nevinstown, situated 1km north west of Navan town between the River Blackwater and the Navan-Donaghpatrick road. The townland overall comprises 240 acres of undeveloped farmland which is currently in pasture. There are no inhabited buildings in the townland, the four houses present being now ruinous or derelict.

The Nevinstown orebody is located to the north of the existing Tara Mines development and extends in an arc for a maximum distance of c 0.75km north of the River Blackwater. The development site is located in an area which is rich in known archaeological monuments ranging in date from the Neolithic to the Post-Medieval periods. In 1966 the National Museum of Ireland carried out a programme of archaeological excavation on a number of sites located on the land overlying the orebody. In addition, there is a strong likelihood of the presence of further archaeological sites of which there are no surface indications.

However, since mining of the Nevinstown orebody will take place underground with no new associated surface developments whatsoever, the development will have no impact on the archaeological heritage in Nevinstown.

8.1.1 METHODOLOGY

The archaeological study comprises the results of desk-based research and a field survey of the proposed development site.

The principal documentary sources consulted for the study were as follows:

- The archives of the Archaeological Survey of Ireland. The Archaeological Survey forms part of the National Monuments and Historic Properties Division of Duchas, The Heritage Service, Department of Arts, Heritage, Gaeltacht and the Islands. The purpose of the Survey is to identify, on a county by county basis, all monuments and places of archaeological importance. In 1985 the Archaeological Survey issued the *Sites and Monuments Record: County Meath*

(SMR), consisting of site lists and a corresponding set of annotated O.S. six-inch maps. This was followed in 1986 by the *Archaeological Inventory of County Meath*, published in book format, based on an examination of numerous sources including 18th and 19th century estate maps, various editions of O.S. maps, records of the National Museum of Ireland and collections of aerial photographs (Air Corps, G.S.I., Cambridge University, Tara Mines Ltd.). In 1996 the National Monuments and Historic Properties Division issued the *Record of Monuments and Places: County Meath* (RMP) in accordance with Section 12 of the National Monuments (Amendment) Act 1994. All archaeological sites listed in the 1996 Record, essentially an updating of the 1985 Sites and Monuments Record, are given statutory protection under the 1994 Act. An extract from the 1996 Record of Monuments and Places: County Meath for the relevant area is attached as Figure 8.1 below.

The first edition of the O.S. six-inch (1:10560) map, Meath Sheet 25 (1837).

- Relevant historical and archaeological books and journals (see Bibliography).
- The first edition of the O.S. six-inch (1:10560) map, Meath Sheet 25 (1836).
- Relevant historical and archaeological books and journals (see Bibliography)

A field inspection was carried out to assess the local topography and current land use. The purpose was also to note the present condition of the archaeological sites previously excavated in the development area and to note any further possible features of archaeological or historical interest.

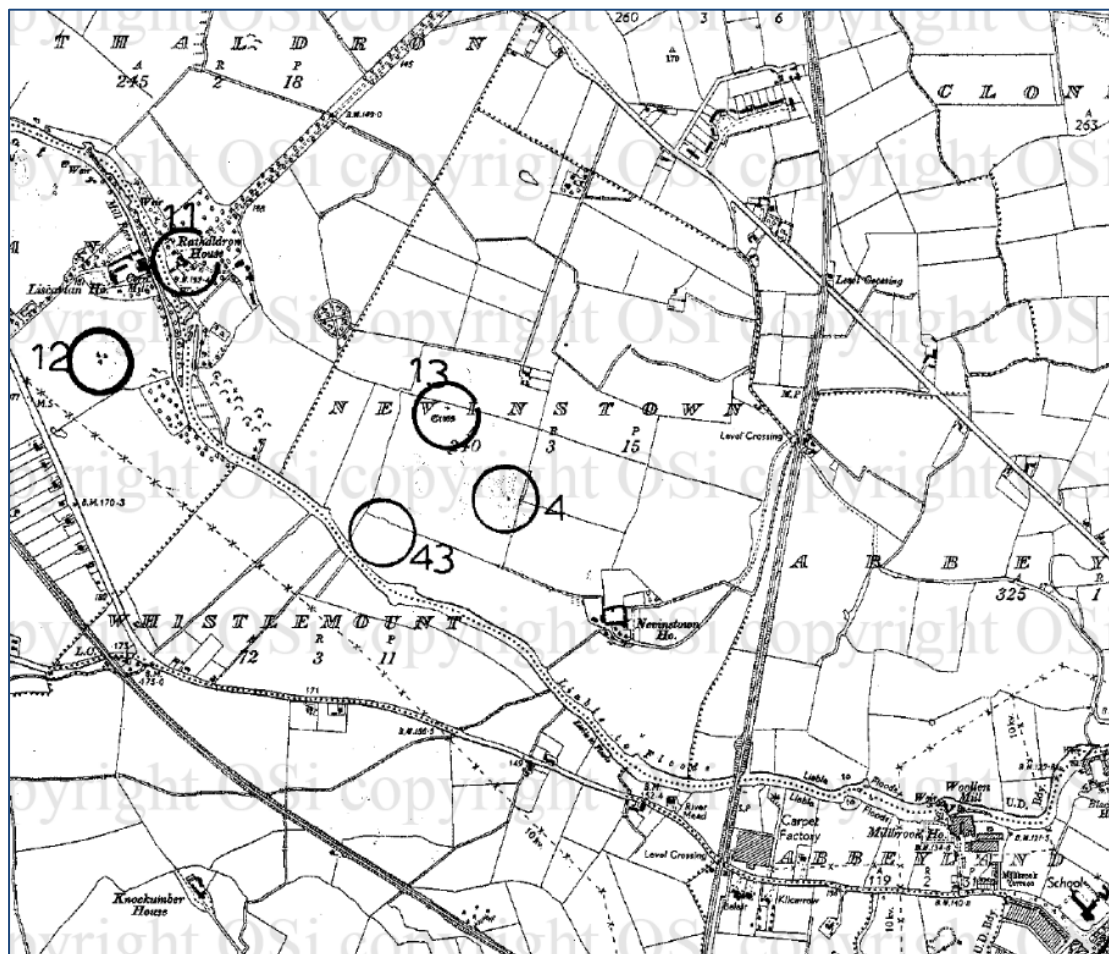


FIGURE 8.1 EXTRACT FROM THE 1996 RECORD OF MONUMENTS AND PLACES: COUNTY MEATH

8.1.2 ARCHAEOLOGICAL AND HISTORICAL BACKGROUND

The development site is located in an area where there is clear evidence of settlement from at least the Neolithic period onwards. Indeed, excavations within the boundaries of the development site itself have uncovered archaeological deposits dating to the Early Bronze Age, Early Christian, Medieval and Post-Medieval periods. These excavations took place in 1966 under the direction of Mary Cahill of the National Museum of Ireland, in advance of a proposed open-cast mining operation which did not proceed. In the vicinity of the Nevinstown evidence of early settlement is present not only in the form of upstanding monuments but also as archaeological deposits which were discovered during development of the Tara Mines Ltd. tailings dam at Simonstown and Randalstown.

8.1.2.1 PREHISTORIC PERIOD

At Simonstown in 1965 E.P. Kelly recorded pits and hearths of Neolithic date (c. 4500-2200 BC) under the banks of an Early Christian period ringfort. More recently, in 1998, Coilín Drisceoil partially excavated the remains of a large rectangular structure (his Area 2) which may have been burnt. A Neolithic date, first indicated by the finding of a leaf-shaped arrowhead on the site, was later confirmed by radiocarbon dating (*pers comm* C. Drisceoil).

Material of Bronze Age date (c. 2200-500 BC) was found at Nevinstown Site 1, by Mary Cahill, where cremated human bone was contained in an Encrusted Urn and a Food Vessel Vase buried in a pit. Burnt mounds or *fulachta fiadh*, presumed communal cooking places typically Bronze Age in date, have been excavated in the borrow areas for the tailings dam at Simonstown (Drisceoil's Area 6) and at Randalstown, where four such sites were excavated by D. Murphy in 1999. At Simonstown, Drisceoil also uncovered 61 circular pits containing burnt stone, charcoal and occasionally cremated bone, suggestive of a Bronze Age date. In Liscartan townland, on the opposite side of the Blackwater c. 0.5km upstream and west of Nevinstown, a tumulus or earthen mound is likely to be of prehistoric date, but without excavation is impossible to assign to a particular period.

8.1.2.2 EARLY CHRISTIAN PERIOD

Large-scale excavations of settlement sites of the Early Christian period took place at Nevinstown itself (Cahill's Site 1) and also at Simonstown and Randalstown. Kelly excavated a large ringfort (65m diameter) at Simonstown in 1965 and an enclosure with a cemetery at St. Anne's Chapel, Randalstown, in 1965-6 and 1981-2. On this latter site Iron Age settlement was indicated by the finding of a 1st century AD Roman brooch. There is a further ringfort surviving at Clomagaddan, to the north east of Nevinstown.

Souterrains, associated with unenclosed settlements, have been excavated at Nevinstown (Cahill's Site III) and on two sites at Randalstown. There is a record of a souterrain with two beehive chambers at Ardraccan. There is annalistic and archaeological evidence for Early Christian churches at Ardraccan, Liscartan and Randalstown but no fabric survives of the actual buildings. Bradley considers that documentary evidence for the foundation of a house for Augustinian Canons at Navan,

before the coming of the Anglo-Normans, supports the tradition of an Early Christian monastery on the site of the town.

8.1.2.3 MEDIEVAL PERIOD

The town of Navan is an Anglo-Norman foundation of the late 12th century although the earliest documentary reference to the town as a borough is 1462, when Edward IV confirmed the right of the town to collect tolls, and its earliest charter dates to 1494. Hugh de Lacy granted Navan and Ardbraccan to Jocelin de Angulo (later Nangle) before 1286 and the town most likely owes its foundation to him or his son William. The motte built by de Angulo at Moathill, marked “Navan Moat” on the O.S. map, is probably the earliest surviving vestige of the medieval town. It is situated to the west of the town on a ridge on the south bank of the Blackwater a little over 0.5km south east of Nevinstown. The town was walled from the 15th century and a portion of the wall with a tower survives at Barrack Lane on the north side of the town. The Augustinian Priory of St. Mary lay between the north wall and the River Blackwater.

Adjacent on the west side of Nevinstown, the core of Rathaldron House is a four-storey late medieval tower house, possibly built by the Cusacks in the 14th century. Another medieval tower house stands at Liscartan, “Liscartan Castle (in ruins)” on Figure 8.1, in company with the ruins of a gatehouse and a later stone house, of 16th or 16th century date. West of the castle are the ruins of the medieval church, still in use into the 18th century.

The late medieval cross at Nevinstown, marked “Old Cross” on the 1836 O.S. map, was erected by Michael de Cusack in 1588 and is believed to have functioned as a wayside cross on an old road from Navan to Rathaldron Castle. The cross was moved to the County Library in Navan in recent times. The site of the cross was the subject of archaeological excavation in 1966 (Cahill’s Site IV), when the remains of 6-8 infants were uncovered around the plinth.

In addition to recognised medieval monuments in the area, material of medieval date has also occurred in the excavation of several Early Christian settlement sites, representing the later phases of use of the sites. Pottery and other domestic artifacts were found in Phase III at Nevinstown Site I. A medieval phase was also recognised on the ringfort excavated by Kelly at Randalstown.

8.1.2.4 POST-MEDIEVAL PERIOD

The *Civil Survey of County Meath*, compiled in 1654-6, lists 'Patrick Cusacke of Rahaldron' as the proprietor of 'Symonstowne and Neivenstowne', with a combined 250 acres. A wing was added to the Cusack castle at Rathaldron in the 16th century, the whole edifice being gothicised c. 1800 with further alteration by new owners in 1843. The prevailing field pattern of large rectangular fields probably dates to the 18th century. The architectural style of Nevinstown House suggests it also dates to this time, although possibly built on the site of an earlier house. In 1836 the house was the only building in the townland; three other small dwellings not appearing until the early 20th century. A limekiln, of 18th-early 19th century date, stands in the field between Nevinstown House and the River Blackwater. One of the more significant changes to the landscape of the immediate area must have been the construction in 1862 of the Navan-Kingscourt branch railway line on the western side of the townland.

8.2 RECORDED ARCHAEOLOGICAL SITES

The relevant SMR and RMP sheet for the proposed development site is Sheet No. 25 for Co. Meath (Figure 8.1). Listed below are the archaeological sites in Nevinstown and adjoining townlands as recorded by Duchas in the SMR/RMP and the *Archaeological Inventory of County Meath*. The Nevinstown sites were excavated by the N.M.I. in 1966. The details of each site are as follows:

- I. Inventory No.
- II. SMR No.
- III. Townland
- IV. NGR
- V. Site type
- VI. Description

8.2.1 RECORDED ARCHAEOLOGICAL SITES IN NEVINSTOWN TOWNLAND

286

025:043.2

Nevinstown

28504 26865

Pit burial

An Encrusted Urn and a Vase Food Vessel were excavated at Site I by Mary Cahill in 1966. The urn and food vessel were contained in a pit dug into the natural ridge and contained the cremated bones of at least two adults and one child.

392

025:043.1

Nevinstown

28504 26865

Early Christian Occupation Site

Excavated as Site I by Mary Cahill in 1966 this was a flat-topped mound at the end of a gravel ridge and was enclosed by three concentric ditches. Excavation produced evidence for three phases of activity dating mainly to the Early Christian period but with finds also from the medieval and post-medieval periods.

441

025:004

Nevinstown

28520 26883

Souterrain

This site, Cahill's Site II excavated in 1966, consisted of a 12m length of destroyed souterrain passage leading to a beehive chamber. This monument type is datable to the Early Christian period. No evidence was found for an enclosure around the souterrain.

1546

025:013.1

Nevinstown

28518 26900

Cross

A wayside cross was erected here in 1588 by Michael de Cusack and his wife Marguerita Dexter. The cross has been moved to the County Library in Navan. Excavations by Mary Cahill in 1966, her Site IV, uncovered the remains of the plinth, which had been constructed of cut-limestone blocks.

1600

025:013.2

Nevinstown

28518 26900

Cillin

Excavated as Site IV by Mary Cahill in 1966, this burial ground contained the remains of 6 or 8 infants and young children at the base of the late medieval wayside cross (**1546** above).

Recorded Archaeological Sites in Adjoining Townlands

189

025:12

Liscartan

28442 26910

Tumulus

A circular mound, planted with trees, measures 23m in diameter and 2.5m high. The mound has been damaged by quarrying.

1646

025:023

Moathill

28598 26665

Motte and Bailey

Flat-topped earthen mound surrounded by the remains of a fosse, with a small lunate bailey defined by a scarp. Motte measures 36m diameter and 6.8m high.

1443

025:008

Liscartan

28396 26945

Church

A medieval church consisting of an undivided nave and chancel with original double-light windows in the east and west walls. Repaired in the 18th century when large round-headed windows were inserted into the south and north walls.

1323

025:024

Abbeylands South

28690 26814

Abbey (site)

No visible remains survive of the medieval Augustinian St. Mary's Abbey on the north side of Navan town. Some medieval mouldings were recovered during construction of the Inner Ring Road. Cut stone from the abbey is kept at St. Patrick's Classical School and in the Church of St. Oliver Plunkett in Navan.

1648

025:009

Liscartan

28403 26951

Tower House

A three-storey rectangular medieval tower house with large corner towers on three angles. An entrance in the east tower leads to a barrel-vaulted ground floor. An enclosing courtyard contains a stone house (1806).

1649

025:010

28412 26945

Liscartan

Gatehouse

A barrel-vaulted gateway, with murder hole over the entrance, is situated 100m from the tower house at Liscartan (1648)

1662

025:012

Rathaldron

28458 26932

Tower House

A four-storey medieval tower house, still inhabited. The castle has been extensively remodelled but retains some original features.

1816

025:025

Abbeylands South/Townparks

28600 26660

Town Defences

The medieval defences of Navan town enclosed an area of c. 13 acres. The town walls probably date from the early 15th century. Portion of the town wall and a tower survive near Barrack Lane.

8.3 RESULTS - FIELD SURVEY

The survey was limited to those fields which directly overlay the proposed mining operation. These fields are numbered 1-10 on Figure 8.2. The topography of Nevinstown townland from the Rathaldron road to the River Blackwater is of undulating farmland set out in large rectangular pasture fields. The field boundaries consist of traditional banks and ditches with tall hedges and many mature trees. Comparison of the present-day field layout with that shown on the 1836 first edition of the O.S. six-inch map (Figure 8.3), surveyed in 1836, shows that changes are limited to some subdivision of fields. The straight lane running north-south through the townland from the Rathaldron road is also a post-1836 addition. The land is currently grazed by cattle and sheep or is in silage.

Field 1

This is a large rectangular pasture field running north from the River Blackwater at the western boundary of Nevinstown townland. The field is on two levels separated by a sharp slope c 50-60m from the river's edge. Nothing of archaeological interest was observed.

Field 2

This is a large elongated pasture field of similar configuration to Field 1, with a drop in level to a flat area by the river's edge. Nothing of archaeological interest was observed. Fields 1 and 2 appear as one large field on the 1836 map.

Field 3

Large pasture field aligned east-west for c 600m along the north bank of the River Blackwater. The field is level by the river's edge with a slope up towards its northern boundary. Over the western half of the field this slope takes the form of a furze-covered scarp above which is a flat area up to c 100m wide (N-S). An archaeological site, *Site I* of the 1966 excavations programme, is located on the top of the scarp at the western end of the field (Figure 8.2). The essential elements of the site, enclosing ditches and flat-topped central area, survive in good condition. The grid squares of the archaeological excavation, now grassed over, remain clearly visible. The scarp is shown wooded on the 1836 O.S. map, as is the slope at the north-western edge of the field. The map also shows a stand of trees at the river's edge midway along the length of the field.

Field 4

This large approximately square pasture field is generally level, with a marked ridge running east-west across the southern half of the field. There is a slight fall towards the western margin and there are natural hollows against the eastern edge which continue into the adjoining fields. There is an small overgrown quarry in the south-east corner of the field which is shown as "Gravel Pit" on the 1836 O.S. map.

Three of the archaeological sites excavated in 1966, *Sites II, III* and *IV*, were located in this field.

- *Site II*, a standing stone, which stood on the east-west ridge across the field, was discounted as an antiquity by the excavator and this site was not included in the *Sites and Monuments Record* or the *Record of Monuments and Places* issued by uchas for County Meath.

- *Site III*, a souterrain, now appears as an area of disturbed ground at the centre of the field. This site is shown in the wrong position, i.e. at the eastern edge of the field, on Sheet 25 of the Record of Monuments and Places: County Meath, issued by Duchas.
- *Site IV*, the site of a 16th century wayside cross and associated *Cillin*, at the northern boundary of the field and outside the limit of the development, is now marked by a shallow excavation and a scatter of loose stones. The cross is now stored in the County Library in Navan. There was a local tradition that unbaptised infants were buried in the vicinity of Nevinstown Cross (Cillín). Excavations carried out by the National Museum would appear to bear this out. The remains of eight very young children were found during these excavations. They would appear to date from the 19th century. It was tradition then not to bury unbaptised babies in concentrated ground.

Field 5

This is a large rectangular pasture higher at the southern side, flattening off to the north and north-east. At the south-east corner of the field there is a depression, 20m across and c1.5m deep, now grassed-over and containing nettles. This is most likely to be a backfilled quarry or gravel pit, perhaps used as a rubbish dump for Nevinstown House. No features of archaeological interest were observed.

Field 6

This large rectangular field with an overall south-facing aspect was in silage at the time of survey. There is a wet hollow at the western boundary of the field. Nothing of archaeological interest was observed.

Field 7

This is a large pasture field of irregular shape, which is level to the south-west with a gentle slope to the east and south-east. Nothing of archaeological interest was observed.

Field 8

This is now a small L-shaped paddock with an undulating surface. The 1836 O.S. map shows this field laid out as a formal garden. Also shown within the area of the present field was an additional range of buildings, aligned east-west to the north of the farmyard, which has now disappeared.

Field 9

A pasture field of irregular shape, bordering the old avenue to Nevinstown House. There is a gradual slope to the east. Nothing of archaeological interest was observed.

Field 10

This is a large irregular pasture field on the north bank of the River Blackwater at the eastern boundary of Nevinstown townland. The field is level to gently undulating over the north-eastern half, with a slope south-west to the river. The field is dotted with occasional bushes and young trees. There are a number of small-scale recent excavations resembling test pits/trenches. A broad gully towards the western end of the field, due south of Nevinstown House, is depicted as "Quarry" on the 1836 O.S. map. It is noted on the 1955 revision of the O.S. six-inch map that the lower part of the field is 'Liable to Floods'. A lime kiln, depicted by a symbol on the 1836 map, survives intact towards the eastern edge of the field, built into the slope c 50m from the river. The lime kiln possesses a fine elliptical stone arch and is in a reasonable state of preservation, although heavily overgrown with bushes around the top.

Nevinstown House

In plan Nevinstown House and outbuildings survive much as they are shown on the 1836 O.S. six-inch map, with few alterations to the layout. As noted above, a range of outbuildings and the formal garden north of the house no longer exist. The house, which is of two storeys and five bays, and the farmyard buildings to the rear, are still roofed but are in a semi-derelict condition. The house in its present form is likely to date to the later 18th or early 19th century.

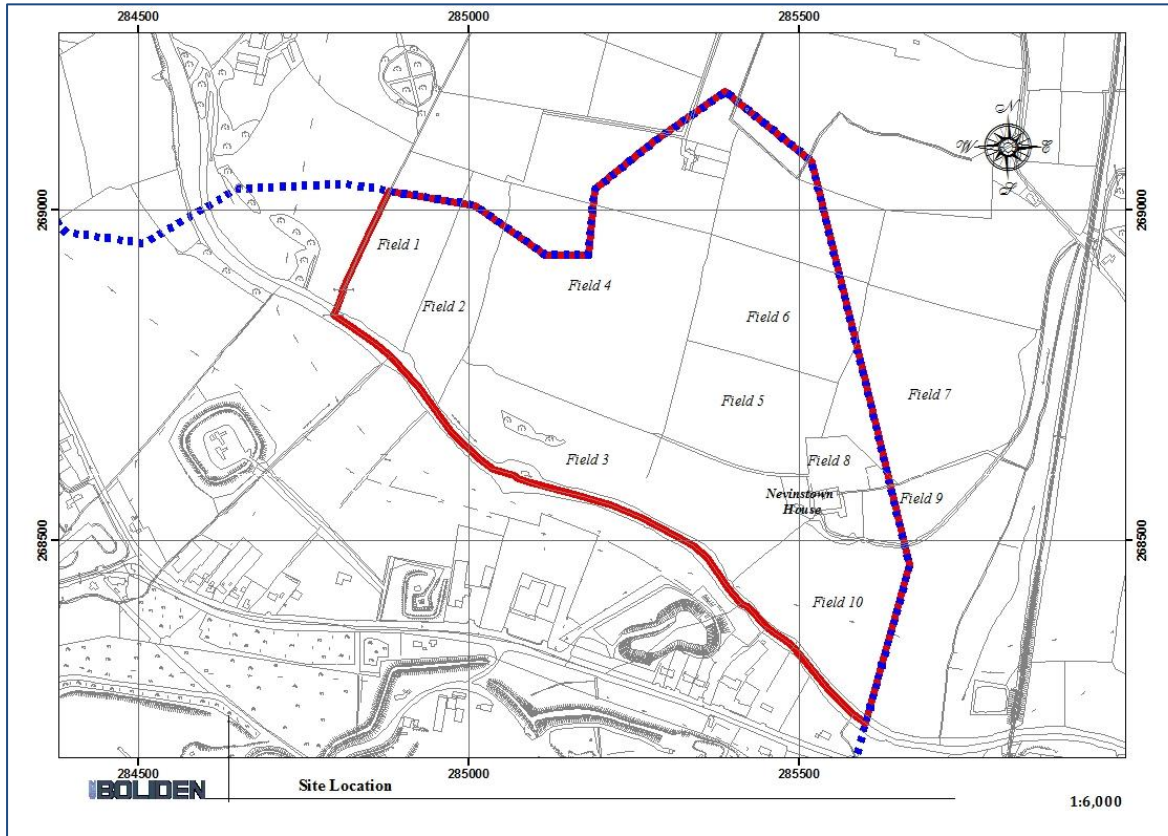


FIGURE 8.2 SITE LOCATION: FIELD SURVEY

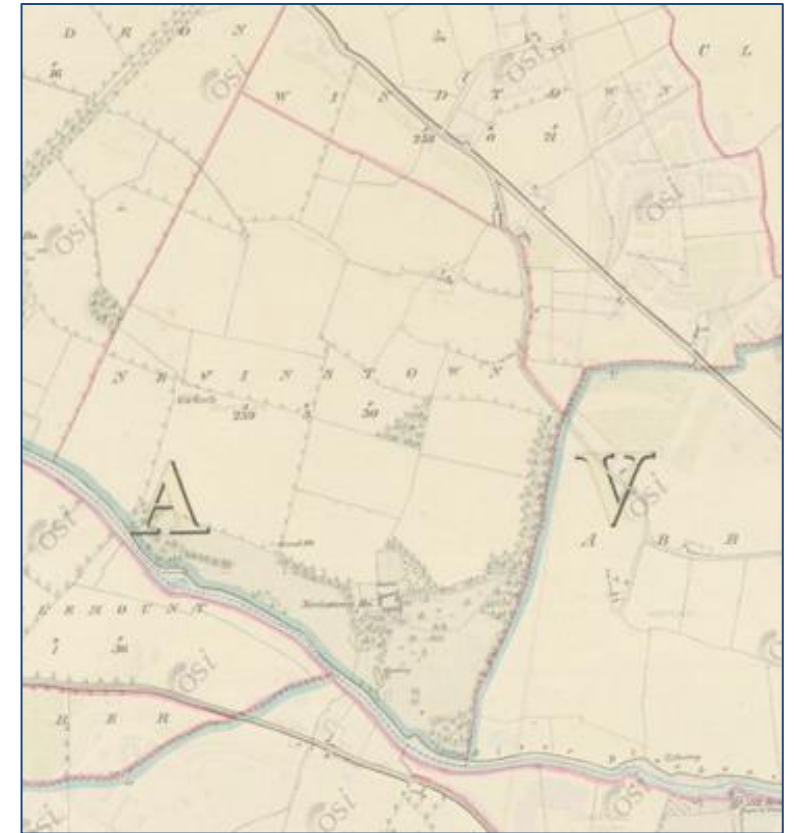


FIGURE 8.3 1836 O.S. SIX-INCH MAP

8.4 CHARACTERISTICS OF THE PROPOSED DEVELOPMENT

It is proposed to develop the Nevinstown orebody, north of the River Blackwater, by means of an underground mining operation extending from the existing mined-out area south of the river. No surface developments, e.g return air raises / ventilation facilities, or other ground works are currently proposed.

8.5 POTENTIAL IMPACT OF THE PROPOSED DEVELOPMENT

The proposed development, confined entirely to underground mining operations, **will not have any impact** on the recorded archaeological sites and monuments at Nevinstown or in the surrounding areas.

8.6 REMEDIAL AND MITIGATIVE MEASURES

The development as proposed does not impact on any known archaeological sites. However, should any above-ground work take place at any future stage of the development, which would involve disturbance of the present ground surface, it is recommended that all topsoil removal be monitored by a qualified archaeologist licenced by Duchas. In the case of large-scale ground disturbance a programme of pre-development test trenching would be advisable. If archaeological material should be discovered in the course of monitoring or testing full archaeological excavation may be necessary. In this event, provision should be made for adequate time and funding for any such archaeological work, including post-excavation work, the preparation of reports and the conservation and analysis of artifacts.

It should be noted that under the National Monuments (Amendment) Act 1994 the owner of a monument or place which is listed in the *Record of Monuments and Places* is required to give two months notice to the National Monuments and Historic Properties Service, D★chas, of any work proposed at such monuments or places.

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9 GROUND VIBRATION

9.1 BACKGROUND: 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.

Vibration is an oscillatory motion that can be described in terms of the displacement, velocity, or acceleration. For a vibrating surface,

- The displacement is simply the distance that a point on the floor moves away from its static position.
- The velocity represents the instantaneous speed of the surface movement
- The Acceleration is the rate of change of the speed.

Most measurement instrumentation (transducers) used for measuring ground-borne vibration use either velocity or acceleration. Furthermore, the response of humans, buildings, and equipment to vibration is more accurately described using velocity or acceleration.

Measurement Parameters

Peak Particle Velocity (PPV)

Peak Particle Velocity indicates the maximum speed particles travel resulting from an event's ground vibrations.

Peak Acceleration

Peak acceleration, the rate of change of velocity, is calculated by dividing the difference in velocity by the difference in time.

d. Peak Displacement

Peak displacement, or particle distance travelled, is calculated by multiplying speed by time.

Peak Vector Sum (PVS)

The vector sum represents the resultant particle velocity magnitude and is calculated by **squaring and adding** the magnitudes and taking the square root.

where:

- T = particle velocity along the transverse plane
- V = particle velocity along the vertical plane
- L = particle velocity along the longitudinal plane

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 5 seconds. It is difficult for the average lay person to differentiate between the various types of vibrations (ground and air), humans commonly associates the level of vibration with the 'loudness' of a blast.

Air Overpressure (Air Blast) Noise

A surface 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 20 Hz. Because the waves associated with air blasts are essentially outside the audible spectrum (below 20 Hz), 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 20 Hz. 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.

Air overpressure is not an issue associated with the operation of BTM as no surface blasting is undertaken.

9.2 GROUND VIBRATION CONTROL

Ground vibration from blasting at any receptor point is influenced in the main by:

- 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 charges 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 (PPV) is closely related to the maximum charge weight per delay.

In modern day mining, the blast designed to be more efficient in terms of cost and production, also minimises the generation of vibration. BTM applies the most up to date technology in its mine blasting operation. In the general area of the main mine and Nevinstown ground vibration is recorded continuously and simultaneously for each blast at six locations. Continuous monitoring is supplemented by the use of portable vibration monitors whenever the need arises.

The Environmental Department liaises on a daily basis with the blast engineer in the mine planning department to ensure maximum vibration control. This is achieved by comparing the planned blast layout with the actual recorded ground vibration waveform and modifying blast designs if deemed necessary.

Production blasting has been carried out in varying locations and at varying elevations. Typically blasting has been carried out at locations ranging in elevations between 70 and 525 meters from the surface and as close as 75m to a Tara residential property (almost directly under an occupied house in the most easterly area of mining close to the Blackwater River).

Historically the eastern most area of the mine which encompasses Zones 2 and 3 (Figure 9.1), and is the higher elevation of mining, has generated the lowest levels of ground vibration at residences (O'Reilly, 2000).

This is in the main caused by high attenuation of the propagating wave as it traverses the B, A, C, D and T series fault structure (FIGURE 9.1).

The ground vibration limit at the nearby relevant monitoring station V2 (FIGURE 9.2) has not been exceeded since blasting commenced in 1973.

Furthermore, the highest level of ground vibration recorded at this station has been less than 5 mm/sec.

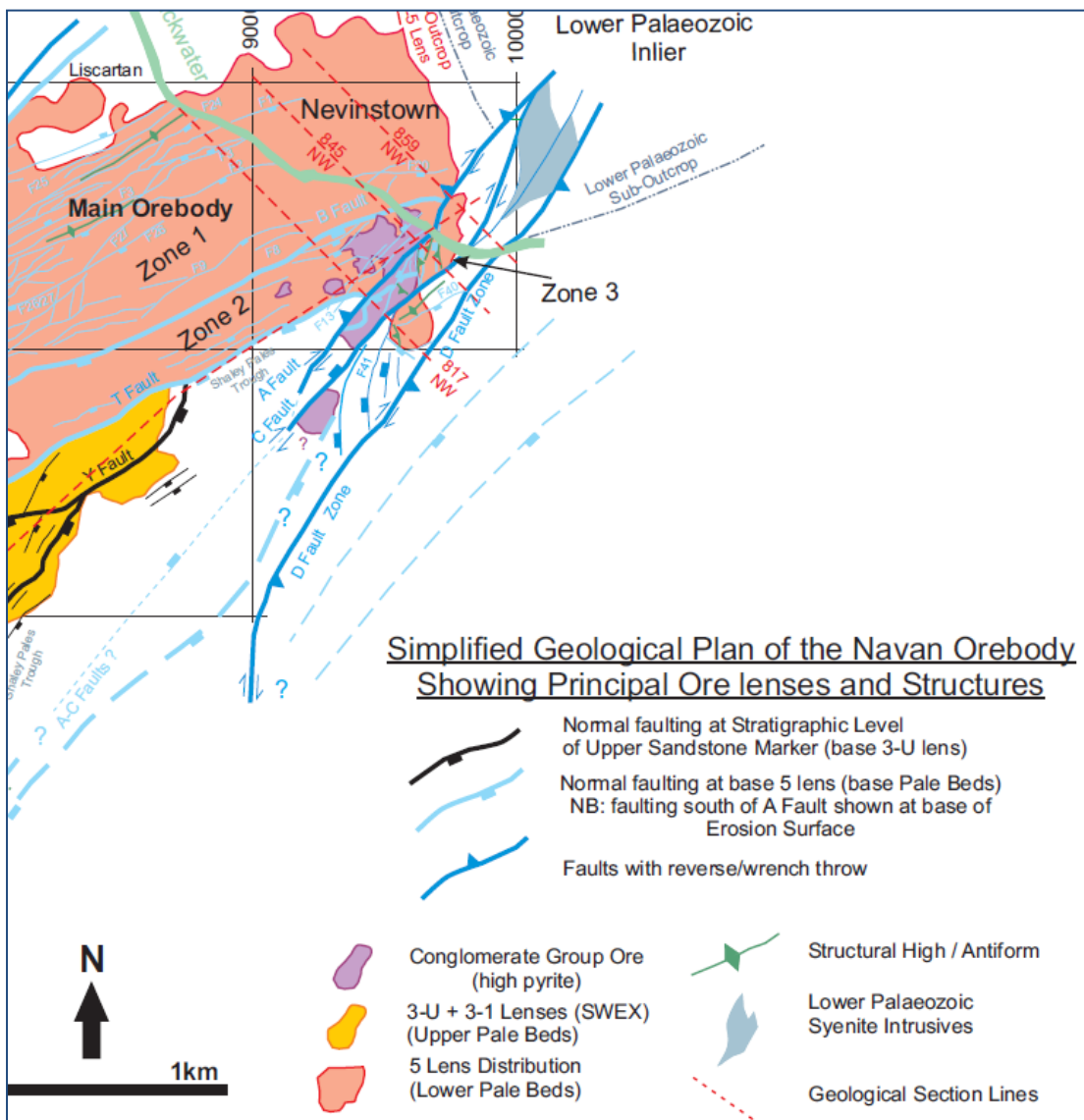


FIGURE 9.1 SIMPLIFIED GEOLOGICAL PLAN OF THE NAVAN OREBODY SHOWING FAULTS AND ZONES

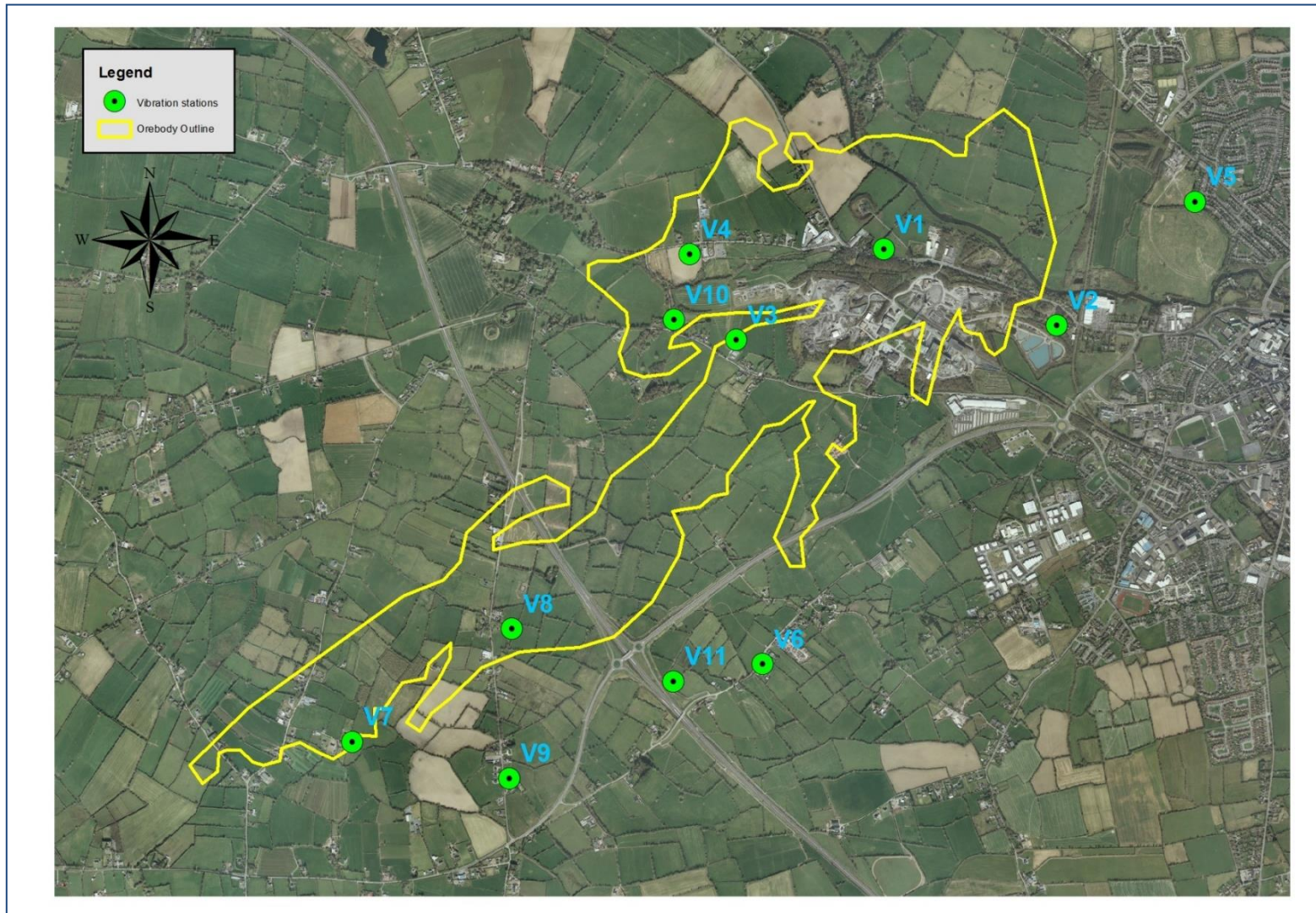


FIGURE 9.2 VIBRATION

MONITORING

LOCATIONS

9.2.1 REVIEW OF VIBRATION GUIDELINES AND STANDARDS

There are currently two British Standards that offer advice on acceptable levels of vibrations in structures. British Standard BS 7385: Part 2: 1993 'Evaluation and measurement for vibration in buildings Part 2. Guide to damage levels from ground borne vibration' gives guidance on the levels of vibration above which the building structures could be damaged. It considers only the direct effect of vibration on a building, since the other mechanisms are different.

For the purposes of BS 7385 damage is classified as cosmetic (formation of hairline cracks), minor (formation of large cracks) or major (damage to structural elements). Guide values given in the Standard are associated with the threshold of cosmetic damage only, usually in wall and/or ceiling lining materials.

For the purposes of BS 7385 damage is classified as

- cosmetic (formation of hairline cracks),
- minor (formation of large cracks) or
- major (damage to structural elements).

TABLE 9.1 GUIDANCE VALUES FOR COSMETIC DAMAGE (FROM BS 7385: PART 2:1993)

Transient Vibration Guide Values for Cosmetic Damage			
Line (see Figure 1)	Type of Building	Peak Component Particle Velocity in Frequency Range of Predominant Pulse	
		4 Hz to 15 Hz	15 Hz above
1	Reinforced or framed structures. Industrial and heavy commercial buildings	50 mm/s at 4 Hz and above	
2	Unreinforced or light framed structures. Residential or light commercial type buildings	15 mm/s at 4 Hz increasing to 20 mm/s at 15 Hz	20 mm/s at 15Hz increasing to 50 mm/s at 40 Hz and above
Note 1. Values referred to are at the base of the building			
Note 2. For line 2, at frequencies below 4 Hz, a maximum displacement of 0.6mm (zero to peak) should not be exceeded			

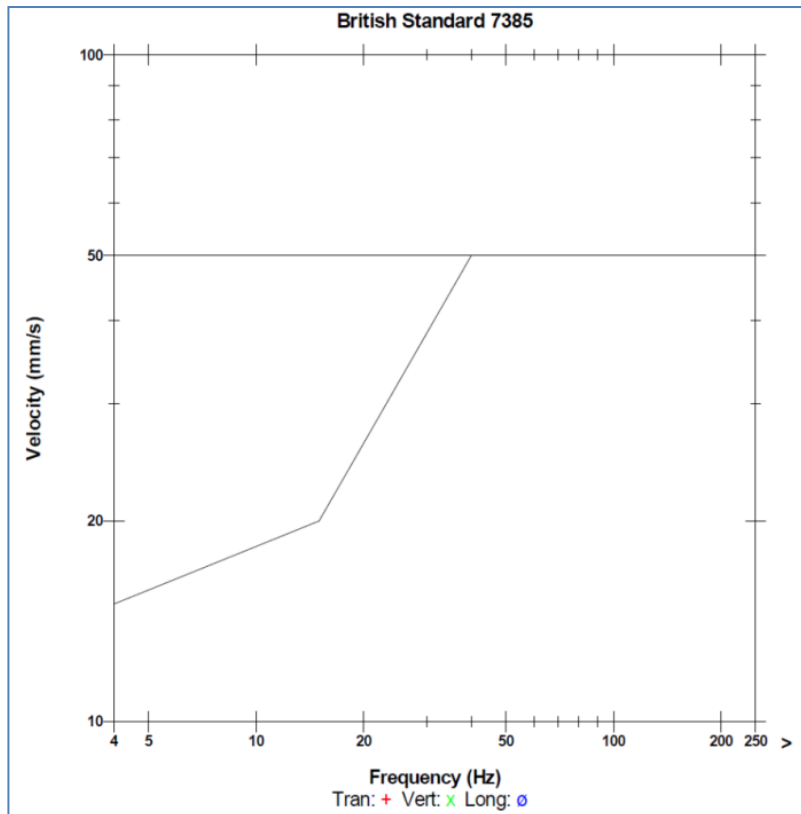


FIGURE 9.3 FREQUENCY-DEPENDENT DAMAGE POTENTIAL

Example

The BS 7385 Standard indicates, for example, that for a residential building

- A PPV of greater than 15mms-1 at 4Hz, Measured at the base of the building, may be expected to result in cosmetic damage.
- A PPV of greater than 50 mms-1 at 40 Hz or above, Measured at the base of the building may be expected to result in cosmetic damage.

9.3 POTENTIAL VIBRATION IMPACTS

BS 7385-2:1993⁸ presents guidance on the assessment of the possibility of vibration-induced damage in buildings due to a variety of sources, and identifies the factors which influence the vibration response of buildings.

This standard provides a standard procedure for measuring, recording and analysing building vibration together with an accurate record of any damage occurring.

BS 7385-2 provides guide values of vibration above which cosmetic damage (such as surface cracks in plaster or brickwork) to buildings could occur. The levels are specified in terms of a Peak Particle Velocity (PPV) in the frequency range 4-250 Hz. These apply to measurement at the base of the building in any of the orthogonal axes.

Frequency-Dependent Damage Potential

The frequency components of the vibrations are important determinants of the damage potential. For this reason, most ground vibration standards take into account the frequency dependence of the vibration damage potential, setting more rigorous standards for lower frequency vibrations nearer the home resonance frequencies than at higher ones.

9.3.1 IMPACTS ON PROPERTY

The Nevinstown orebody is simply the up-dip section of the main orebody on the north east side of a surface feature - the River Blackwater. A recent study review and analysis carried out by geotechnical consultants concluded that it is apparent that the characteristics of the rock types and structures which occur in Nevinstown are essentially identical to those that occur in the Tara 'main orebody' immediately to the south of the river.

The proposal for underground mining methods is similar to the existing methods being used and that carried out in the Nevinstown orebody between 2004 and 2015.

⁸ BS 7385-2:1993 Evaluation and measurement for vibration in buildings. Guide to damage levels from ground-borne vibration.

Blasting will be carried out at greater distances from residential property than that already experienced on the periphery of the existing mine. The nearest housing developments north and north-east (*Silverlawn Estate*) will continue to be in excess of 700m away as mine development progresses north of the Blackwater River. The mining development progression northwards will increase the distances from blasting vibration sources for all residential property on the east and south-east of the mine.

Mining will not be only marginally closer to the nearest residents than it has historically been in the past. Figure 9.4 shows the surface infrastructure the location of the crown pillar in red and locations of ground vibration monitoring. The area shown in black has been mined out and VML refers to 'vibration monitoring location'.

The level of ground vibration predicted should be no more intense than that experienced over the last 40 years. Blasting ground vibration will be limited by adhering to control regime currently in place - sequential detonation, control on maximum instantaneous charge of explosives used and continuous measurement of ground vibration to ensure compliance.

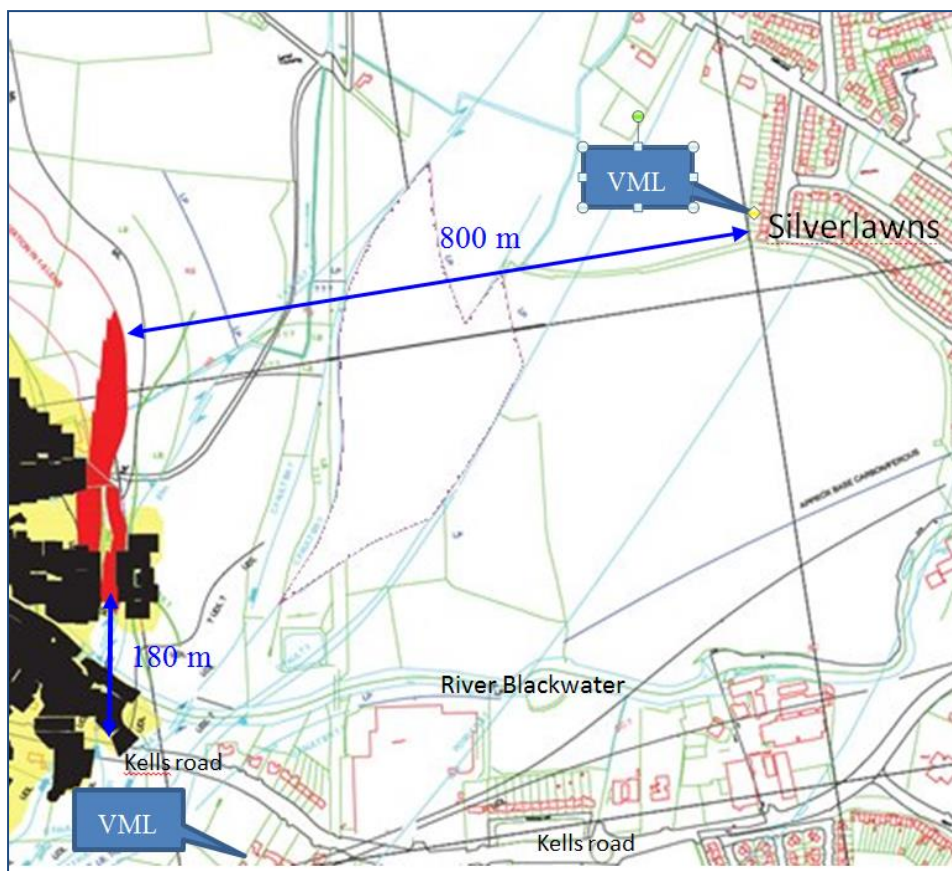


FIGURE 9.4 SURFACE INFRASTRUCTURE AT THE LOCATION OF THE CROWN PILLAR (OUTCROP SHOWN IN RED).

9.3.2 IMPACTS ON HUMAN HEALTH

There are no international standards dealing with the health effects of blast induced ground vibration. As a point of reference ISO 2631-1:1997, the current International standard for evaluation of human exposure to whole-body vibration, is referred to.

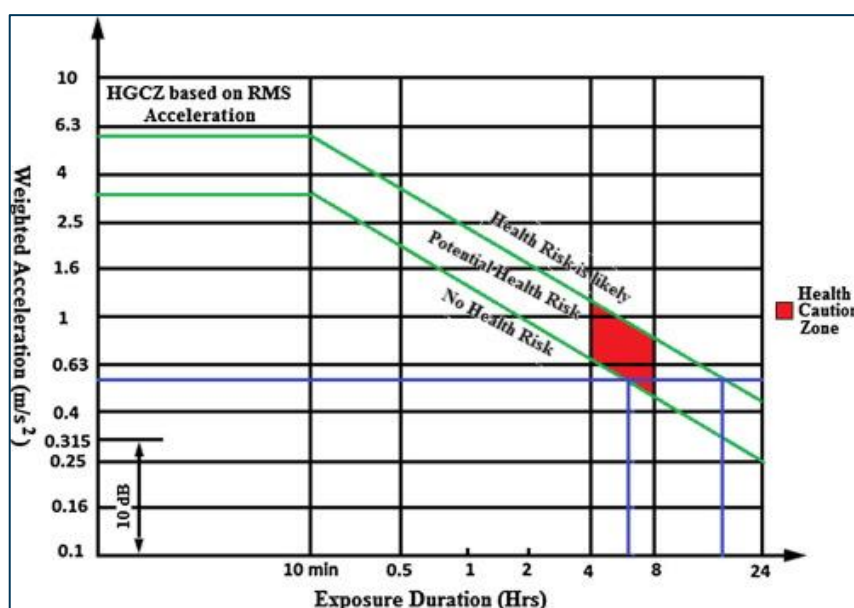
This standard outlines methods for quantifying vibration exposure. It is important to note that this standard is more applicable to vibration associated with the used of tools or mobile equipment and not ground vibration.

Whole-body vibrations are usually in the frequency range of 1-100Hz, although the range 0.1-1Hz is the predominant frequency for the generation of motion sickness symptoms (kinetosis).

The standard suggests quantitative guidelines for human response to vibration in terms of comfort levels and health guidance caution zones. Guidance on the effects of vibration on health is presented in annex B to the standard.

The guidance is applicable to vibration in the frequency range 0.5 Hz to 80 Hz that is transmitted to the seated body as a whole.

- Ground vibration associated with BTMs underground blasting typically fall with the frequency range 10 – 50 Hz.
- The duration of blasts are typically between 2 and 6 seconds.



9.3.2.1 IMPACT ON COMFORT

Human response to vibration depends on a range of factors, such as vibration levels, location and time of day. General guidance on human response to building vibrations is given in AS 2670.2–1990 Evaluation of human exposure to whole-body vibration—continuous and shock-induced vibration in buildings (1 to 80 Hz).

TABLE 9.2 GROUND VIBRATION GUIDANCE FOR HUMAN COMFORT (BLASTING)

Category	Type of operations	Peak component particle velocity (mm/s)
Sensitive site*	Operations lasting longer than 12 months or more than 20 blasts	5 mm/s for 95 per cent blasts per year 10 mm/s maximum unless agreement is reached with the occupier that a higher limit may apply
Sensitive site*	Operations lasting for less than 12 months or less than 20 blasts	10 mm/s maximum unless agreement is reached with the occupier that a higher limit may apply
Occupied non-sensitive sites, such as factories and commercial planes	All blasting	25 mm/s maximum unless agreement is reached with the occupier that a higher limit may apply for sites containing equipment sensitive to vibration, the vibration should be kept below manufacturer's specifications or levels that can be shown to adversely affect the equipment operation

Currently BTMs Industrial Emission Licence Limits are set at 4mm/s for nighttime periods. In excess of 95 % of measured ground vibration resulting from blasting would be less than 2 mm/s. The maximum ground vibration level experienced during previous mining in the Nevinstown orebody was 3.5 mm/s.

The vibrations from blasting at Tara generate a frequency range which is well outside the range which is can cause sickness range (0.1-1Hz) and well below a magnitude which would impact

on health. Furthermore since blasting commenced at Tara in 1973 (which is over 45 years ago) there have been no known instance of negative health aspects.

Adherence to the IE limits should minimise the potential nuisance at sensitive receptors.

9.3.3 IMPACT ON FAUNA

The Blackwater river flows close to the proposed mine. Along the river the natural environment produce vibrations from water flowing / splashing and the wind effects on air and on vegetation. The larger species of fish which live in the river generate high levels of vibration by their own movement. Animals, vertebrates and invertebrates are exposed to the aforementioned vibrations sources. Fish have a frequency range between 1Hz up to 3 kHz depending on the species. Reptiles have a frequency range of 0.1 to 5 kHz while birds have a frequency range of 1 to 6 kHz and the barn owl range up to 9kHz. Most species living along the river and in the river are mobile and move around.

A number of surveys along the river had been carried out over the years on the Flora and Fauna impacts due to mining. There has been no negative impacts detected on the river over the 45 years of blasting, or indeed by the mining operation.

9.4 AMELIORATIVE MEASURES FOR BLAST VIBRATION CONTROL

9.4.1 BTM VIBRATION CONTROL LIMITS

Company's EPA Industrial Emissions Licence, P0 516-03:

"Condition 5.8: 'No blast, or combination of simultaneous blasts shall give rise to a vibration level at any noise sensitive location which exceeds the following limits:

- Daytime 8 mm/sec
- Night-time 4 mm/sec

'Condition 5.9: No blast, or combination of simultaneous blasts shall give rise to an air-overpressure level at any noise sensitive location which exceeds the following limits:

-
- | | |
|--------------|-------------------------|
| ➤ Daytime | 125 dB (Lin). max. peak |
| ➤ Night-time | 105 dB (Lin). max. peak |

9.4.2 ADDITIONAL CONTROL MEASURES

The following controls will be put in place so that ground vibration, air overpressure / noise is minimised.

- Ensure that the optimum blast ratio is maintained and ensure that the maximum amount of explosive on any one delay, the maximum instantaneous charge is optimised so that the ground vibration levels are kept below those specified in IEL P0516-03.
- The adequate confinement of all charges by means of accurate face survey and the subsequent judicious placement of explosives.
- Blasting will be carried out at regular times and production blasting will be avoided during night-time.
- All blasts will be measured using our existing continuously monitoring systems and by the re-installation of a the monitoring station, V5 as shown in Figure 9.2. Furthermore this monitoring will be complimented by additional portable ground vibration monitoring should the need arise.

NB The measures which control ground vibration generated from underground blasting will also control air overpressure noise.

9.4.3 FREQUENCY OF BLASTING

There are two distinct types of mining development and production as detailed in EIAR section 3. Subsequently there are two types of blasting undertaken; Development and Production.

- Development blasting (Tunnelling) are small tonnage blasts c 600 tonnes and are undertaken at the end of the nightshift (early morning). There are up to 10 tunnel blasts undertaken on a daily basis
- Production blasting (Stoping) are larger tonnage blasts ranging between 5K and 15k tonnes. Blasting is undertaken at the end of the day shift (between 18:00 and 19:00 Hours). There are typically two production blasts daily.

The rate and frequency of blasting will remain consistent throughout the life of the project.

9.5 CONCLUSION

The ground vibration / air overpressure noise levels will be contained within the conditions given in our existing licence. Accordingly the ground vibration generated from blasting will be maintained well below 8mm/sec and at a level well below the level at which superficial damage to property is likely (Siskind et al. 1980b). A review and analysis of over 40 years of vibration monitoring data has shown that Tara's vibration limit compliance has exceeded 99.9%.

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GLOSSARY OF TERMS

Peak Particle Velocity (PPV) – the maximum rate of change of particle displacement, measured in millimetres per second (mm/sec).

Frequency (Hz) – the number of cycles per second of vibration usually expressed in Hertz (Hz)

dB – Decibel, a unit of measure on a logarithmic scale used to quantify pressure fluctuations such as those associated with air overpressure

dB(A) – Decibel measured within an A weighted frequency curve that differentiates between sounds of different frequency in a similar way to the human ear

Maximum Instantaneous Charge Weight – The maximum amount of explosives detonated at any one precise time

Blast Ratio – The amount of work per unit of explosive measured in tonnes of rock per kilogram of explosives detonated

Delay Interval – The time between successive detonations of detonators

Sequential Detonation – The method of control of time intervals between explosions of individual charges

10 NOISE

10.1 INTRODUCTION

It is proposed to resume mining in the 'Nevinstown' section of the orebody.

There will be no additional surface infrastructure associated with this development.

The necessary infrastructure, both underground and on surface, for its operation is already in place; including administration, mining and processing facilities, tailings storage capacity, ventilation, effluent discharge facilities and road/rail links to Dublin Port.

This notwithstanding the noise impact associated with the existing plant and facilities is evaluated in this section of the EIAR.

10.1.1 BACKGROUND - ACOUSTIC TERMINOLOGY

Sound is simply the pressure oscillations that reach our ears. These are characterised by their amplitude, measured in decibels (dB), and their frequency, measured in Hertz (Hz). Noise is unwanted or undesirable sound, it does not accumulate in the environment and is normally localised. Environmental noise is normally assessed in terms of A-weighted decibels, dB(A), where the A weighted filter in the measuring device elicits a response which provides a good correlation with the human ear. The criteria for environmental noise control are of annoyance or nuisance rather than damage. In general a noise level is liable to provoke a complaint whenever its level exceeds by a certain margin the pre-existing noise level or when it attains an absolute level. A change in noise level of 2 dB(A) is 'barely perceptible', while an increase in noise level of 10 dB(A) is perceived as a twofold increase in loudness.

Historically road traffic noise has been assessed using the L10 dB(A) parameter, the levels expressed as the arithmetic hourly mean value over an 18 hour period.

Recent draft guidelines by the National Roads Authority recommend the use of the equivalent continuous levels, L(Aeq). For construction or industrial noise sources the assessment is usually expressed in equivalent continuous levels, L(Aeq). Table 10.1 gives comparative noise levels and sources in our environment.

TABLE 10.1 COMPARISON OF NOISE LEVELS IN OUR ENVIRONMENT

Source/Activity	Indicative noise level dBA
Threshold of hearing	0
Rural night-time background	20-50
Quiet bedroom	35
Wind farm at 350m	35-45
Busy road at 5km	35-45
Car at 65km/hr at 100m	55
Busy general office	60
Conversation	60
Truck at 50km/hr at 100m	65
Inside a typical shopping centre	70-75
Inside a modern car at around 90km/hr	75-80
Passenger cabin of jet aircraft	85
City Traffic	90
Pneumatic drill at 7m	95
Jet aircraft at 250m	105
Threshold of pain	140

10.2 EXISTING ENVIRONMENT

Noise monitoring is undertaken on a continuous basis in the environs of the mine site facilities (four permanent stations, ref Figure 10.1).

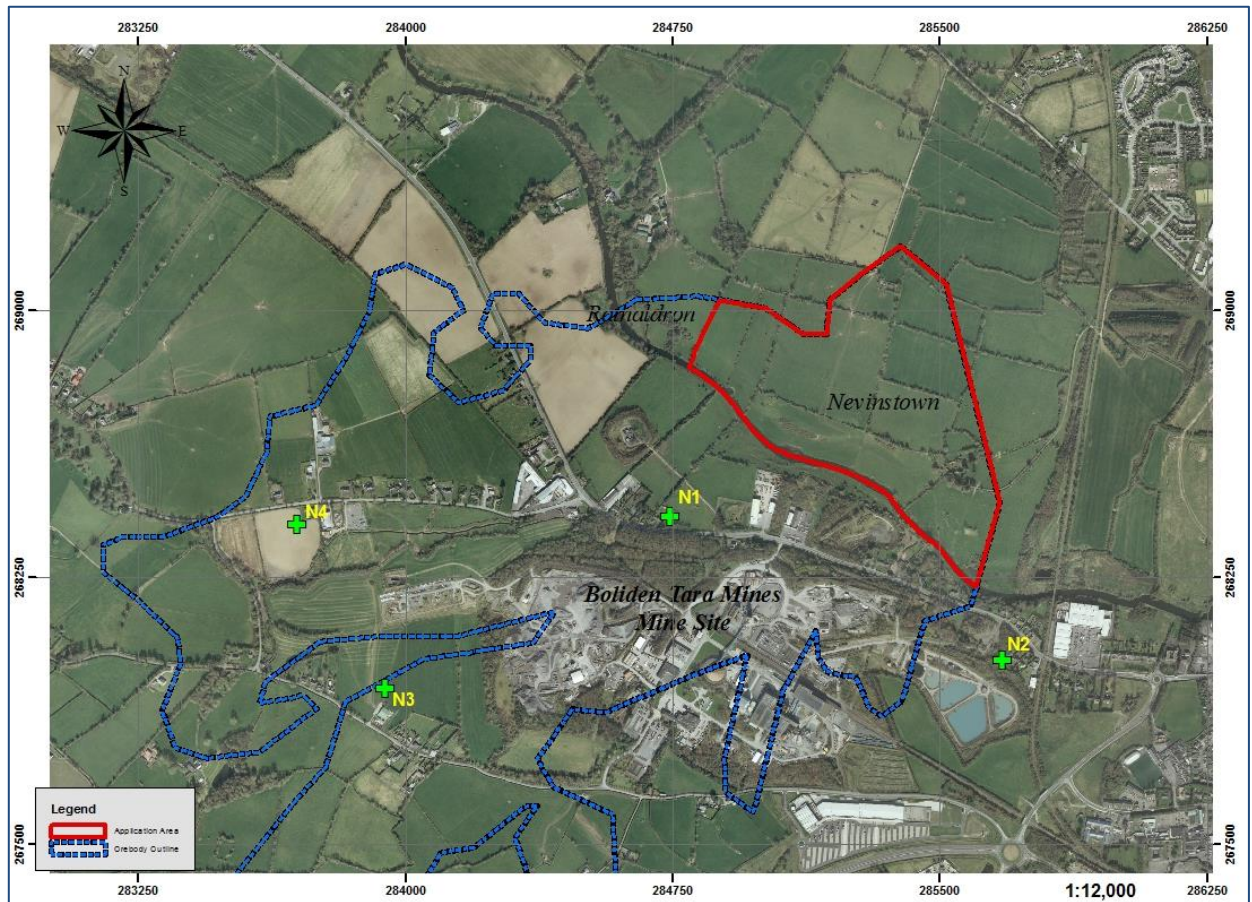


FIGURE 10.1 NOISE MONITORING LOCATIONS

The local noise environment is dominated by anthropogenic sources predominantly road traffic on the busy local road network (M3 Motorway, Navan Relief road, R 147 Kells road) consequently ambient and background noise levels are elevated during both daytime and night-time periods.

Table 10.2 Typical Noise Levels: Environs of Mine Site

Date of monitoring	Noise sensitive location -NSL (if applicable)	LA _{eq}	LA ₉₀	LA ₁₀	Tonal or Impulsive noise* (Y/N)	If tonal /impulsive noise was identified was 5dB penalty applied?	Comments (ex. main noise sources on site, & extraneous noise ex. road traffic)	Is site compliant with noise limits (day/evening/night)?
Mean values of continuous monitoring at each of the four permanent monitoring stations (Around the Knockumber mine site)	N1	59	49	65	No	No	Road traffic noise from the old R147. Mine site emission less than L90	Yes
	N1	54	39	55	No	No	Road traffic. Mine site emissions less than L90	Yes
	N2	47	41	50	No	No	Road traffic noise from the R147. Mine site emission less than L90.	Yes
	N2	42	37	43	No	No	Road traffic. Mine site emissions less than background	Yes
	N3	47	41	49	No	No	Road traffic noise from the r147. Mine site emission less than L90	Yes
	N3	42	37	44	No	No	Road traffic. Mine site emissions less than background L90	Yes
	N4	49	42	52	No	No	Road traffic noise and mine site enissions less than background	Yes
	N4	47	41	51	No	No	Road traffic. Mine site emissions inaudible less than background	Yes

10.3 POTENTIAL NOISE IMPACT

- There will be no additional noise impact associated with the proposed development.
- Noise emissions from the mine site facility will remain consistent
- There will be no additional road traffic noise generated by the proposed development.
- The noise levels will be controlled to remain compliant with the Company's Industrial Emissions Licence (see 10.4)

10.4 TARGET CRITERION AND NOISE LIMITS

BTM operates within conditions mandated in its IE license for their operation. Noise limits are set out in Schedule.

- | | |
|-----------------------------|---|
| ➤ Daytime (07:00- 19:00) | 55dB(A) expressed as L_{eq} , 30 min |
| ➤ Evening (19:00 – 23:00) | 50dB(A) expressed as L_{eq} , 30 min |
| ➤ Night-time(23:00 – 07:00) | 45dB(A) expressed as L_{eq} , 15/30 min |

'There shall be no clearly audible tonal component in the noise emission from any activity at any noise sensitive location'.

Other pertinent IEL conditions include 4.5, 5.5, 4.26.

10.5 MONITORING

Monitoring will continue as mandated by IEL condition 4.26.

10.6 CONCLUSION

There will be no additional surface infrastructure associated with the proposed development.

The proposed development will not constitute an increase in production.

Noise emissions from the facility will remain consistent and will be controlled within industrial Emissions Licence Limits.

10.7 REFERENCES

- (1) Noise Control on Construction and Open Sites - Part 1. Code of Practice for Basic Information and Procedures for Noise Control)
- (2) BS 5228: Part 1: 2009, Noise and Vibration Control on Construction and Open Sites
- (3) ISO 1996/1 Acoustics – Description and Measurement of environmental noise- Part 1: Basic quantities and procedures
- (4) ISO 1996-2: Acoustics – Description and Measurement of environmental noise Part 2: Acquisition of data pertinent to land use
- (5) ISO 1996-3: Acoustics- Description and Measurement of environmental noise Part 3: Application to noise limits
- (6) Calculation of Road Traffic Noise, Department of Welsh Office, 1988 HMSO
- (7) EPA guidance Note for Noise in Relation to Scheduled Activities (1995)
- (8) The National Roads Authority (NRA), Guidelines for the Treatment of Noise and Vibration in National Roads Schemes (2004)
- (9) BS 5228: Noise Control on Construction and Open Sites Part 1: Code of Practice for Basic Information and Procedures for Noise Control (2009)

11 MATERIAL ASSETS

11.1 AGRICULTURE

Agricultural land forms an intrinsic part of the landscape of Co. Meath. Accordingly, any potential impact of the proposed Nevinstown development on material assets with respect to agriculture and agricultural enterprises have to be considered.

11.1.1 EXISTING ENVIRONMENT

The entire Nevinstown property is within the ownership of BTM and comprises agricultural land. The land has been extensively managed as pasture land since the early 1970s (refer to Section 4 Biodiversity).

The site is dominated by improved grassland, either pasture or meadow, with hedgerows the main field boundary type. Several patches of scrub and wet ditches or drainage channels occur. Some planted woodland (formerly a plantation nursery) occurs in the northern sector of the site. The main channel of the River Blackwater forms the southern boundary to the site, and there is some marginal wetland vegetation along the riverbank. The site also includes a number of buildings and a section of railway track.

No land will be lost to the development.

The proposed development of the Nevinstown orebody should have no significant impact with respect to land use and agricultural activity.

11.2 PROPERTY

11.2.1 IMPACTS ON PROPERTY

11.2.2 VISUAL IMPACTS

The proposed Nevinstown Development is by underground methods and does not require any surface structures / infrastructure. Accordingly there should be no visual impacts with respect to the landscape / residences.

11.2.3 BLASTING VIBRATION (REFER TO SECTION 10 NOISE & SECTION 11 VIBRATION)

The only potential impact is that associated with ground vibration from blasting. High levels of ground vibration can cause structural damage to buildings. However, blast vibration levels will be contained within current ground vibration limits (8mm/sec) as set by the Industrial Emissions Licence (P0 516-03).

Furthermore these vibration limits are well below the level at which even superficial damage to structures is likely. The impacts of blasting vibration should have a negligible impact on property.

Surface Settlement

The only surface infrastructure within the Nevinstown property that could potentially be affected by surface settlement is the uninhabited *Nevinstown House*, owned by BTM, located to the centre of the mining area.

The extent of the effect depends largely upon whether any small differential settlement occurs.

11.3 EXTRACTIVE INDUSTRY:

Section 10.2 of the Meath CDP Extractive Industry and Building Materials Production states that

‘Meath contains a variety of natural resources such as building raw materials in the form of sand, gravel, stone reserves including high purity limestones and shale used in cement and magnesia manufacture and base metal deposits. The potential of these resources to underpin construction output and provide employment and economic growth in the local and regional economy is recognised as is the need to exploit these in an environmentally sound and sustainable manner’

The development plan also provides policies in relation to extractive industries which include;

Policy RD POL 22:

“To facilitate the exploitation of the county’s natural resources and to exercise appropriate control over the types of development taking place in areas containing proven deposits, whilst also ensuring that such developments are carried out in a manner which would not unduly impinge on the visual amenity or environmental quality in the area.”

Policy RD POL 23:

“To support the extractive industry where it would not unduly compromise the environmental quality of the county and where detailed rehabilitation proposals are provided.”

Policy RD POL 24:

“To seek to ensure that the extraction of minerals and aggregates minimise the detraction from the visual quality of the landscape and do not adversely affect the environment or adjoining existing land uses.”

RD POL 27:

‘To ensure that development for aggregates / mineral extraction, processing and associated concrete production does not significantly impact on the following areas:

- i) Existing & Proposed Special Areas of Conservation (SACs);*

-
- ii) Special Protection Areas (SPAs);*
 - iii) Existing & Proposed Natural Heritage Areas (pNHAs);*
 - iv) Other areas of importance for the conservation of flora and fauna;*
 - v) Areas of significant archaeological potential;*
 - vi) In the vicinity of a recorded monument;*
 - vii) Sensitive landscapes, and;*
 - viii) World Heritage Sites*

11.4 ROADS AND TRAFFIC

11.4.1 ACCESS TO THE DEVELOPMENT

Access to the Nevinstown orebody will be from within the existing main mine plant site. The existing portal access (underground roadway) from the surface of the existing plant site will provide a vehicle route via the existing mine. There will be no other access point from surface to the development. No additional transportation infrastructure is therefore required.

The development will not lead to any additional surface traffic.

11.5 LANDSCAPE AND VISUAL IMPACT

Since there is no surface structures / infrastructure required for the mining of Nevinstown it is therefore proposed that there will be no further descriptions on visual impacts on the existing landscape in the EIAR.

12 HUMAN HEALTH

12.1 INTRODUCTION

Human beings and their socio-economic environment are a vital element to be considered in an Environmental Impact Assessment (EIA). This section of the EIAR examines the existing environment and the potential impact the proposed development may have on population and human health and the mitigating measures to address any likely impacts.

Specific impacts/risks associated with Air, Water, Noise, Vibration are dealt with in individual sections of the report.

12.2 METHODOLOGY

Consultation was carried out with the planning authority and various statutory consultees to identify relevant issues, and a public meeting was held with the local communities to address issues of potential concern.

A desk study was carried out in order to examine all relevant information.

The following were consulted:

- National and Regional Planning Policy (NSS, NDP, RPGs);
- Meath County Development Plan 2013-2019;
- Navan Development Plan 2009-2015;
- Central Statistics Office (CSO) online database;
- National Monuments Service *Map Viewer* ;
- Failte Ireland website;
- Ordnance Survey maps and satellite imagery

12.3 EXISTING ENVIRONMENT

It is proposed to resume mining in the 'Nevinstown' section of the orebody. *Nevinstown* forms the most northerly section of the known 'Navan Orebody' which has been mined successfully over the past 40 years.

There will be no additional surface infrastructure associated with this development. The necessary infrastructure, both underground and on surface, for its operation is already in place; including administration, mining and processing facilities, tailings storage capacity, ventilation, effluent discharge facilities and road/rail links to Dublin Port. The property has been operated as a grassland farm unit since 1972 and will remain as farmland used by grazing tenants.

The effects on biodiversity (Section 4), air quality (Section 5), water quality (Section 6 and 7) and noise/vibration (Section 9 and 10) in the surrounding environment are dealt with individually in those relevant sections of the EIAR and are summarised in this Section.

12.3.1 LAND-USE

Navan is identified as a large growth town in County Meath. Land use zoning objectives to the south of Tara Mines include General Enterprise & Employment (E2), to the north Community Infrastructure (G1) and White Lands (WL) and to the east Existing Residential(A1). (Refer to Figure 12.1 Zoning Map)

According to the Meath Landscape Character Assessment, Tara Mines is located in the Blackwater Valley Landscape Character Area, which is marked as an area of very high value and high sensitivity. The topography of the Blackwater river corridor is described as relatively flat around Navan to low undulating drumlins beyond Kells. It is described as a pleasant and balanced pastoral landscape with agricultural land, river corridor and small areas of settlement and woodland. Agricultural land consists of open farmland which is characterised by a loss of internal field boundaries. The urban fringe of Navan is characterised by some warehouse development, which has encroached into the edge of the flat river plain

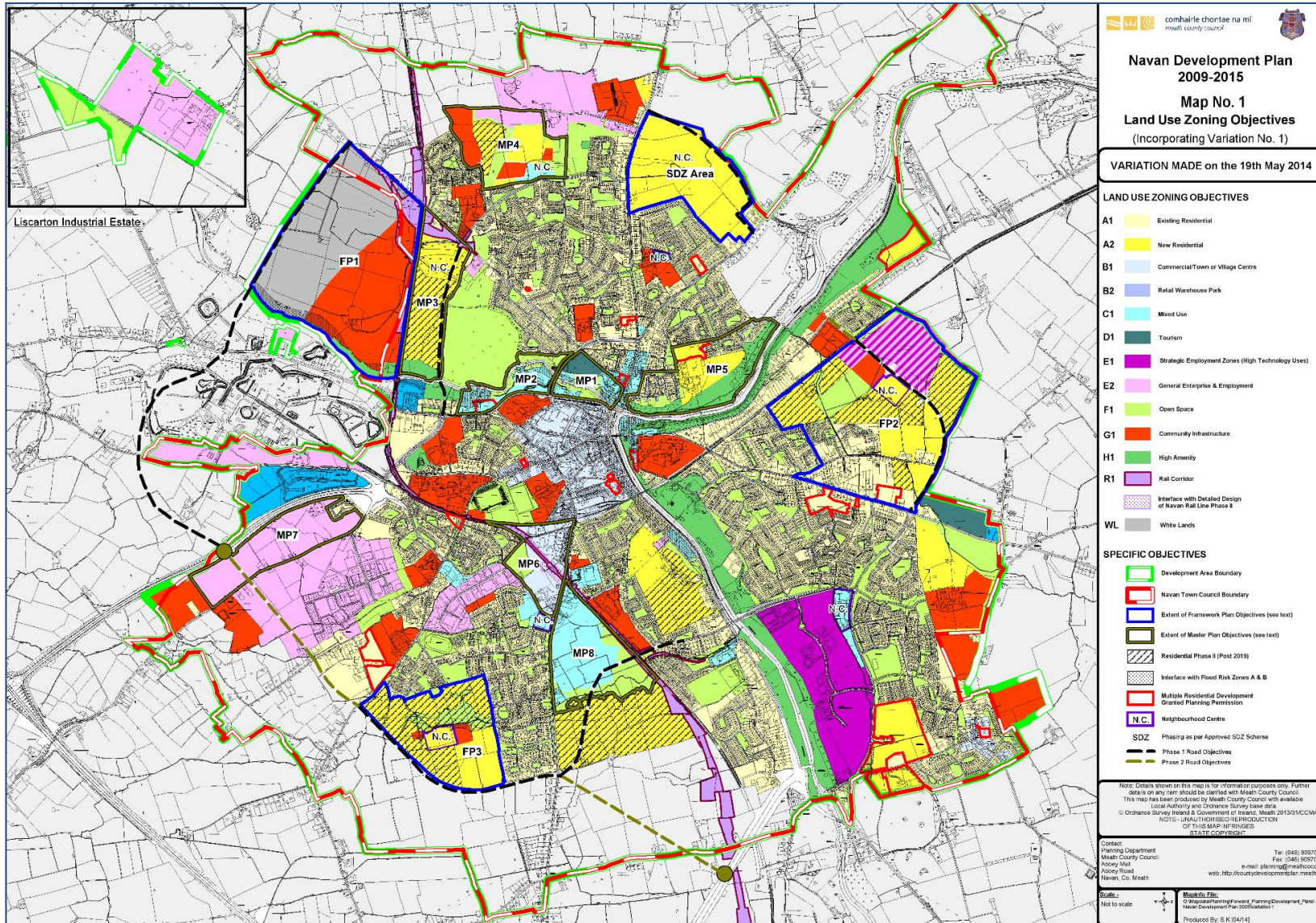


FIGURE 12.1 ZONING MAP

12.3.2 POPULATION

Navan is identified as a large growth town in the Meath County Development Plan (CDP). It has grown significantly over each census with unprecedented growth between 2002 and 2011 which was amongst the highest experienced by any urban centre in the country, to its current population of 30,173 (*April 2016*).

The Meath County Development Plan 2013-2019 states that the county has had unprecedented growth within the residential sector, unparalleled by any other county, even those within the Greater Dublin Area or Mid-East Region. There has been significant growth in Navan's population and it is predicted that Navan will grow in the longer term (2022) to a population of 50,000 persons. The County Managers Foreword in the Meath CDP states that *'with this expansion comes the need for a new economic configuration of the county to create the necessary conditions for significant generation of high quality employment to sustain our existing and new communities'*.

12.3.3 EMPLOYMENT

Employment is an important indicator of the economic standing of an area. This section examines unemployment levels, employment status and industrial groups within the state and region.

The Quarterly National Household Survey (QNHS), published by the Central Statistics Office, provides details of unemployment⁹ at a regional level. The most recent survey is for Quarter 2, 2017. Navan is located in the Mid East Region, which had an unemployment rate of 5.8% and a participation rate¹⁰ of 61.4%, demonstrating slightly higher employment figures than the State overall.

Table 12.1 illustrates the findings from the QNHS Quarter 2 2017.

⁹ The unemployment rate is the number of unemployed persons expressed as a percentage of the total labour force.

¹⁰ The participation rate is the number of persons in the labour force expressed as a percentage of the total population (over the age of 15 years)

TABLE 12.1 QUARTERLY NATIONAL HOUSEHOLD SURVEY, Q2 2017

	<i>Unemployment Rate</i>	<i>Participation Rate</i>
State	6.4%	59.9%
Mid East Region	5.8%	61.4%

Source CSO, 2017

The CSO also publishes Live Register figures. These figures are not strictly a measure of unemployment as they include persons who are legitimately working part-time. However, they can be used comparatively to provide an overall trend within an area. The September 2016 and September 2017 Live Register figures (seasonally unadjusted) are shown in TABLE 12.2 below:

TABLE 12.2 LIVE REGISTER (PUBLISHED OCTOBER 2015)

	Sept 2016	Sept 2017	% Change
State	286,319	244,319	-14.6
Mid East Region	27,374	23,022	-15.9
County Meath	6,791	5,567	-18.0

Source CSO, 2017

These figures show that County Meath and the Mid-East Region are consistent with current national trends in that there has been a significant decrease in people signing on between 2016 and 2017.

BTM, one of the largest employers in the Navan area, provides significant employment, both directly and indirectly, in the locality and wider region (currently 572 direct employees). It is estimated that there are 3 to 4 additional jobs indirectly supporting each Tara job.

12.3.4 SOCIO-ECONOMIC PROFILE OF THE LOCALITY

It is valuable to compare the employment numbers (by industrial group) for the State, Meath and Navan.

TABLE 12.3 INDUSTRIAL GROUPS (EMPLOYMENT NUMBERS)

Occupational Group	State	Meath	Navan
Agriculture, Forestry and Fishing	5.06%	4.96%	1.65%
Manufacturing industries	11.60%	11.8%	13.61%
Building & Construction	4.83%	6.28%	5.33%
Transport & communications	8.10%	9.36%	8.87%
Commerce & Trade	25.25%	26.02%	26.21%
Public administration	6.30%	6.71%	6.35%
Professional Services	23.53%	21.50%	23.60%
Industry not stated	15.3%	13.34%	14.35%

Source: CSO, 2014

TABLE 12.3 illustrates the industrial groups of persons living in the State, Meath and Navan. However these statistics do not convey the percentage of workers in the mining or quarrying sector nor do they convey other industrial groups that benefit from operations at Tara Mines such as construction, manufacturing etc.

12.3.5 TOURISM AND AMENITIES

According to the Meath County Development Plan (CDP), 2013-2019,

‘Tourism makes an important contribution to the economy of County Meath with income derived from tourist activity being distributed across a wide range of economic sectors’.

Meath, according to Fáilte Ireland, is located in the Mid East Tourist Region and consists of Counties Kildare, Meath and Wicklow. The latest available statistics from Fáilte Ireland (2016) are presented in Table 12.4 and show it received over 626 thousand overseas visitors generating revenue of €251 million for the year.

TABLE 12.4 OVERSEAS TOURISM TO THE MID EAST 2016

	Britain	M. Europe	N. America	Other	All Overseas
<i>Number of Visitors (000s)</i>	241	234	108	42	626
<i>Revenue Generated (€m)</i>	68	99	65	18	251

Source: Fáilte Ireland 2016

Designated Areas:

One Special Areas of Conservation (SAC), one Special Protection Area (SPA), one Natural Heritage area and one proposed Natural Heritage Areas (pNHAs) are located within the wider study area surrounding the application site. Designated areas are illustrated in TABLE 12.5 and further detail is presented in the Biodiversity Chapter of this EIAR (Section 4).

TABLE 12.5 DESIGNATED AREA

Type	Site Code	Site Name	Distance and Direction from application area
SAC	002299	River Boyne And River Blackwater	1.2km southwest
SPA	004232	River Boyne And River Blackwater	1.2km southwest
NHA	001324	Jamestown Bog	7.4km southwest
pNHA	001592	Boyne Woods	5.2km southeast

12.4 POTENTIAL IMPACTS ON HUMAN HEALTH

12.4.1 BIODIVERSITY

The local area is relatively rich in biodiversity as discussed in Section 4. However the development primarily relates to underground activities and thus biodiversity across the local area at surface level will be largely unaffected. A number of recommendations to help enhance biodiversity are presented in the EIAR. These include the protection of the river bank and water quality of the River Blackwater, the improvement in biodiversity in agricultural grassland in the area and a recommendation on the development of a Biodiversity Management Plan.

12.4.2 AIR QUALITY

The mine ventilation systems will provide oxygen-rich air to operators in the mine and remove and dilute noxious gases from the mine. Exhaust gases are removed from the mine via Return Air Ventilation Raises – there are seven systems currently at the facility and the proposed development will utilise these existing systems.

As discussed in Section 5 there will be no surface structures or additional air emission sources associated with the proposed development, therefore there is no predicted impact on aboveground air quality.

There is an ambient air quality monitoring protocol in place as part of the site's IE Licence and this will continue to be in effect during the operation of the proposed development.

12.4.3 WATER

The mining works are dewatered to facilitate the mining process. Pumped water enters the existing processing plant where it is screened, clarified and pumped to the surface. The water is then either

reused in the process or discharged under licence to the Boyne. The existing plant will be used to treat the various water streams and no adverse or additional impact will arise.

12.4.4 NOISE & VIBRATION

Noise and vibration levels will be managed by the current monitoring systems in place and regulated, as currently. Blasting will be carried out at a greater distance from residential properties than currently on the periphery of the existing mine. The measures which control ground vibration will control air overpressure noise. Therefore there is no anticipated impact on human health in relation to noise and vibration.

12.5 EFFECTS ON EMPLOYMENT AND ECONOMY

12.5.1 CONTRIBUTION TO EMPLOYMENT

BTM currently employs a total of 572 employees directly and up to 150 contract workers. It is estimated that there are 3 to 4 additional jobs indirectly supporting each job. The proposed mine development will underpin the future operation of Tara Mines.

12.5.2 CONTRIBUTION TO LOCAL ECONOMY

The effect of wages and salaries generated by Tara being spent in the local and greater Navan areas are considerable. Currently, between €65 - €70 million is generated into the local community annually, made up of €45 million in gross payroll costs, €10 million by way of contractor and indirect employee earnings and €10 - €15 million of local spend with local suppliers.

In addition an average of c. €2 million is paid, annually, to the local authority in rates, water rates and planning charges.

The development is essential to the sustainability of the mine, and will be of major economic importance at local and national level. The Navan-Drogheda-Dublin rail link currently serving Tara depends on the business for its survival. So long as the mine remains in operation the future of this valuable transportation link is assured.

12.5.3 CONTRIBUTIONS TO THE NATIONAL ECONOMY

The national economy also benefits, substantially, from a fully operating mine in the form of payments to state enterprises (e.g. Iarnrod Eireann, Dublin Port Company) and to the Revenue Commissioners in the form of PAYE, PRSI, Corporation and other taxes. Approximately €55 million (inclusive of local purchases) is spent annually for the purchases of goods and services within the state.

A major contribution to the country's Balance of Payments arises from the sales of zinc and lead concentrates. The annual contribution to the Balance of Payments is in the region of €156- million.

12.6 EFFECT ON LAND-USE

The proposed development will not require a change of landuse or will not take land from the agricultural landscape above the orebody.

12.7 EFFECTS ON AMENITIES AND TOURISM

The impact the proposed mining development would have no visual impacts and will not impact on tourist facilities in the area.

12.8 MITIGATION MEASURES

12.8.1 BIODIVERSITY

The mine is located in an ecologically sensitive location. Section 4 of the EIAR comments on the existing ecology and makes recommendations for the enhancement of the biodiversity in the area. These include the protection of the river bank and water quality of the River Blackwater, the improvement in biodiversity in agricultural grassland in the area and a recommendation on the development of a Biodiversity Management Plan.

12.8.2 WATER

The discharge of treated water to the River Boyne is strictly controlled by the monitoring systems stipulated in the EPA licence. Continuous monitoring is in place for suspended solids, dissolved oxygen, pH and temperature and if these parameters deviate from the prescribed limits, the clear water discharge system is stopped automatically. The control systems for tailings and reclaim pipelines have on-line flow monitoring and leak detection with automatic pump shutdown upon the raising of an alarm.

12.8.3 NOISE & VIBRATION

As discussed in Section 8 measures will be put in place to minimize the impacts of noise and vibration.

These include:

- Optimisation of blast ratios and charges
- Adequate confinement of all charges
- Avoidance of blasting at night-time
- Vibration measurements of blasts

12.8.4 REGULATORY MANAGEMENT

The existing mine currently operates under the relevant health and safety legislation, i.e. The Safety, Health and Welfare at Work Act, 2005, The Mines and Quarries Act, 1965 and subsequent regulations relating to health and safety, training, appropriate site management etc.

The Tara mine site and the TSF also operate under the conditions of its current Industrial Emissions (IE) Licence P0516-03. The IE Licence imposes strict emission limits on the facility in line with international best practice for such facilities and these requirements are supported by a robust environmental management programmes. Potential impact on human health is addressed by the environmental management programme.

In relation to health & safety, the facility also falls under the Chemicals Act (Control of Major Accident Hazards Involving Dangerous Substances) Regulations 2015 (S.I. No. 209 of 2015). Under these regulations, a Safety Report is under development for the Tara Mine site. These will be overseen by the Health & Safety Authority which is the competent COMAH authority in Ireland. Potential impacts on human health are mitigated by the safety measures incorporated into site operations based on COMAH risk assessments, which are documented in the Safety Report.

In summary, the development is tightly regulated and these regulations will ensure there will be no adverse impact on the health and safety of the local community arising from the development.

12.8.5 EMPLOYMENT AND ECONOMY

The impact on employment and both the local and national economy is positive and therefore no mitigation measures are proposed.

12.8.6 LAND-USE, AMENITIES AND TOURISM

The proposed development will not impact land-use, amenities and tourism and no mitigation measures are required.

12.9 CONCLUSION

This section has examined the impact on population and human health.

In summary the continued operation of the Nevinstown Orebody will have a positive impact in relation to the socio-economic standing of the surrounding area. This will take the form of retaining and providing direct and indirect jobs and will continue to assist in the economic recovery of the Mid-East region, with potential export benefits to the Irish economy in general.

All activities on site will be carried out with regard to strict environmental and safety guidelines. Both the IE licence and the requirements under the COMAH Regulations strengthen regulatory controls governing the health and safety of employees working at the facility, and the neighbouring population. When all mitigation measures are complied with there will be no significant impacts arising from the resumption of mining in the Nevinstown orebody. The development will not have a negative impact on the everyday activities and human health of the local communities.

13 GEOLOGY & GEOTECH

13.1 INTRODUCTION

This section presents the geotechnical and mine design aspects of the proposed underground mine development at Nevinstown.

An independent study was commissioned to evaluate the rock mechanical conditions and consequences of mining the crown pillar, with particular focus on surface impact. The independent report is presented in appendix 13.

Issues addressed include:

- The potential for surface settlement at Nevinstown, and whether any impacts can occur beyond the Nevinstown boundary.
- The stability of the proposed underground mining at Nevinstown. This includes definition of the upper limit of mining close to surface.
- The stability of the strata beneath the River Blackwater, and potential for water ingress into the mine workings beneath.
- Defining of detailed, long-term monitoring strategy to be implemented

The Navan Orebody is made up of a number of distinct but integrated mining sub-areas: The Main Mine, Liscartan/Rathaldron, the Southwest Extension (SWEX), and Nevinstown (Figure 13.1). The Nevinstown Extension is located immediately northeast of the Main Mine, the original area of mining at Tara. The Nevinstown orebody is an uninterrupted northern continuation of the 'main orebody' currently being mined by Boliden Tara Mines (BTM). The orebody is present at the surface level of the Nevinstown townland and dips steeply below the River Blackwater into the property of BTM.

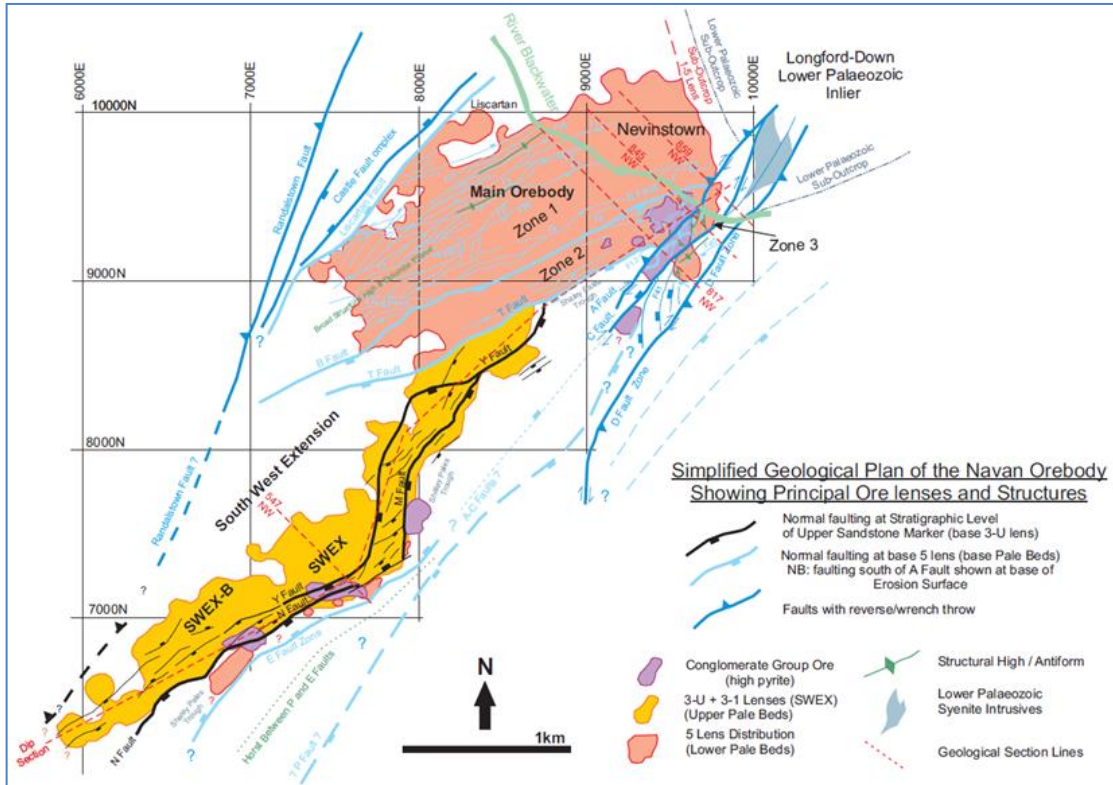


FIGURE 13.1 THE NAVAN OREBODY'S MAIN SECTIONS

The planned mining in Nevinstown as per the current life of mine plan, can be divided into two sections

- Main development (**Crown Pillar and Z1NEV**) and
- Completion of existing mining blocks (**N2 to N6**) Figure 13.2.

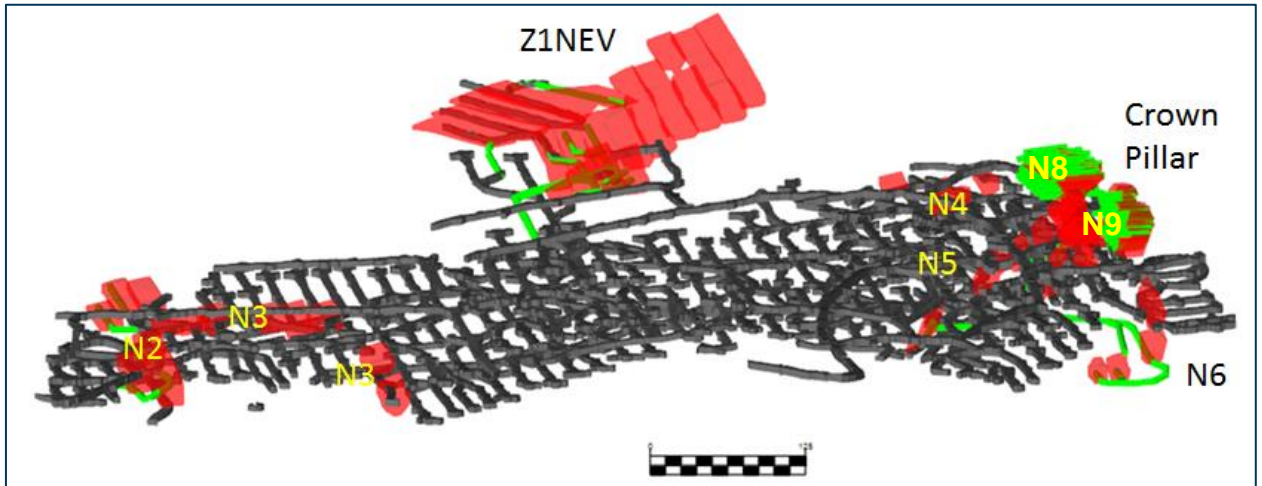


FIGURE 13.2 ISOMETRIC VIEW OF NEVINSTOWN. PLANNED DEVELOPMENT (TUNNELLING) IN GREEN, PLANNED STOPING IN RED. EXISTING DEVELOPMENT IN GREY.

The proposed development will include the mining of the area known as the “Crown Pillar”. The Crown Pillar (mining blocks N8 and N9) are situated in the north-eastern part of the Nevinstown orebody where the orebody outcrops on the surface just north of the river Blackwater.

When mining the the “Crown Pillar” the proposed stope size is 10m wide, up to 30m long and approximately 22m high leaving a pillar to surface of 8m. The remaining “crown pillar” will be supported by cablebolts from the development drifts above the stopes.

The stopes will be filled immediately after the ore is extracted with slag-cement stabilised backfilling using continues pour backfilling minimising the risk of water from the river entering the mine.

13.2 EXISTING GEOLOGICAL ENVIRONMENT

The existing Navan Zn-Pb orebody is a Lower Carboniferous, carbonate-hosted deposit currently being mined by underground trackless methods, at rates exceeding 2 million tonnes per annum. The vast majority of the economic mineralisation is contained within shallow-water limestones known as the Pale Beds. The ore occurs as complex strata-bound tabular lenses, often dislocated by faulting, and truncated against an erosional surface. Above this unconformity is often a conglomerate (the Boulder Conglomerate), followed upwards by a thick succession called the Upper Dark Limestones (UDL). The Nevinstown area is simply an up-dip extension of the same geology and orebodies mined to the south of the River Blackwater (FIGURES 13.3 AND 13.4).

The deposit stratigraphy is relatively complex in detail, with numerous marker horizons used to define sub-horizons within the main stratigraphic units. The ore occurs in numerous lenses, some as intense high grade massive sulphides, and others as lower grade disseminated sulphide layers between barren limestones.

The original Ore Reserves (ca. 1971) south of the River Blackwater were 60.9Mt @ 10.1% Zn, 2.6% Pb. Updated resource calculations at the end of 2002 defined the Nevinstown Ore Reserve as 6.1Mt @ 9.6% Zn, 1.8% Pb, plus Mineral Resources of 3.0Mt @ 7.6% Zn, 1.5% Pb.

Of primary interest are the rocks hosting the mineralisation (the Pale Beds), where the bulk of the mining activity is concentrated, and those lying above the ore (the Boulder Conglomerate and UDL – see Figures 13.3 and 13.4). The Pale Beds comprise strong, medium to coarse grained limestones, partly dolomitised, commonly thickly bedded, but with minor shale / sandstone layers which may contain polished bedding planes. A number of these distinctive layers form marker horizons which are invaluable for detailed structural interpretations of the deposit. The Pale Beds are not generally folded, but do contain pervasive, variably developed NNW-trending carbonate veins/joints. The Pale Beds are truncated by an erosion surface, onto which is deposited the Boulder Conglomerate, varying in thickness from <1m to >50m. The characteristics of the conglomerate vary, with a wide range of clast types and sizes, enclosed in a dark argillaceous matrix. In places the conglomerate is mineralised (referred to as Conglomerate Group Ore - CGO), but there is no significant CGO in the Nevinstown orebody.

The UDL are a generally thick sequence of variably (often thick) bedded limestones, comprising dark mudstones with well-bedded turbiditic calcarenites and calcirudites. The remaining thickness of the UDL reduces north of the River Blackwater, and it is absent for much of the Nevinstown area. Frequent carbonate-filled extensional veins are usually restricted to the thicker beds. Polishing of bedding planes is common. The UDL may also be folded, especially close to major faults where the folding can be very tight. The lowest unit of the UDL is termed the *Thin Bedded Unit*, consisting of thinly bedded (<10cm) calcarenites and mudstones, commonly with laminae of fine pyrite and carbonaceous layers, and up to 20m thick, though it is better developed in the southern part of the orebody, and less apparent in Nevinstown.

Figure 13.3 also illustrates the change in the dip of 2-5 Lens close to surface, in the Nevinstown area. The increased dip corresponds to an increase in ore grade.

13.2.1 GEOLOGICAL STRUCTURES

At Navan the Lower Carboniferous is draped, with strong unconformity, over Lower Palaeozoic sediments and intrusives. The local structure is dominated by a complex anticline, which plunges gently to the southwest at 20-30°. This is affected by a series of faults, an earlier ENE-trending, and a later northeast-trending set, which are considered to have developed in response to reactivation of major basement fault structures at various times .

The B-Fault (and other similar faults, eg. F1, F20, F23 etc) is one of the earliest to affect the orebody, striking east-northeast, and mostly dipping moderately to the southeast, and with a throw of 60-120m (decreasing significantly eastwards). This fault series does not significantly penetrate the overlying UDL formation. Typically the B-Fault is a zone of partly open fractures, shears and carbonate veins a few metres wide, with several generations of movement. The B-Fault is locally water bearing but flows are indicative of the drainage of stored water in the rock mass surrounding the structure. The F1- and F23- faults are also water bearing where they intersect with northwest joints. These flows are generally sustained and are indicative of recharge from either precipitation infiltration or regional groundwater flow. The fault characteristics vary depending on the adjacent lithologies. In the southern part of Nevinstown these faults swing to the east, and truncates against the A-Fault (FIGURE 13.3).

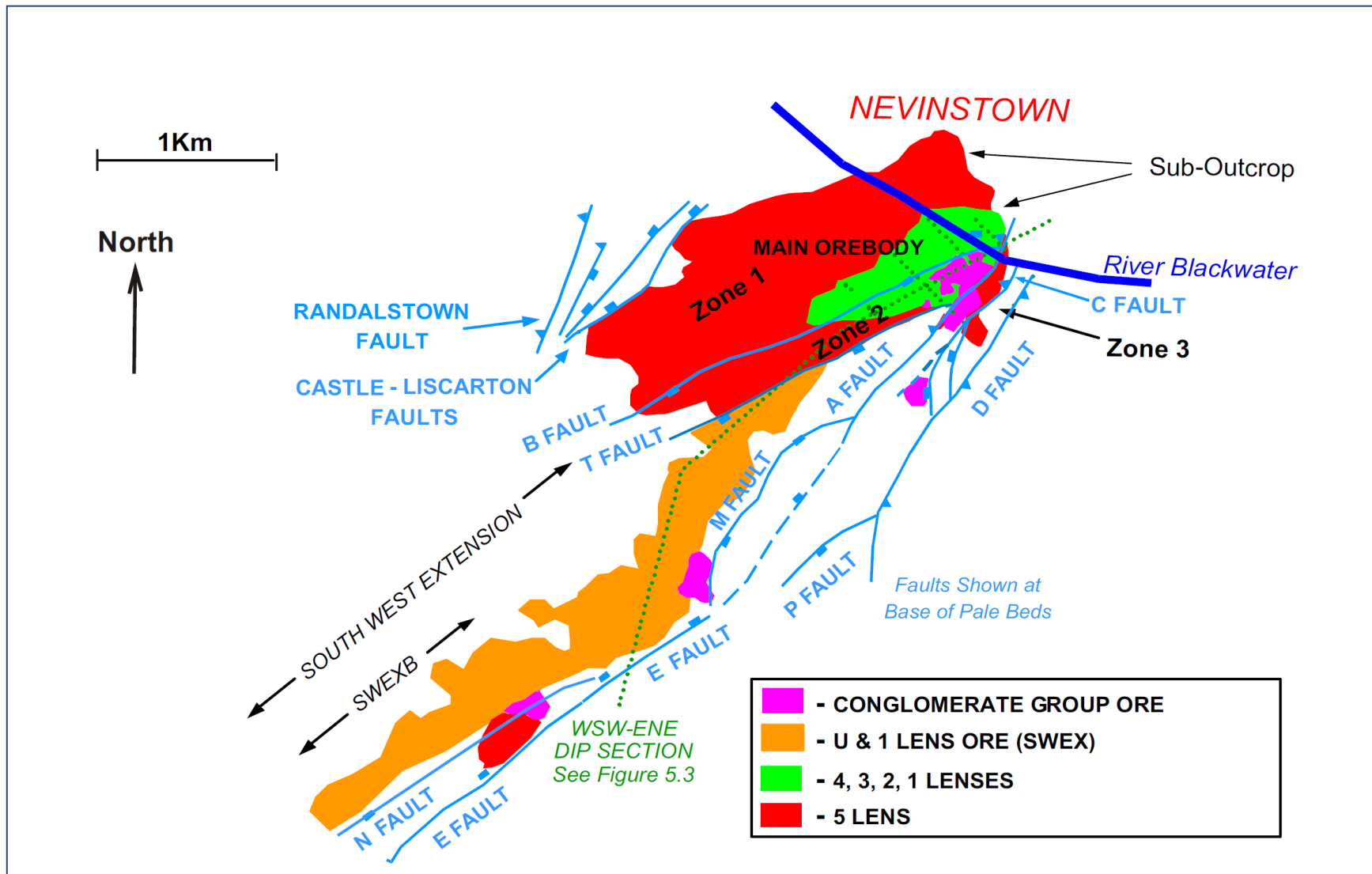


FIGURE 13.3 Nevinstown Simplified Geology Plan

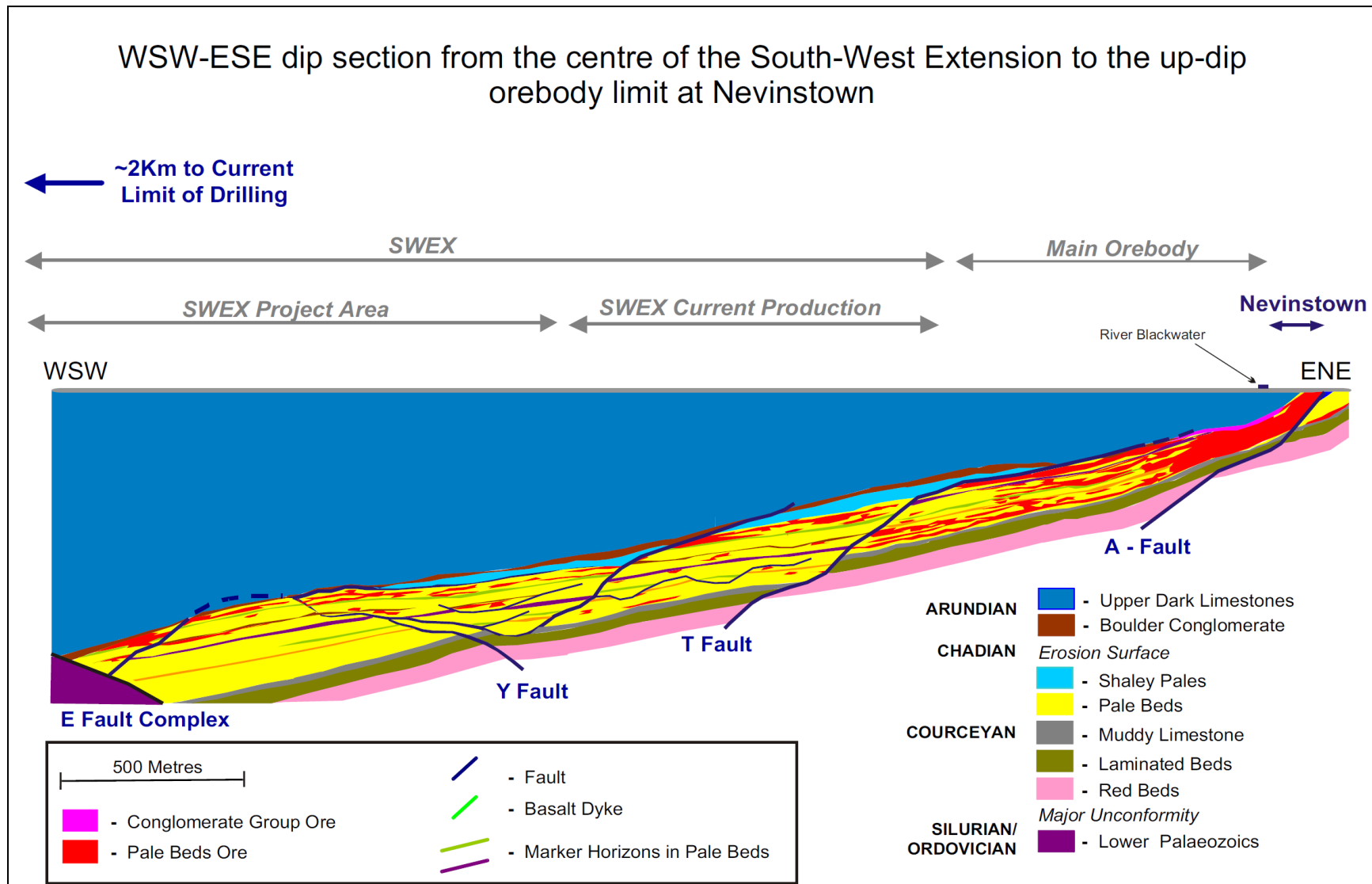


FIGURE 13.4 Nevinstown Geology Dip Section

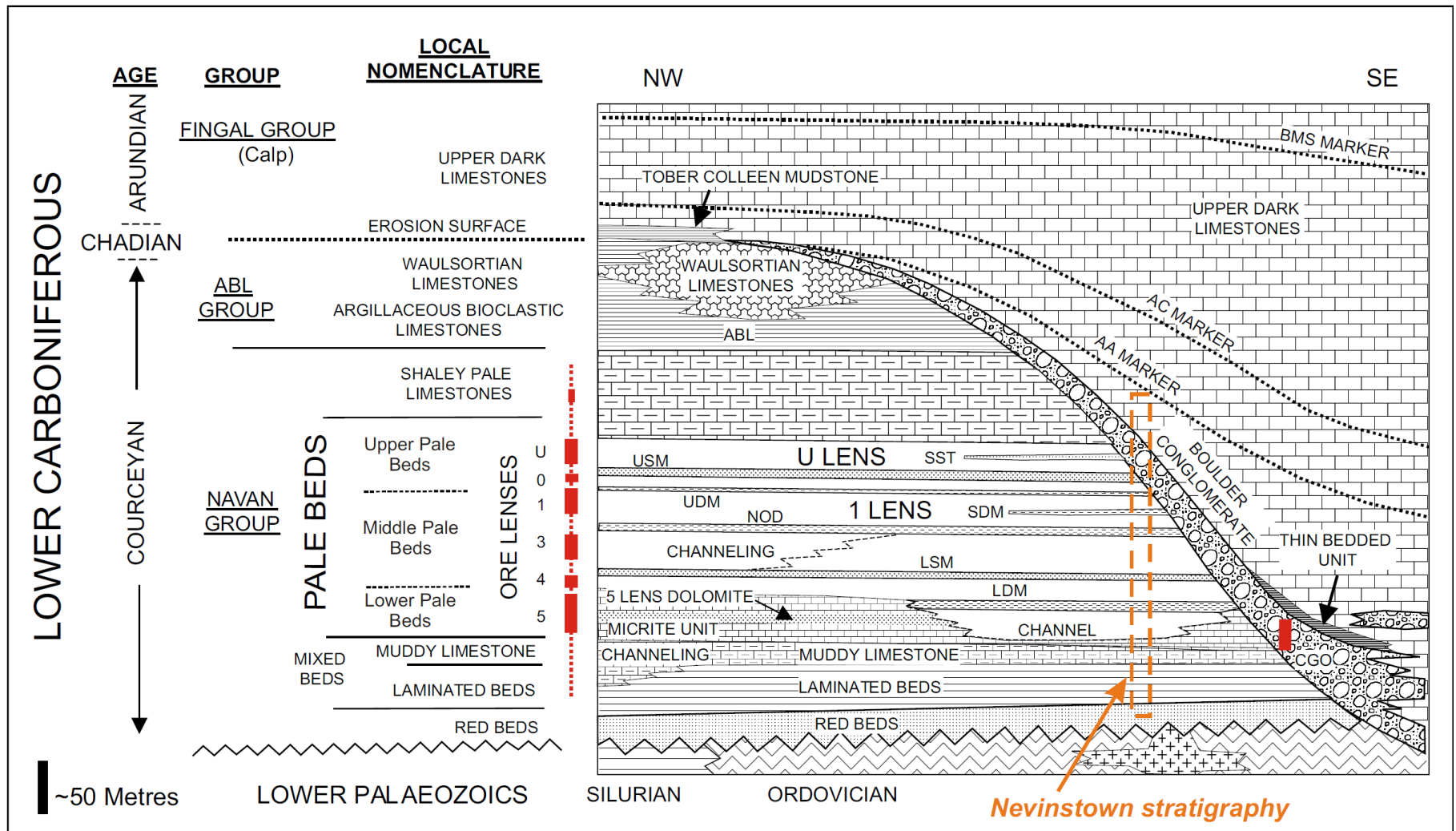


FIGURE 13.5 Nevinstown Stratigraphic Column

Later movements resulted in the A-Fault and similar structures (C, D, Castle and Randalstown faults), all of which cut and displace the UDL. Of most relevance to Nevinstown is the A-Fault, which dislocates the ore and UDL, and subcrops at surface in the south-eastern corner of Nevinstown, close to the River Blackwater. The A-Fault zone is several metres wide, and contains several thin, tight, gouge-filled shears. Folding, pressure solution and strong carbonate veining are common within the fault. The zone of deformation is wider to the east of the fault, where UDL rocks are very deformed. North-trending folding within the UDL increases in intensity towards these faults, but not so in the more massive Pale Beds. The A-Fault has never produced any water inflows in the existing operation, even when exposed directly beneath the river.

Further Late-Carboniferous activity is thought to have generated the ubiquitous northwest trending jointing and carbonate veining. Occasionally (every few hundred metres) an open, water-bearing joint occurs, the most significant of which occur in the west of Nevinstown, near the F1-Fault.

Finally, several transgressive dolerite sills (known locally as basalt sills/dykes) were intruded during Tertiary times. These strike north-northwest, dip variably to the west, and follow older structures for short distances. The sills have a tendency to slake rapidly on exposure to air and moisture.

13.3 GEOTECHNICAL STUDY

13.3.1 DESIGN

The basic 'design' requirements considered are presented in TABLE 13.1

TABLE 13.1 BASIC DESIGN REQUIREMENTS

Surface Conditions (Section 13.3.2)	Topography Presence or absence of water body
Overburden Characteristics (Section 13.3.3)	Thickness, Material Properties Stratigraphy (no info on this) Groundwater regime Bedrock/overburden interface topography
Rock Mass Conditions (Section 13.3.4)	General geological regime Ore zone dip Rock types and classification characteristics: Hangingwall, Footwall, Ore zone in crown pillar Structural controls: Jointing, faulting, cleavage, etc. Geometry of crown pillar and upper openings, width, thickness, stope spans, filling if present, support methods if present Other factors: available data on stresses, complicating geometry, multiple ore zones etc.

13.3.2 SURFACE CONDITIONS

13.3.2.1 TOPOGRAPHY

The Nevinstown orebody to include the crown pillar outcrop is in a flat field with no surface infrastructure,

FIGURE 13.6 and

FIGURE 13.7. located approx. 180 m north of the R147(Kells Road).

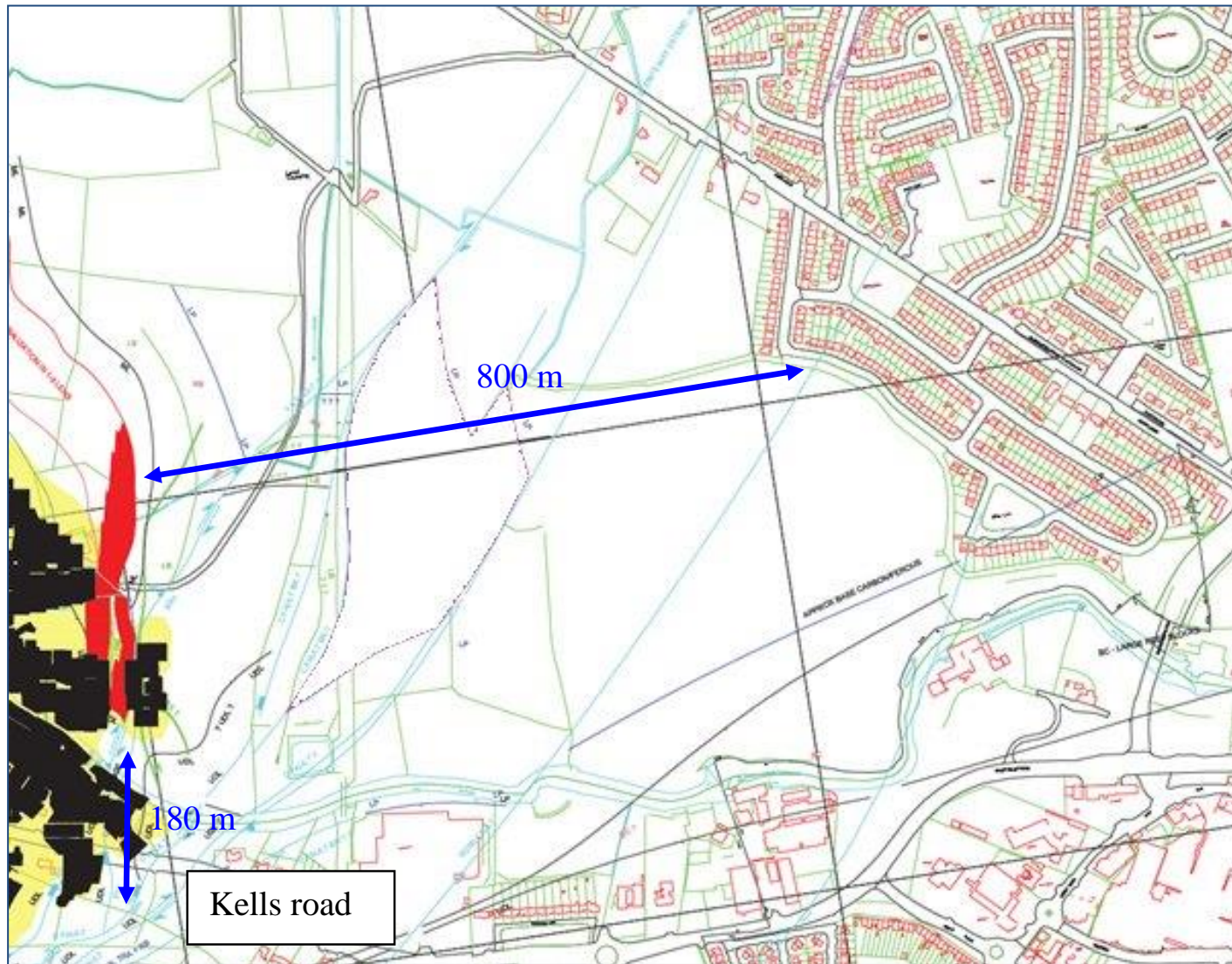


FIGURE 13.6 Surface infrastructure at the location of the crown pillar outcrop shown in red.

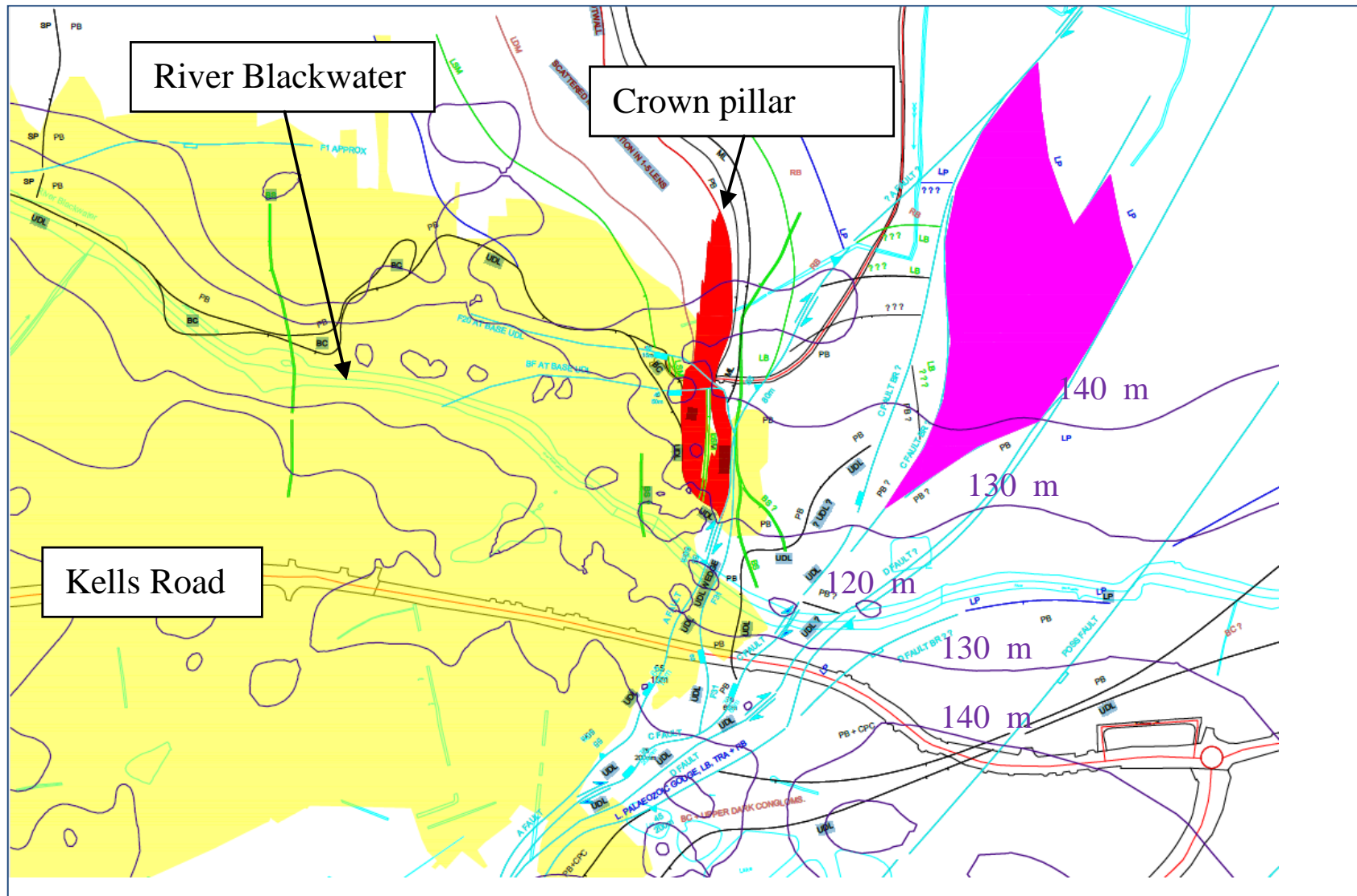


FIGURE 13.7 Topography

elevation.

Recent numerical analysis of surface settlement (Csicsek, 2017) has included studies of mining the crown pillar. The numerical modelling shows that this will not influence the overall large scale surface settlement at the mine. Surface settlement monitoring data from 2016 is presented in Figure 13.8.

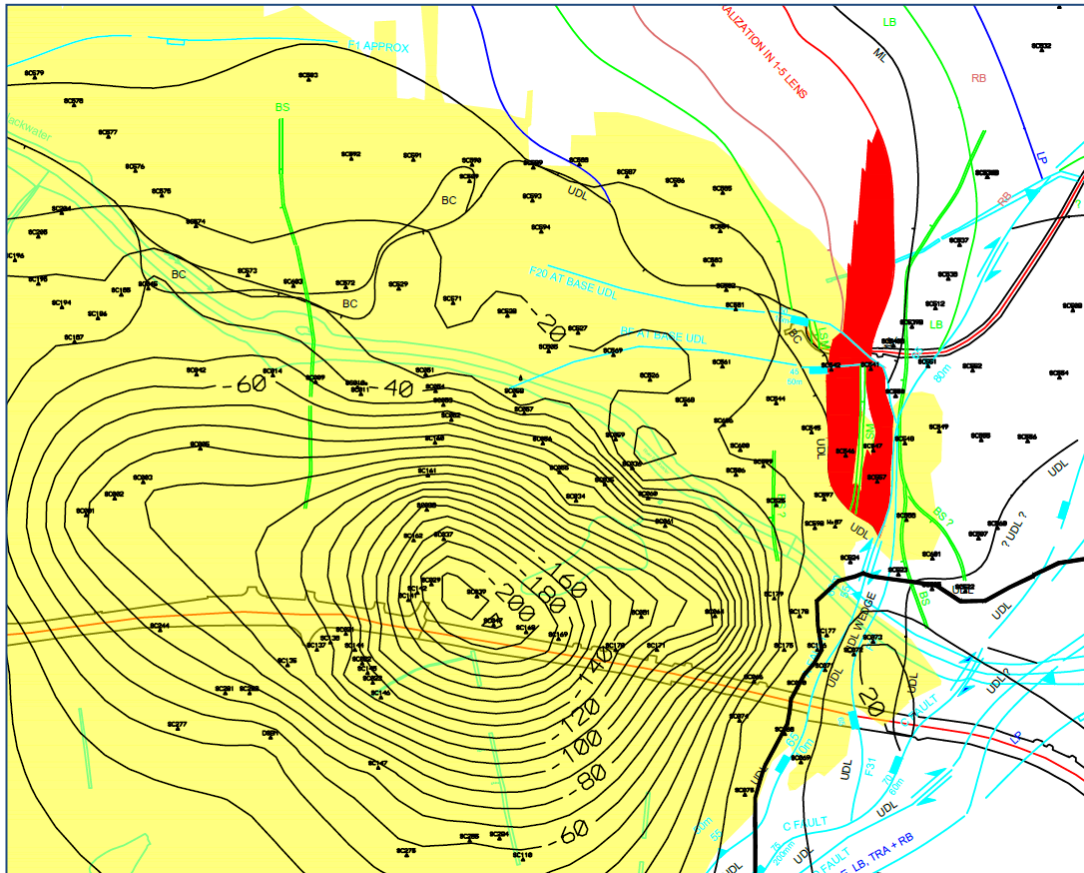


FIGURE 13.8 2016 Surface settlement monitoring data. Values in mm, negative down.

13.3.3 RIVER BLACKWATER

The bedrock beneath the River Blackwater is currently being dewatered over the mine workings, and there is an unsaturated zone between the river and the water level in the bedrock. The degree of leakage from the river is constrained by the thickness and low permeability of this unsaturated zone. Over most of the river length, this unsaturated zone is composed of low

permeability UDL and flood plain deposits. This is demonstrated by current underground mining directly beneath the southern side of the river, only 50 m from surface, and also by hydrological data, which confirms that the host rocks beneath the river in this area are dewatered. It is estimated that inflows derived from the river and flood plain deposits account for less than 2% of the total mine inflows (Schlumberger, 2016).

Nevertheless, when mining the crown pillar it is recommended to have a safe distance (30 m) to the river to minimize risk for water connection developed by stope blasting.

13.4 OVERBURDEN CHARACTERISTICS

13.4.1 THICKNESS AND MATERIAL PROPERTIES

The overburden at the location of the crown pillar within the Nevinstown orebody is 1-3 meter thick measured from several surface drill holes. The overburden consists of Elton soil, a fine loamy drift with limestones (<http://gis.teagasc.ie/soils/>). A map showing overburden at the location of the crown pillar is shown in Figure 13.9.

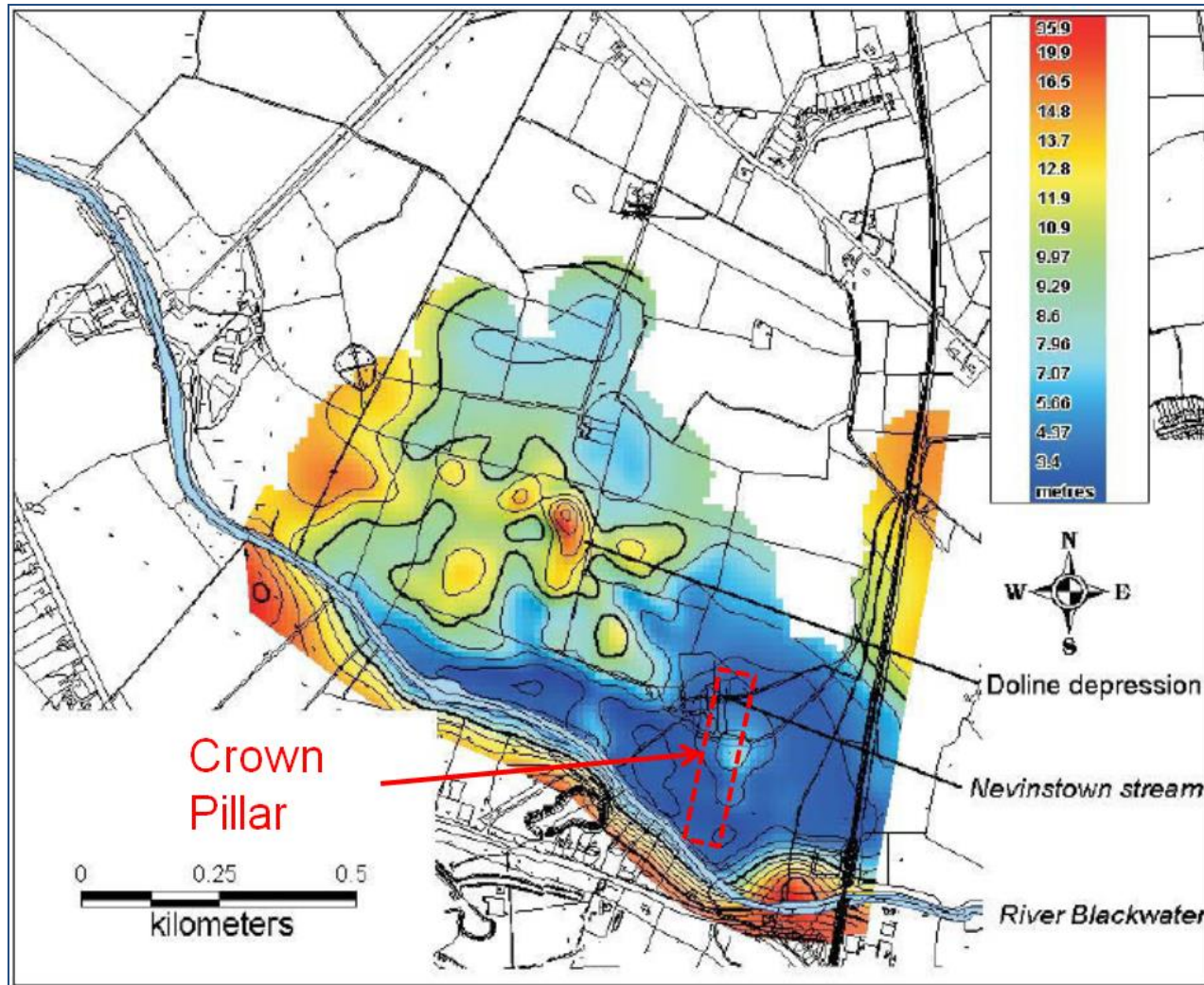


FIGURE 13.9 Overburden in the Nevinstown area highlighting the location of the “crown pillar”.

13.4.2 GROUNDWATER REGIME

Groundwater level is continuously monitored as illustrated in Figure 13.10. At the location of the crown pillar the groundwater is below the suggested mining except for the north most part of the crown pillar.

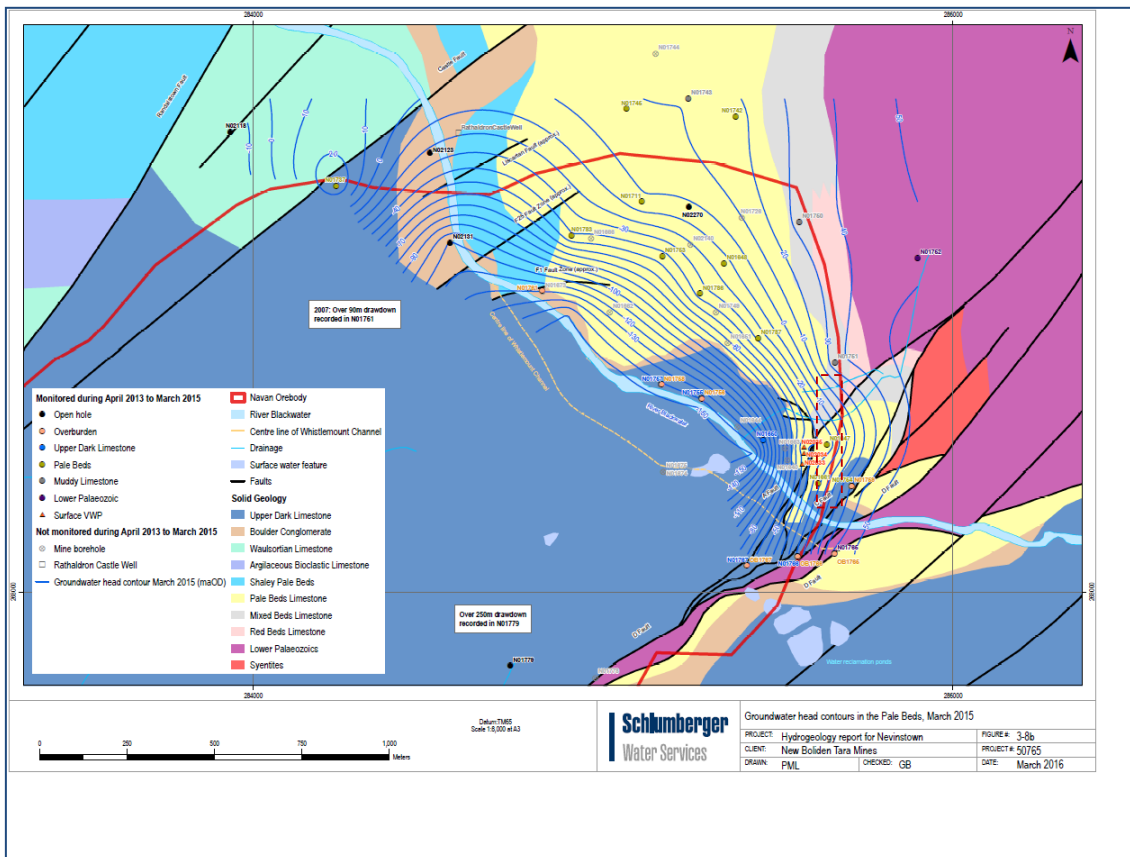


FIGURE 13.10 GROUNDWATER HEAD CONTOURS IN THE PALE BEDS, MARCH 2015 (SCHLUMBERGER, 2016). CROWN PILLAR SHOWN AS RED DASHED RECTANGLE.

Regardless of any future dewatering activities, the influence of the mine dewatering on the shallow groundwater system will continue to be negligible”. “Overall, groundwater conditions in the Nevinstown area have remained relatively stable with water levels being mostly affected by variations in the rainfall and recharge pattern. There are no apparent trends of continuing drawdown in the Nevinstown area”.

When calculating the Q-values for the rock mass classification (Barton, 2015) it is suggested that the water inflow may vary with the seasons and amount of precipitation due to close approximation to surface. It is assumed that seasonal rain will only affect from surface down to 15 m where it will be reduced and then have no influence at 30 m below the surface. Commonly $J_w=0.66$ has been used for the Q-values calculated from core logging which can be translated to the following:

- $J_w=0.66$ for a trickle or small jets of water in a concentrated area, or frequent dripping in a wide area;
- If a concentrated jet of water is coming out of a drill hole, $J_w=0.66$.

13.5 ROCK MASS CONDITIONS

13.5.1 GENERAL GEOLOGICAL REGIME

The rock types in the crown pillar consist of Pale Beds ore including some Bottom Dark Marker and Lower Dark Marker. Boulder Conglomerate, Modular Marker, Upper Dark Limestone and Thinly Bedded Unit can be found in the crown pillar hangingwall. The footwall consists of Muddy Limestone, Laminated Beds and Sandstone/Siltstone/Shale/ Calcarenite (CB).

TABLE 13.2 ROCK PROPERTIES COLLECTED OVER TARA MINING HISTORY (FENG 2000, 2002, 2015).

Rock type	Density (kN/m ³)	UCS (MPa)	RMR ⁱ	E (GPa)	E _{RM} (GPa)	Poissons ratio	RM strength (MPa)
Pale Beds (PB) (ore low values, waste high)	28	125-167 117	73-79, 79	73	38-52, 35	0.25	60-92
Bottom Dark Marker (BDM)*							
Lower Dark Marker (LDM)*							
Modular Marker (NOD)*							
Boulder Conglomerate (BC)	28	79, 117	62		19	0.30	
Upper Dark Limestone (UDL)	28	190	65		23	0.30	80
Thinly Bedded Unit (TBU)	28	108, 120	59, 64		16	0.30	45
Muddy Limestone (ML)	**	78	72		35	0.25	35
Laminated Beds (LB)	**	108	64		22	0.30	50
Sandstone/Siltstone/Sh ale/ Calcarenite (CB)**							
* Part of the Pale Beds group							
** No data							
i Bienawski							

The different rock types are explained below:

Pale Beds (PB)

A varied sequence of limestones, dolomites, and calcareous sandstones, with minor shale-silt interbeds. The Pale Beds contain a number of distinctive sandstone, siltstone and shale layers,

usually several meters thick, which form recognizable "marker" horizons. These are very useful for geological interpretation. Often massive and thickly bedded, but polished bedding planes occur locally, especially within shaley marker horizons. Commonly contains NW-striking joints, dipping to the NE.

Boulder Conglomerate (BC)

Varying from <1m to >50m in thickness, this conglomerate lies above the "erosion surface", and contains mostly limestone clasts of large size variation, in a dark argillaceous mudstone matrix. The latter may be highly sheared and polished, especially close to faults.

Upper Dark Limestone (UDL)

Variably (often thick) bedded limestones, with thin, dark (occasional carbonaceous) mudstone or shale interbeds. Frequent carbonate-filled jointing is usually restricted to thicker beds (i.e. tension gashes etc). Persistent through-going structures are rare. Polishing of bedding planes is common. The UDL may also be folded, especially close to major faults where the folding can be very tight. The basal contact with the Boulder Conglomerate may be sharp or gradational.

Upper Dark Limestones - Thinly Bedded Unit (UDL – TBU)

Thinly bedded, usually pyritic mudstone forming basal sequence of UDL.

Muddy Limestone (ML)

Dark well bedded argillaceous and crinoidal limestones, strongly bioclastic and microconglomeratic in places.

Laminated Beds (LB)

Series of thinly bedded dark argillaceous siltstones and mudstones, with local paler siltstones, sandstones and calcarenites.

13.5.2 ORE ZONE DIP

The general ore zone dip from surface down to 800 m depth is 10-15°. The ore zone is steeper in the crown pillar as shown in TABLE 13.3.

TABLE 13.3 ORE ZONE DIP

2-3, 2-4 and 2-5 lens		1-5 lens	
Footwall	Hangingwall	Footwall	Hangingwall
50-60°	35-45°	35-45°	30°

13.5.3 ROCK MASS CLASSIFICATION

Rock Mass Classification with the Q-system (Barton, 2015) has been used for a total of 22 surface drill holes through the Nevinstown orebody. The drill holes are drilled through the hanging wall rock and then in to the ore or mainly in the ore directly from start of the drill hole close to the A- and B-Fault (FIGURE 13.1 AND FIGURE). The size of the drill holes is NQ (47.6 mm).

Drill holes through the hanging wall

Drill holes mainly in the ore from start
--

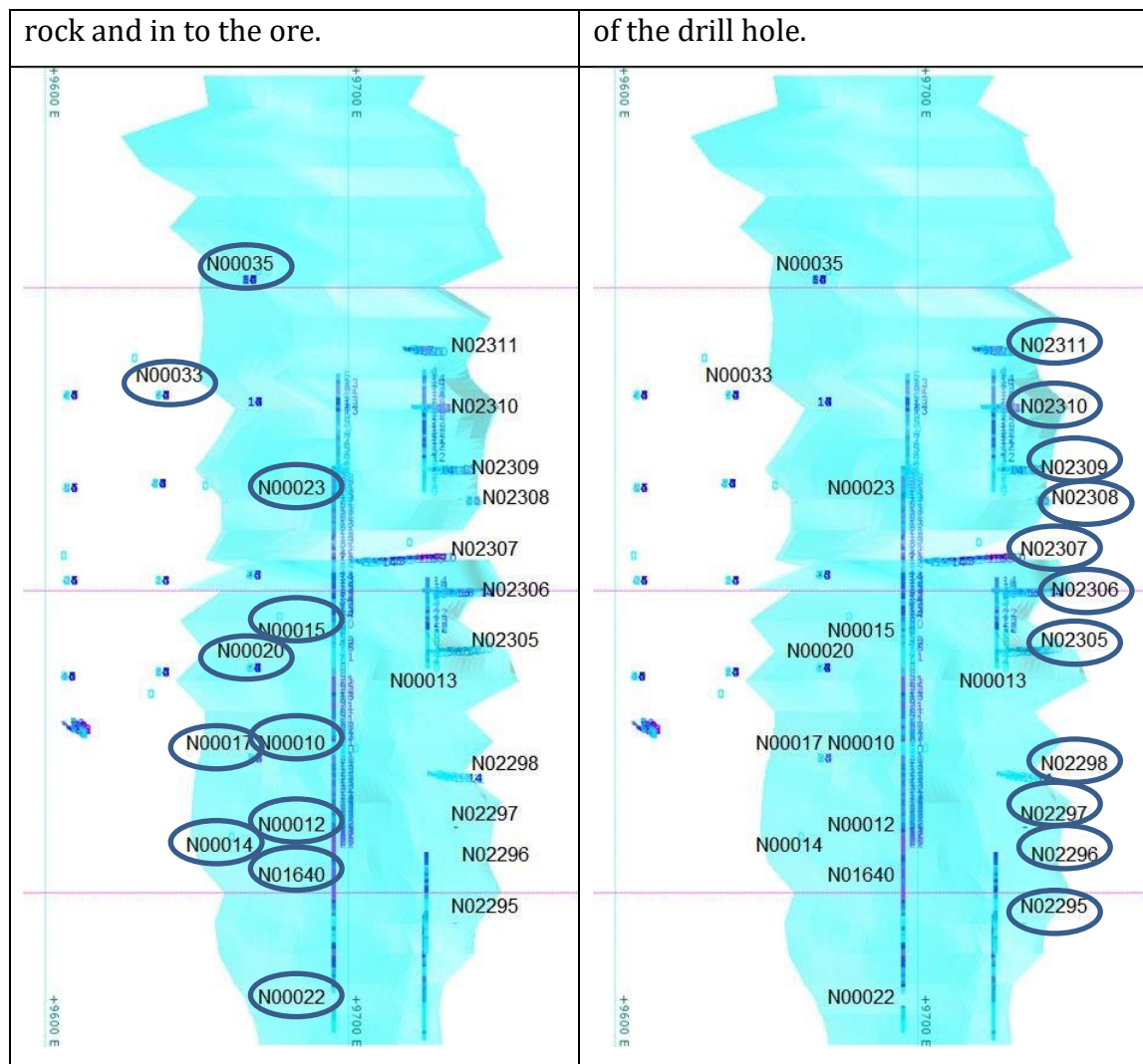


Figure 13.11 PLAN VIEW. DRILL HOLES USED FOR GEOTECHNICAL CORE LOGGING.

TABLE 13.4 Q-PARAMETERS FOR DRILL HOLES. DRILL HOLES IN ORE STARTS AT 3 M WHICH IS THE ROCK SURFACE LOCATION.

Parameter	Interval (m) (hanging wall drill holes)	Parameter values	Interval (m) (ore drill holes)	Parameter values
RQD	0-5	36	3-6	63
	5-10	58	6-10.5	71
	10-15	52	10.5-15	80
	15-20	69	15-21	84
	>20	77		
Jn	0-5	4.69	3-6	3.86
	5-10	3.36	6-10.5	4.48
	10-15	3.25	10.5-15	4.09
	15-20	3.00	15-21	3.48
	>20	2.52		
Jr	0-5	0.80	3-6	2.59
	5-10	1.00	6-10.5	2.66
	10-15	0.81	10.5-15	2.41
	15-20	1.00	15-21	2.05
	>20	0.95		
Ja	0-5	4.53	3-6	6.18
	5-10	3.12	6-10.5	6.18
	10-15	2.79	10.5-15	6.00
	15-20	2.90	15-21	6.09
	>20	2.38		
Jw	0-5	0.66	3-6	0.66
	5-10	0.64	6-10.5	0.66
	10-15	0.58	10.5-15	0.66
	15-20	0.66	15-21	0.74
	>20	0.66		

Parameter	Interval (m) (hanging wall drill holes)	Parameter values	Interval (m) (ore drill holes)	Parameter values
SRF	0-5	1.00	3-6	2.41
	5-10	0.98	6-10.5	1.95
	10-15	0.88	10.5-15	1.40
	15-20	1.00	15-21	1.01
	>20	1.00		

Q-values in the drill holes for each interval are given in TABLE 13.5.

TABLE 13.5 Q-VALUES FOR DRILL HOLES IN THE NEVINSTOWN OREBODY

Parameter	Interval (m) (hanging wall drill holes)	Parameter values	Interval (m) (ore drill holes)	Parameter values
Q	0-5	3.1	3-6	2.0
	5-10	6.1	6-10.5	3.7
	10-15	5.9	10.5-15	5.6
	15-20	9.3	15-21	8.5
	>20	12.0		

When rock support is used it is suggested that the Q-values can be compensated for influence of support in improving effective rock quality (Carter, 2014) as shown in FIGURE 13.13.

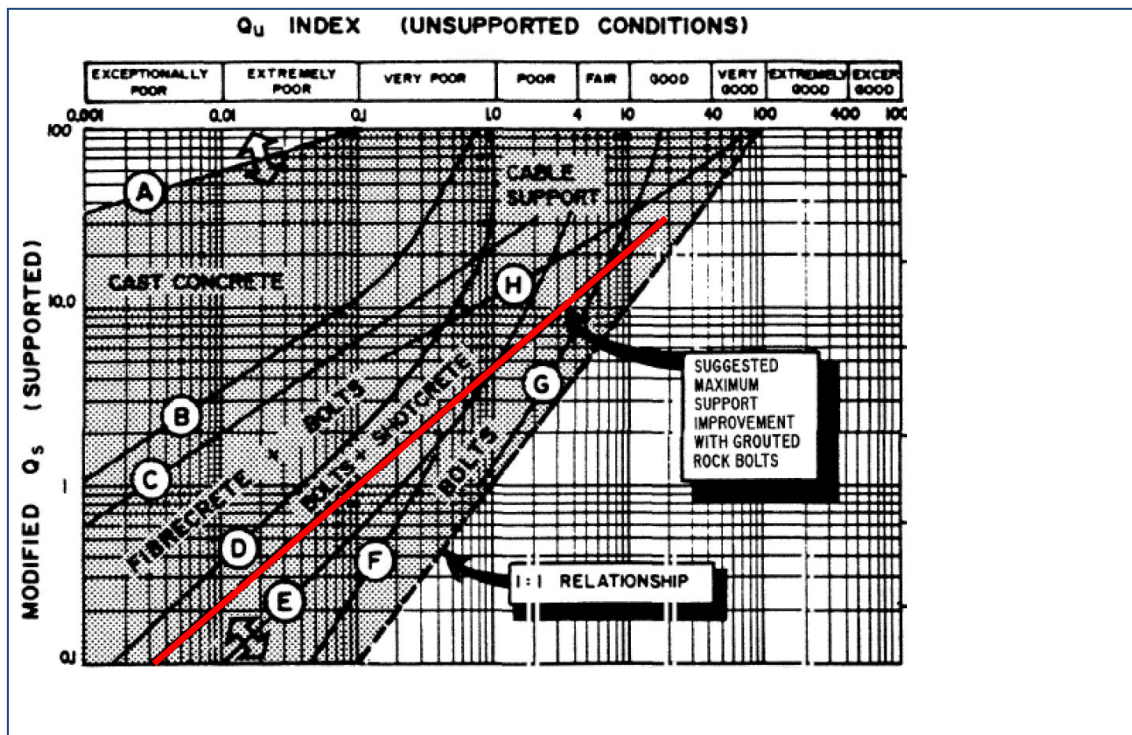


FIGURE 13.13 RELATIONSHIP Q UNSUPPORTED AND SUPPORTED CONDITIONS (CARTER, 2014).

If grouted rock bolts and shotcrete are used the Q-values for the supported rock can be increased as presented in TABLE 13.6.

TABLE 13.6 Q-VALUES FOR ROCK MASS SUPPORTED WITH GROUTED ROCK BOLTS AND SHOTCRETE.

Parameter	Interval (m) (hanging wall drill holes)	Parameter values	Interval (m) (ore drill holes)	Parameter values
Q _s	0-5	7.3	3-6	4.9
	5-10	13.6	6-10.5	8.5
	10-15	13.2	10.5-15	12.6
	15-20	20.4	15-21	18.9
	>20	26.2		

13.5.4 STRUCTURAL CONTROLS

The A-Fault and B-Fault are connected with the crown pillar as shown in FIGURE 13.14 (AMC, 2003). The A-Fault follows the ore footwall contact for the 2-4 & 2-5 lenses and the B-Fault crosses the orebody at the south border of the 1-5 lens.

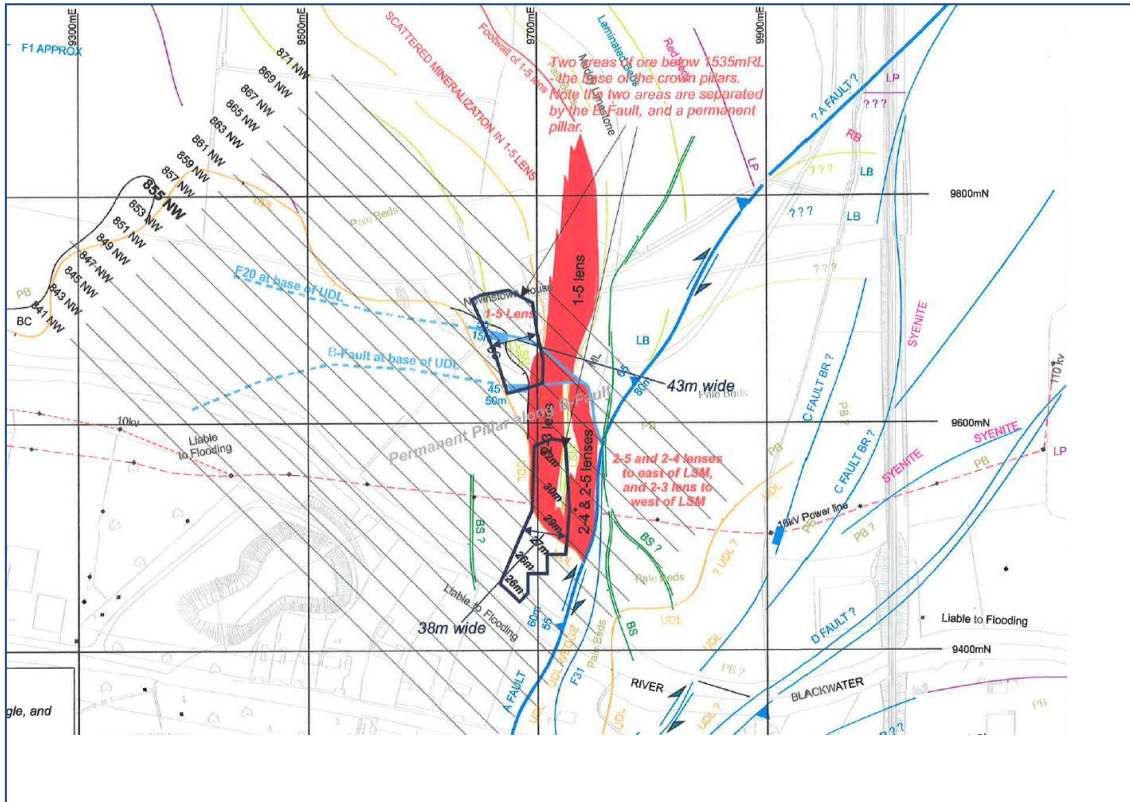


FIGURE 13.14 FAULTS SURROUNDING THE CROWN PILLAR.

13.5.4.1 A DETAILED DESCRIPTION OF THE FAULTS

The B-Fault and similar faults (F1, F20, F23 etc.) was one of the earliest to affect the orebody, striking east-northeast, mostly dipping moderately to the southeast, and with a throw of 60-80 m (decreasing eastwards). This fault series does not significantly penetrate the overlying UDL formation in the eastern areas of the mine, most of the throw pre-dating the UDL. Typically the B-Fault is a zone of partly open fractures, shears and carbonate veins a few meters wide, with several generations of movement. The fault can be locally cavernous, and some leaching of adjacent sulphides may have occurred.

The B-Fault is locally water bearing, as are the F1- and F23- faults where they intersect with northwest joints. However, the B-Fault has not shown any evidence of recharge, and is believed to be draining storage only. The fault characteristics vary depending on the adjacent lithology. For example, where the fault throws Pals Beds against Pale Beds it is either cavernous and composed of branching fractures, or occasionally tight and difficult to recognize. Where Pale Beds or earlier lithology are thrown against Red Beds, Laminated Beds or Muddy Limestone, the fault is tighter and composed of tight gouge-filled shears.

Later movements resulted in the A-Fault and similar structures, all of which cut and displace the UDL. Of most relevance to Nevinstown is the A-Fault, which dislocates the ore and UDL, and sub crops at surface in the south-eastern corner of the property, beneath overburden tillites and close to the River Blackwater. The A-Fault zone is several meters wide, and contains several thin, tight, gouge-filled shears. Folding, pressure solution and strong carbonate veining are common within the fault. The zone of deformation is wider to the east of the fault, where UDL rocks are very deformed. North-trending folding within the UDL increases in intensity towards these faults, but not so in the more massive Pale Beds.

The A-Fault exhibits dextral reverse displacement, with over 100 m of wrench movement. It has never produced any water inflows in the existing operation, even very close to the river.

FIGURE 13.1 shows drill cores going through the A-Fault and the Basalt dyke that is close to the A-Fault but further away from the crown pillar (FIGURE 13.1).

The B-Fault is shown in FIGURE 13.17.



FIGURE 13.15 DRILL HOLE NO2295 SHOWING A-FAULT AT LOCATION APPROX. 24-27 M.

Basalt dyke 28-34.5

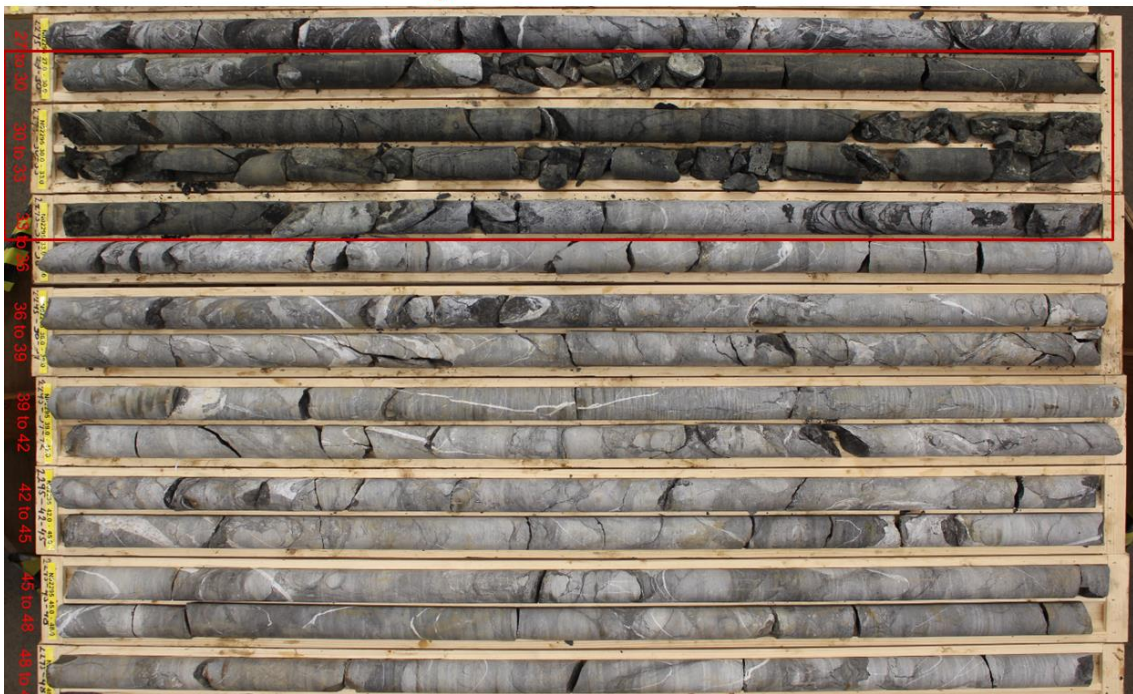


FIGURE 13.16 DRILL HOLE NO2295 SHOWING BASALT DYKE AT LOCATION APPROX. 28-34.5 M.

B-fault at 11.7 – in red circle

FIGURE 13.17 DRILL HOLE NO2308 SHOWING THE B-FAULT AT LOCATION APPROX. 11.7 M.

Along the hanging wall ore contact of the 2-3 lens there is also low strength pyritic rock associated with the Thinly Bedded Unit that can be seen as crushed rock in the drill cores (FIGURE 13.1).

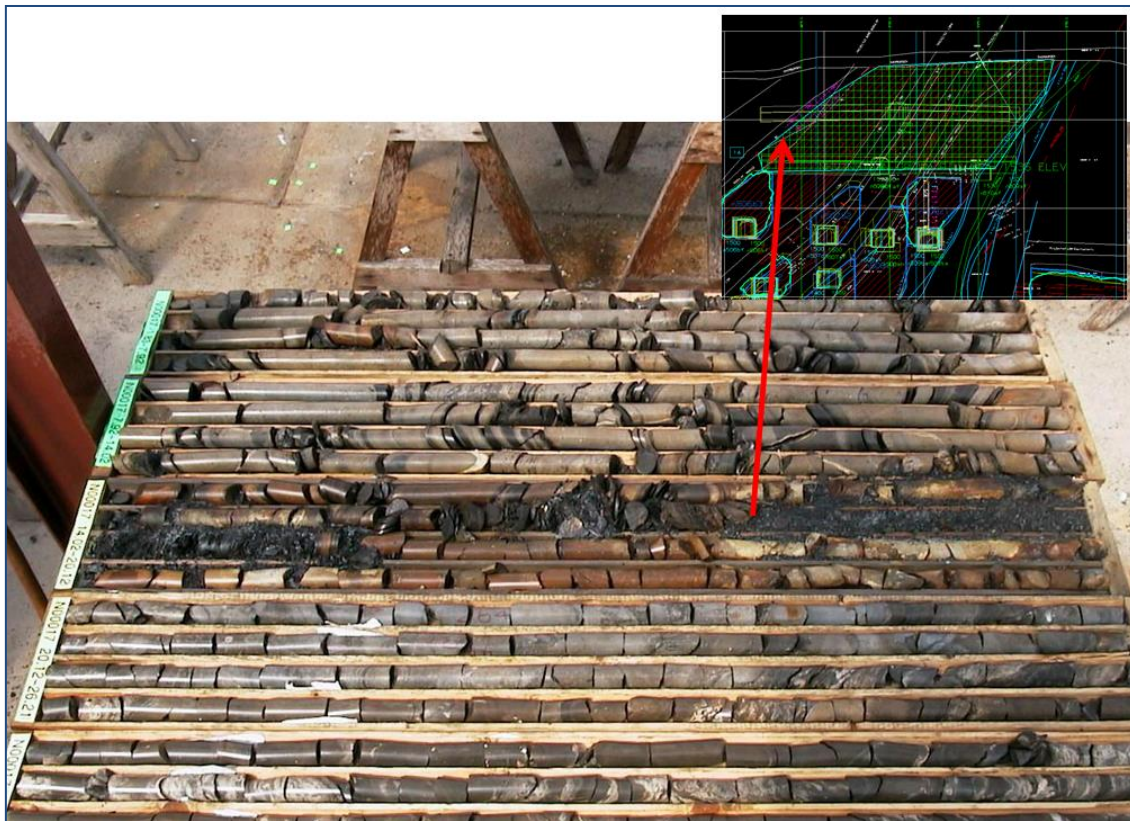


FIGURE 13.18 DRILL HOLE N00017 SHOWING CRUSHED ZONE OF PYRITIC ROCK IN THE HANGING WALL ORE CONTACT.

A rock mass classification of the faults and Basalt dyke is given in TABLE 13.7 (Feng, 2015).

Table 13.7 Q-values for structural controls.

Fault	Q-value
A	$0 < Q < 1$
B	$2.4 < Q < 7$
F20	$11 < Q < 14$
Basalt	$0.1 < Q < 4$

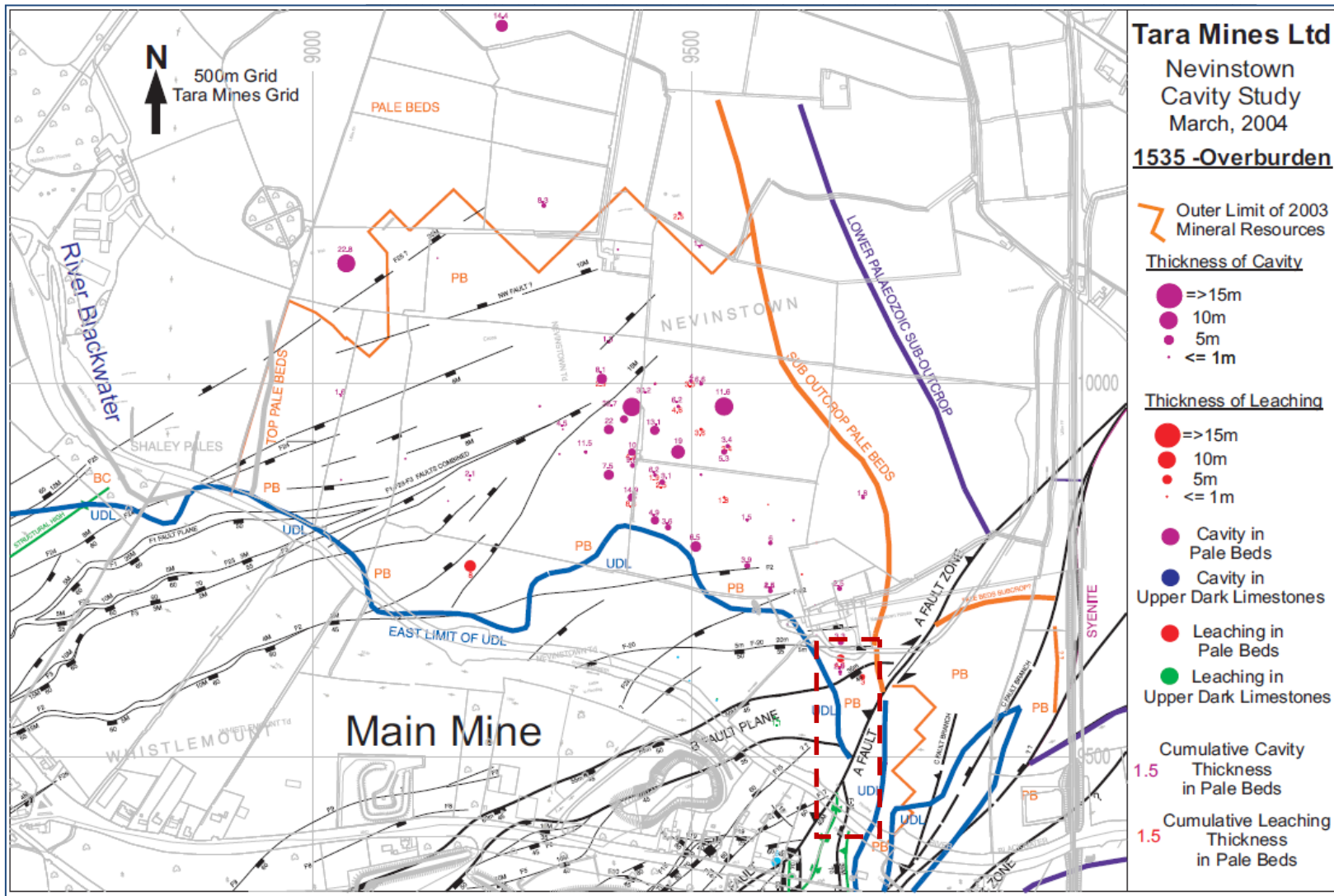


Figure 13.19 Cavities and leaching in diamond drill holes between 1535 elevation and base overburden . Crown pillar shown as red dashed.

Cavities

A few cavities have been found in the vicinity of the crown pillar (Figure13.19). The cavities are small (<5 m) and have been dry. Risk of production disturbances due to cavities are deemed small. If a cavity is found that will influence stability it can be injected by cement grouting.

13.4.4.2 GEOMETRY AND CONDITIONS OF MINED STOPES BELOW CROWN PILLAR

The ore below the Crown Pillar will be mined by 'longhole stoping' and backfilled. The angled stope backs and mining sequence of the stopes insures that the stopes have been tightfilled. The stopes belong to the N4, N5 and N6 group of stopes (N=Nevinstown). The N6 stopes are mined on the far side of the A-Fault and Basalt. The crown pillar is located above the N4 and N5 stopes. The stopes are mined along ore strike and stope dimensions shown in Table 13.8..

TABLE 13.8 STOPE DIMENSIONS FOR STOPES BELOW THE CROWN PILLAR.

Stopes	Width (m)	Length (m)	Height (m)
N4	15	40	25-35
N5	15	25-35	18-45
N6	20	30-45	12-25

The stope geometries are shown in FIGURES 13.20 to FIGURE 13.2

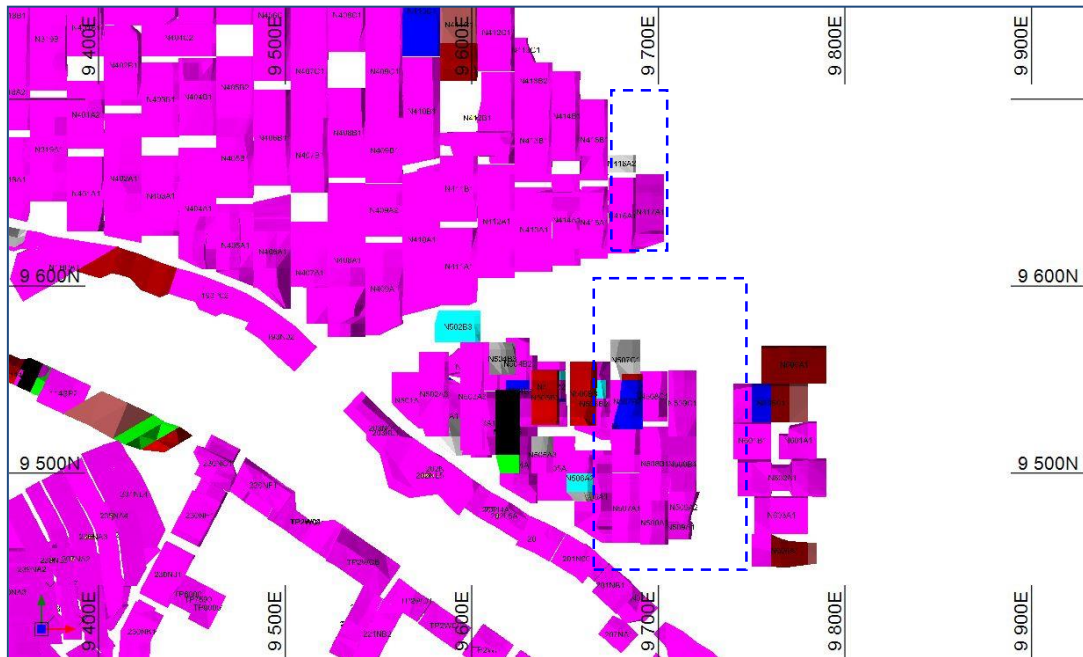


FIGURE 13.20 PLAN VIEW OF THE STOPES MINED BELOW THE CROWN PILLAR SHOWN AS DASHED BLUE BOXES.

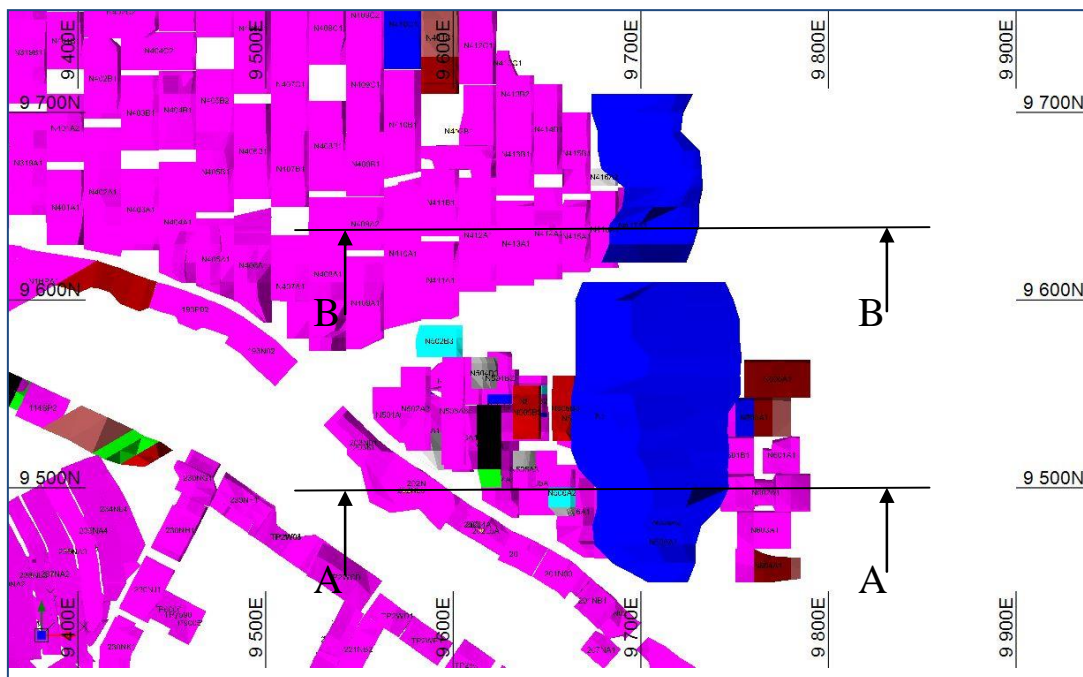


FIGURE 13.21 PLAN VIEW OF THE MINED STOPES WITH THE CROWN PILLAR SHOWN AS BLUE SOLIDS. SECTION A-A AND B-B ARE SHOWN IN THE FOLLOWING FIGURES.

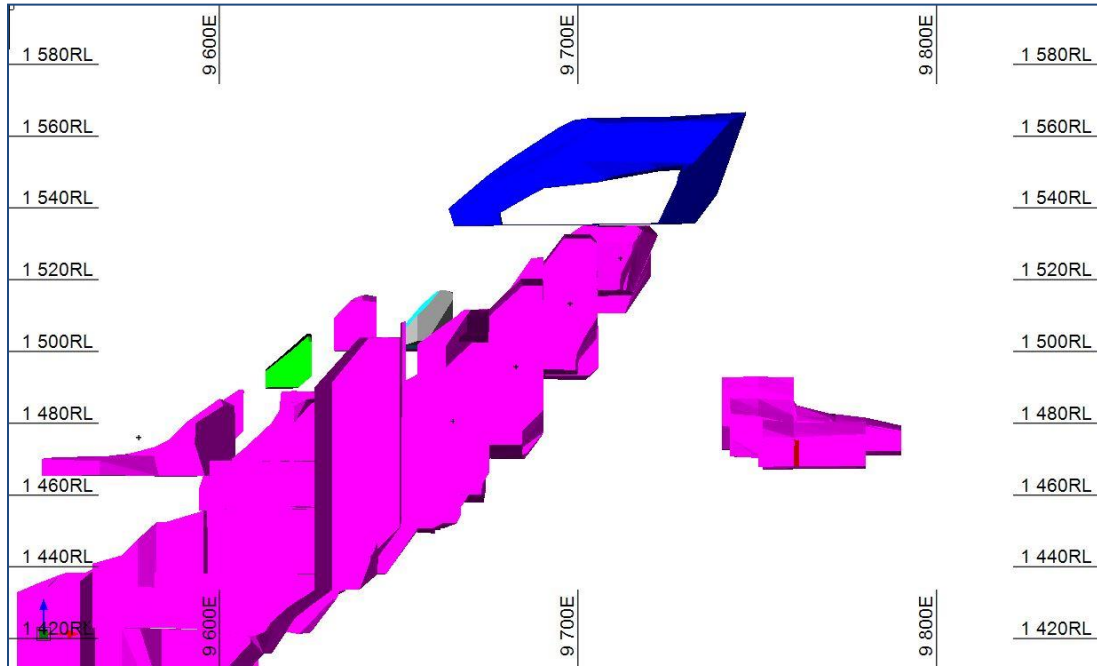


FIGURE 13.22 SECTION A-A THROUGH 2-3, 2-4 AND 2-5 LENSES. DISPLAY DEPTH 50 M.

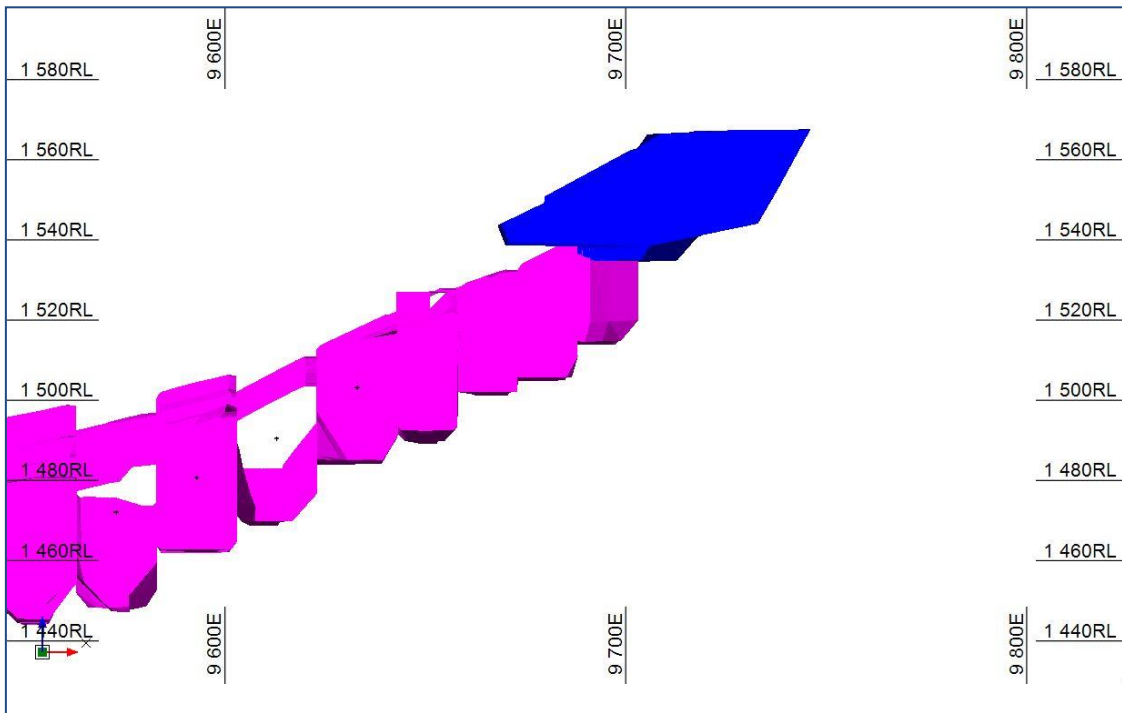


FIGURE 13.23 SECTION B-B THROUGH 1-5 LENS. DISPLAY DEPTH 50 M.

The N416A1 stope mined in 1-5 lens and the N509B1 stope mined in 2-5 lens are shown as examples how mining has proceeded up to the existing crown pillar limit (30 m) (FIGURE 13.24 AND 13.25).

The N416A1 stope dimension is 15 m width x 32 m length x 31 m height. The back of the stope has been supported by 11-12 m long double strand cables in a 2.5 x 2.3 m pattern. 15:1 backfill recipe has been used. This corresponds to approx. 1.2 MPa for 28 days UCS laboratory tests with drained backfill samples (Nyström, 2016).

The N509B1 stope dimension is 15 m width x 30 m length x 23 m height. The back of the stope has been supported by 11-12 m long double strand cables in a 2.5 x 2.3 m pattern. 18:1 backfill recipe has been used which corresponds to a UCS of approx. 0.8 MPa.

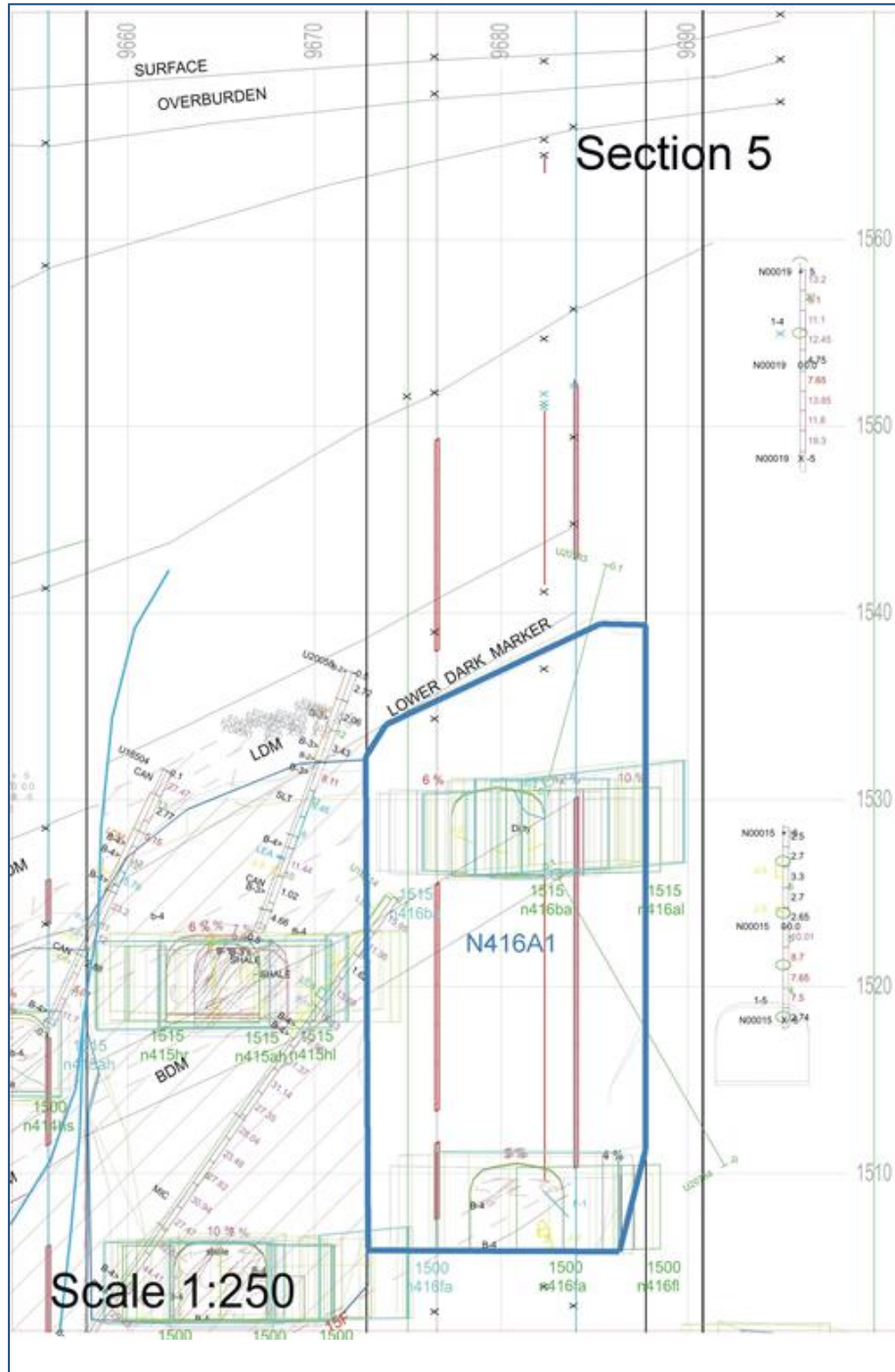


FIGURE 13.24 STOPE N416A1 SECTION 5 (FENG, 2008).

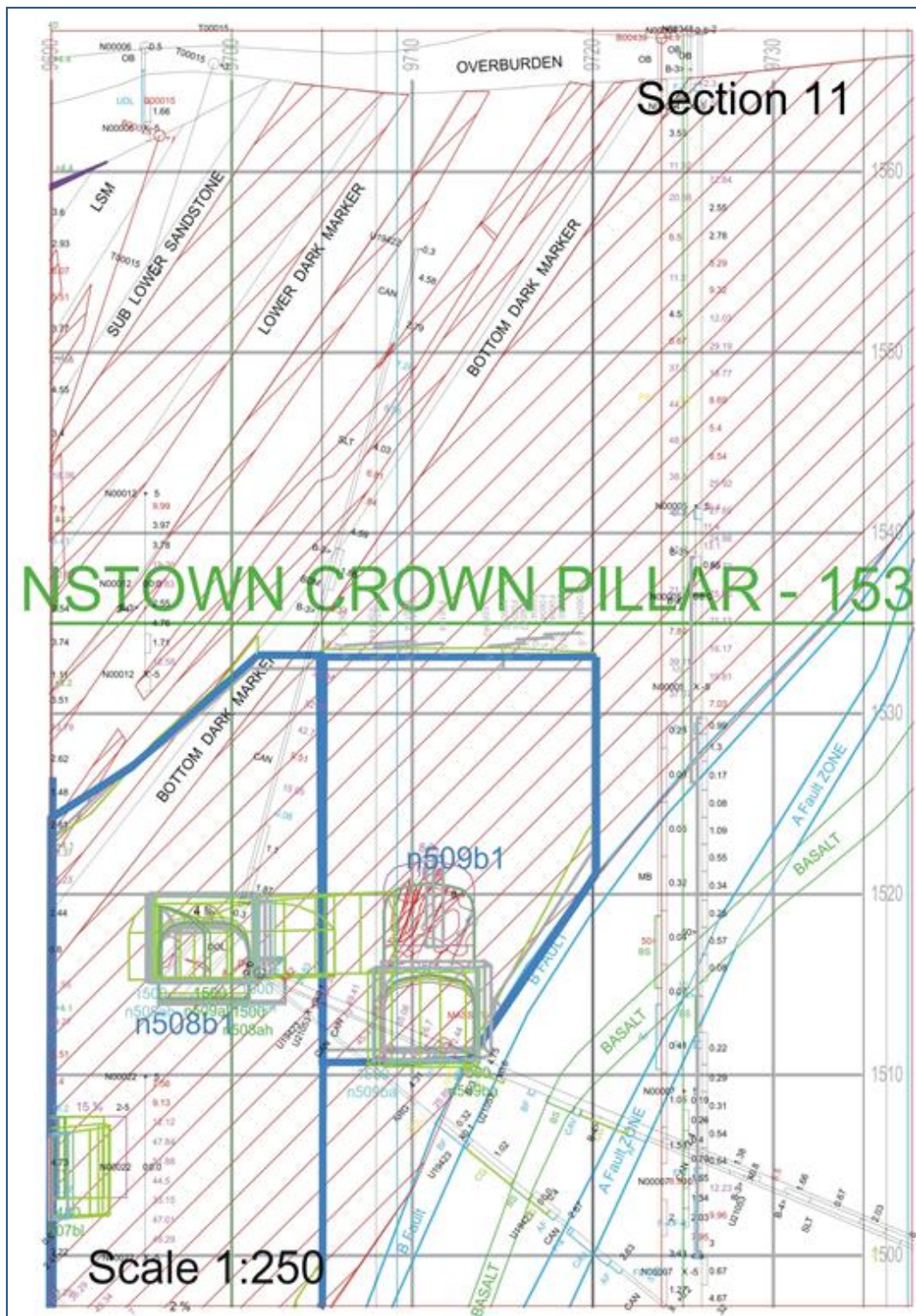


FIGURE 13.25 STOPE N509B1 SECTION 11 (FENG, 2009).

13.5.5 OTHER FACTORS

13.5.5.1 STRESSES

In-situ stress has been measured on a number of occasions in different areas of the Mine. The general mine stress field in the upper part of the mine is stated as being (Feng, 2014):

Major principal stress (σ_1) = $2.5 \times 0.028 \times \text{depth}$, trend from north 135° and plunge 1°
 Intermediate principal stress (σ_2) = $1.0 \times 0.028 \times \text{depth}$, trend from north 45° , Plunge 75°
 Minor principal stress (σ_3) = $0.7 \times 0.028 \times \text{depth}$, trend from north 225° , Plunge 15° .

Calculated in-situ stress at the location of the crown pillar is shown in TABLE 13.9.

Table 13.10 In-situ stress at the location of the crown pillar.

Depth (m)	σ_1 (MPa)	σ_2 (MPa)	σ_3 (MPa)
10	0.7	0.28	0.2
20	1.4	0.56	0.39
30	2.1	0.84	0.59
40	2.8	1.12	0.78

The in-situ stress at Nevinstown was measured in January 2004 using the HI Cell overcoring technique (Table 13.10). The measurements were done at site 1450-N408EX (primary stope development, prior to stope extraction) at 1474 mRL, approx. 90 m below surface.

TABLE 13.0 NEVINSTOWN IN-SITU STRESS MONITORING DATA.

Azimuth is given in relation to Mine North. Dip convention is positive down.

Principal Stress	Magnitude (MPa)	Azimuth	Dip
Major	4.1	243°	18°
Intermediate	2.2	106°	66°
Minor	1.9	339°	15°
Vertical	2.3	0°	90°

The measured vertical stress of 2.3 MPa is consistent with the theoretical vertical stress (from the of weight overburden) of 2.4 MPa.

13.6 STABILITY ASSESSMENT

13.6.1 METHODS

For stability assessment of mining the Nevinstown orebody to include the crown pillar two different approaches have been used, namely;

- The empirical method called Scaled Span Method developed by Carter, 2014, and
- Numerical analysis with Flac3D done by Itasca, Sweden, 2017.

13.6.2 SCALED SPAN METHOD

The Scaled Span approach, developed in the late 1980's, provides an effective means for empirically sizing a rock crown pillar over a near-surface excavation based on precedent experience (Carter, 2014). The database today includes well over 500 cases with over 70 failures records of crown collapses.

The stability of a crown pillar can be expressed as follows:

$$Crown\ Stability = f\left(\frac{T\sigma_h\theta}{SL\gamma u}\right)$$

Where **increased stability** for any rock mass quality would be reflected by an increase in:

T, the rock crown thickness

σ_h , the horizontal in-situ stress

and/or in θ , the dip of the foliation or of the underlying opening, and

Where **decreased stability** for any crown would result from increases in:

S, the crown span

L, the overall strike length of the opening

γ , the mass (specific gravity) of the crown pillar

and/or in u , the groundwater pressure.

From these parameters that influence the crown stability a scaled span relationship has been defined as follows:

$$C_s = S \left(\frac{\gamma}{T(1 + S_R)(1 - 0.4 \cos \theta)} \right)^{0.5}$$

Where:

S = crown pillar span (m);

γ = specific gravity (dimensionless but same numerical value as mass unit weight, tonnes/m³);

T = thickness of crown pillar (m);

θ = orebody/foliation dip;

S_R = span ratio = S/L (crown pillar span/crown pillar strike length).

In the same manner as the Q-chart in the Q-system, this scaling expression, C_s , is plotted on the y-axis against rock quality on the x-axis.

In the revision to the basic relationships published in 2002, the controlling span has been redefined to take into account the equivalent “effective” span, S_{EFF} , which has been suggested to be used for shallow dipping orebodies (dip <45°). However, despite that the crown pillar orebody is shallow dipping this has not been accounted for in the analysis because the stopes will be tightfilled which means the span is limited to the opening of single stopes. The tightfilling will also insure that there is no risk for caving due to long term deterioration of the crown pillar rock quality. Therefore, the original critical span line can be used to assess stability (Figure 13.26).

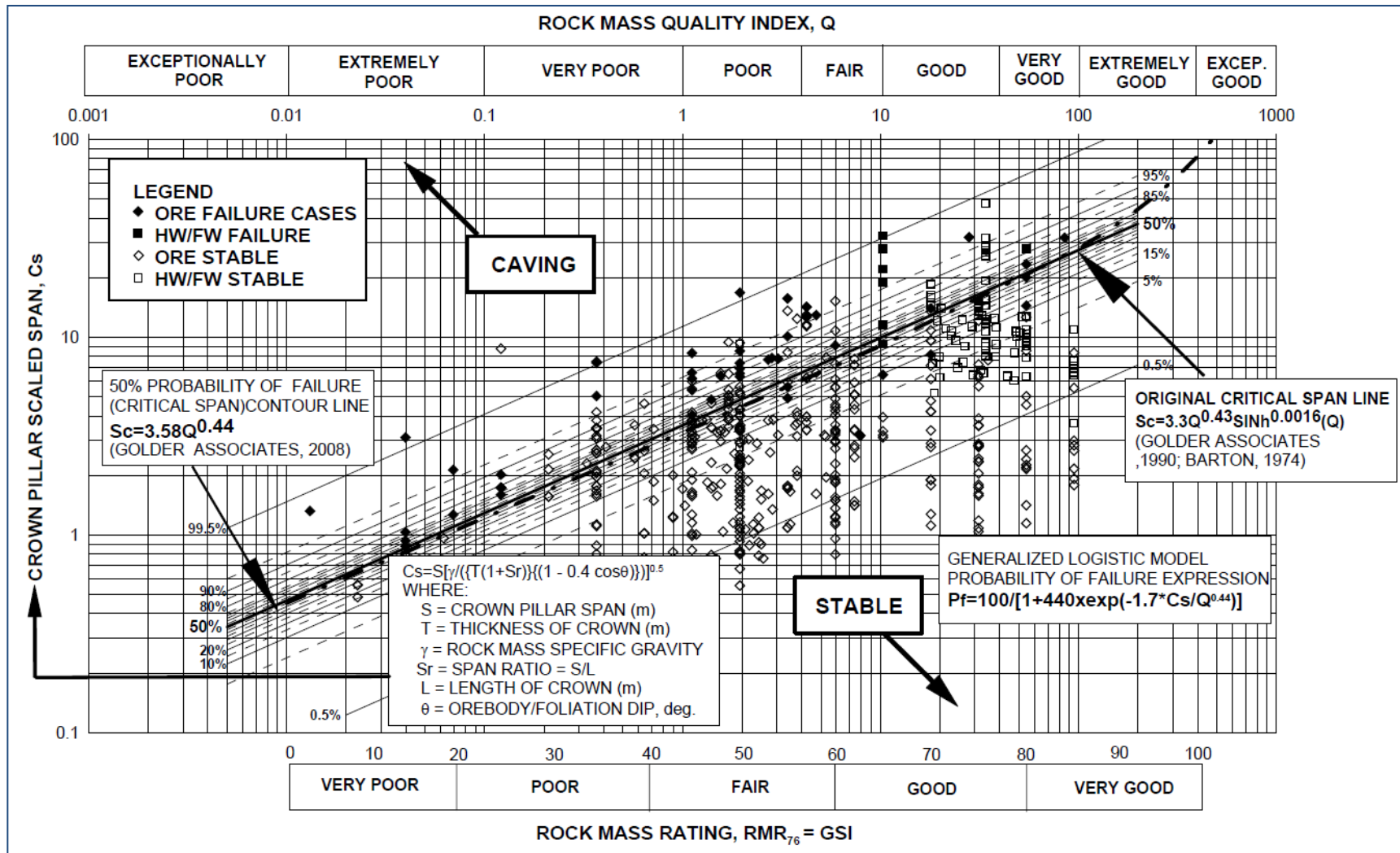


FIGURE 13.26 SCALED SPAN CHART WITH PROBABILITY OF FAILURE CONTOUR INTERVALS.

In Figure 13.277 calculations for different stope dimensions and crown pillar thicknesses are shown for stopes where the crown pillar consists mainly of ore above the back of the stopes. The crown pillar Scaled Span, C_s , for different stope dimension has been calculated and is shown as colored curves in the chart. A conservative orebody/foliation dip of 20° is used for the calculations. Two Critical Span lines, S_c , are shown as dashed lines in the chart. One calculated with average Q-values for different drill hole intervals. Rock mass classification and one where average Q-values have been adjusted for the use of rock support.

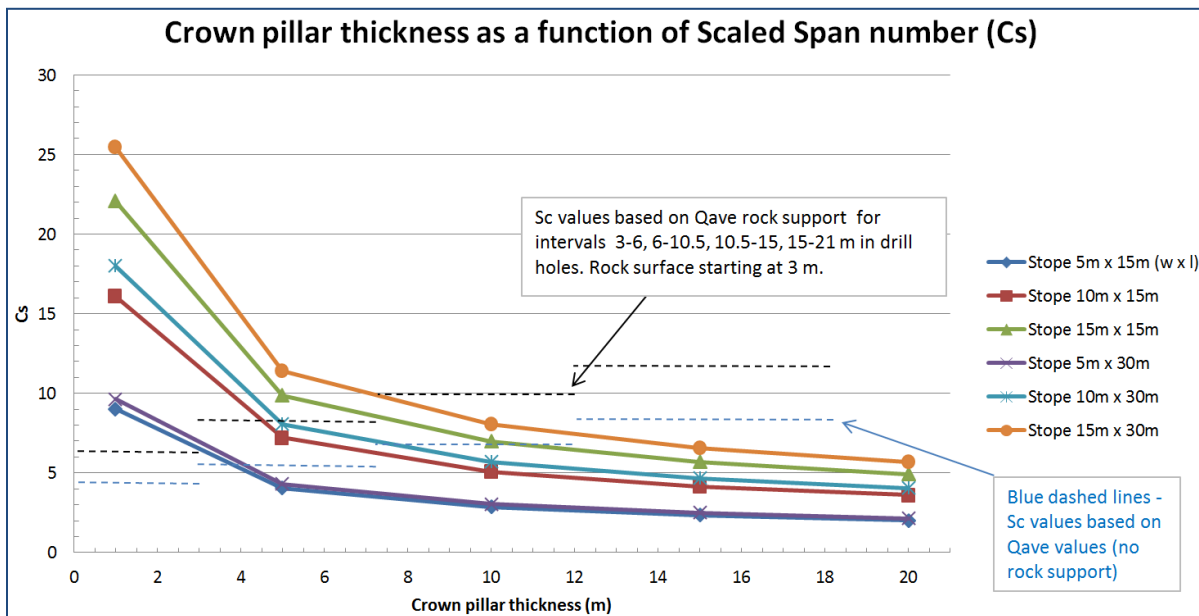


FIGURE 13.27 ANALYSIS OF CROWN PILLAR THICKNESS AND STOPE **dimensions with the Scaled** Span method where the back of the stopes mainly consists of ore (footwall side).

In

Figure 13.28 calculations for different stope dimensions and crown pillar thicknesses are shown for stopes where the back of the stopes partly consists of hanging wall rock types and partly of ore.

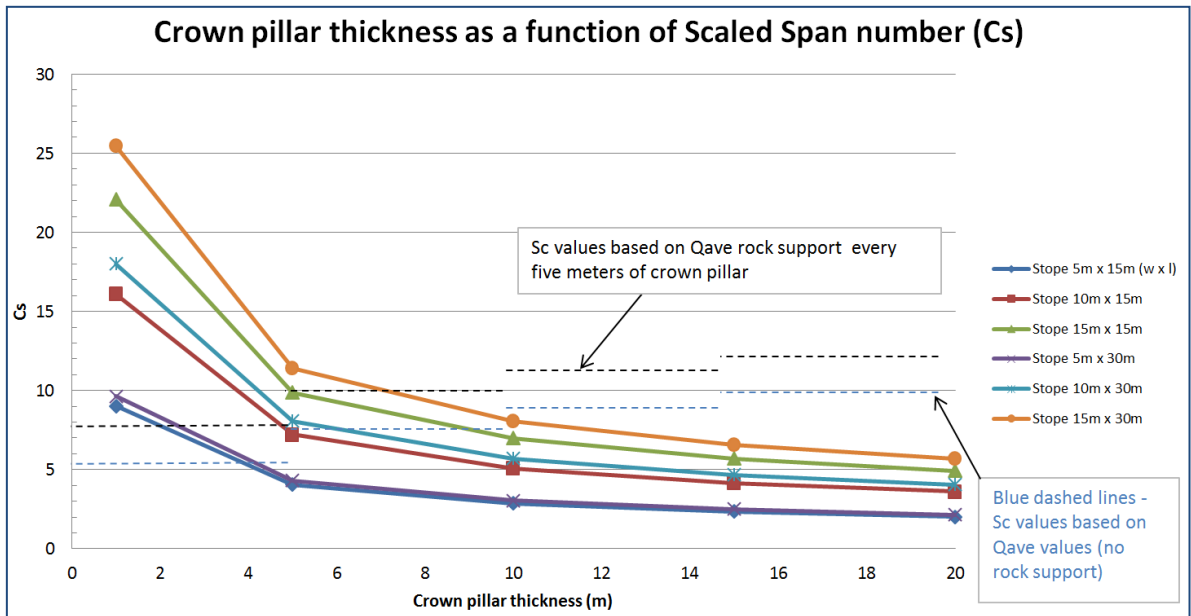


FIGURE 13.28 ANALYSIS OF CROWN PILLAR THICKNESS AND STOPE DIMENSIONS WITH THE SCALED SPAN METHOD FOR STOPES WHERE THE BACK OF THE STOPES PARTLY CONSISTS OF HANGING WALL ROCK TYPES AND PARTLY OF ORE.

From the charts different stable options for stope dimensions and crown pillar thicknesses can be chosen as presented in TABLE13.11.

The following has to be achieved for the stope dimensions and thicknesses of the crown pillar to be stable:

- Rock reinforcement of the stopes and crown pillar (bolts, shotcrete and cables);
- Tightfilling of the stopes.

TABLE 13.11 STABLE STOPE DIMENSIONS AND CROWN PILLAR THICKNESSES. Q-VALUES ADJUSTED FOR ROCK SUPPORT USED.

Stope dimension (width x length)	Crown pillar thickness for stope backs mainly in ore	Crown pillar thickness for stope backs with hanging-wall rock types but partly in ore
5 m x 30 m	7 m	3 m
10 m x 30 m	8 m	6 m
15 m x 30 m	12 m	15m

13.6.3 NUMERICAL ANALYSIS

The numerical analysis study is presented in the report “Rock mechanics analysis for the planning application for crown pillar extraction at Tara” (Itasca, 2017). The following gives a brief summary of the major findings from the study.

Several different stope dimensions with varying thickness of the crown pillar were planned to be analysed but the results from the initial modelling showed that worst case scenarios, i.e. largest stope dimension with the thinnest crown pillar were already stable and therefore the number of modelling cases was reduced to four different cases. Three cases were modelled with large stope dimensions (15 m wide, 15-25 m high and length equals approx. half the width of orebody) and one case where the width of the stopes was reduced to 10 m and stope height 20 m (TABLE 13.12).

TABLE 13.11 MODELLED STOPE DIMENSIONS AND CROWN PILLAR THICKNESS.

		Pillar thickness *		
		15 m	10 m	5 m
		Stope height		
		15 m 1550-1535	20 m 1555-1535	25 m 1560-1535
Stope width	10 m		Case 3 w10 h20	
	15 m	Case 4 w15 h15	Case 2 w15 h20	Case 1 w15 h25

Rock properties in the models are shown in Table 13.12. Faults have been excluded in these models due to limitations in the Flac code when large models with complex geometry and small elements are used. Different rock properties are used for the waste rock and the ore and also the hangingwall contact that consists of pyritic rock with poor quality. The stopes are backfilled and soil is used on top of the rock surface.

TABLE 13.12 ROCK PROPERTIES IN THE FLAC3D MODELS.

Parameter	Rock	Ore	Pyrite	Backfill	Soil
Young's modulus, E_m [GPa]	40 ¹	59.6 ²	0.6 ³	0.010 ¹	0.005 [*]
Poisson's ratio, ν	0.25 ¹	0.33 ²	0.25 [*]	0.25 [*]	0.35 [*]
Cohesion, c [MPa]	10 ¹	10 ¹	0.6 ³	0.125 ^{1,4}	-
Friction angle, ϕ [°]	40 ¹	40 ¹	35 ³	26 ⁴	-
Tensile strength, σ_t [MPa]	4.2 ¹	4.2 ¹	0 ³	0.065 ¹	-
Density, ρ [kg/m ³]	2700 [*]	3066 ²	3000 [*]	2000 [*]	1600 [*]

¹ AMC (2003),

² AMC (2003),

³ RocLab, assumed values

⁴ Belem et al (2000), (CT-2 FP)

* Assumed value

In-situ stresses have been chosen according to Feng's (2015) recommendations as shown in

Table 13.13.

TABLE 13.134 IN-SITU STRESSES IN THE FLAC3D MODELS.

Magnitude σ_1 [MPa]	Orientation σ_1 [°]	Magnitude σ_2 [MPa]	Orientation σ_2 [°]	Magnitude σ_3 [MPa]	Orientation σ_3 [°]	Reference
0.070z	135/01	0.028z	045/75	0.020z	225/15	Nyström (2017) ¹⁾

The mining sequence used in the models is to incrementally mine stope by stope starting with stope number 1A and 1B closest to the river and then continue to the north until all 64 rows of stopes have been extracted (FIGURE 13.). In the same manner, backfilling is done incrementally stope by stope. A model was also run where full extraction of the orebodies was done in one step to compare the effect on surface settlement. In the following figures results are presented for section S7.

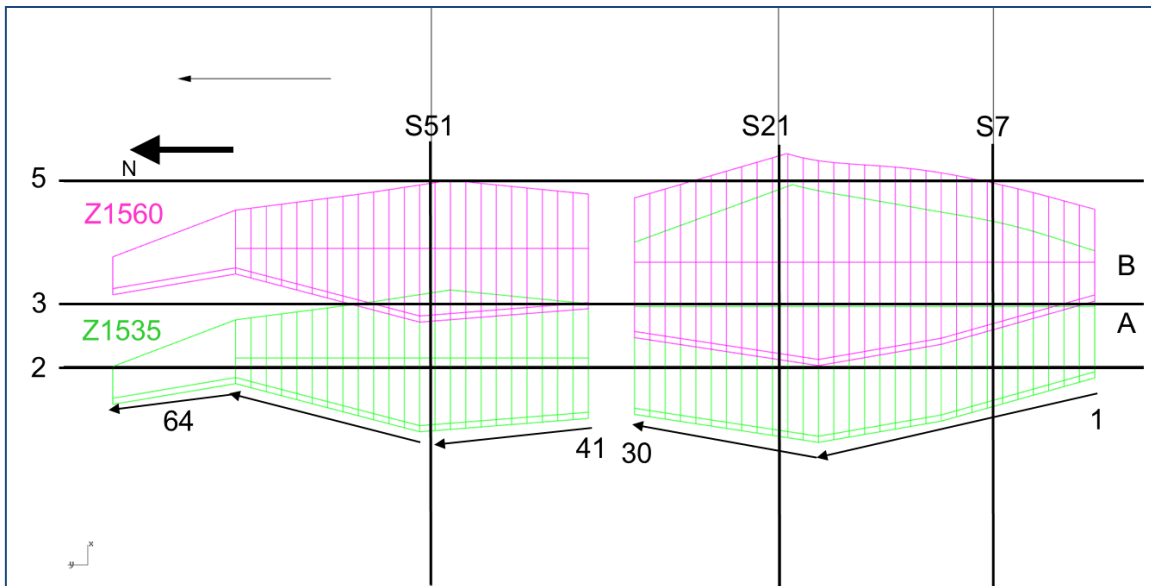


FIGURE 13.30 STOPE SEQUENCE AND LOCATION OF SECTIONS USED FOR PRESENTATION OF RESULTS.

The analysis give low compressive stresses ($\sigma_1=0-5$ MPa) and tensile stress ($\sigma_3=0-1$ MPa) above the crown pillar stopes, footwall and hangingwall for every mining step (FIGURE 13.30 AND FIGURE 13.31).

The tensile stresses extend far out in the hangingwall which proves the importance of achieving tightfilled stopes to minimize surface settlement. The models are all stable and yielding only occurs in the backfill and in the pyritic rock along the hangingwall contact (FIGURE 13.3). The displacement on surface is low, less than 1 cm, when stopes are mined incrementally but a

model where all of the stopes were mined in one step resulted in displacements exceeding 10 cm (FIGURE 13.33).

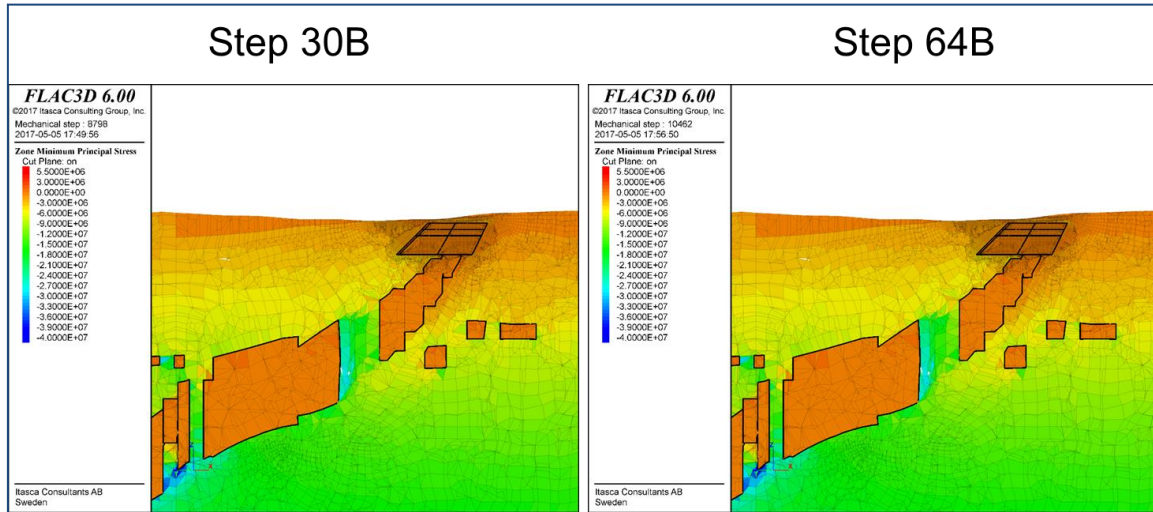


FIGURE 13.30 MAXIMUM PRINCIPLE STRESS (σ_1) IN SECTION S7 FOR MINING STEP 30 AND 64. NEGATIVE VALUES MEANS COMPRESSIVE STRESSES.

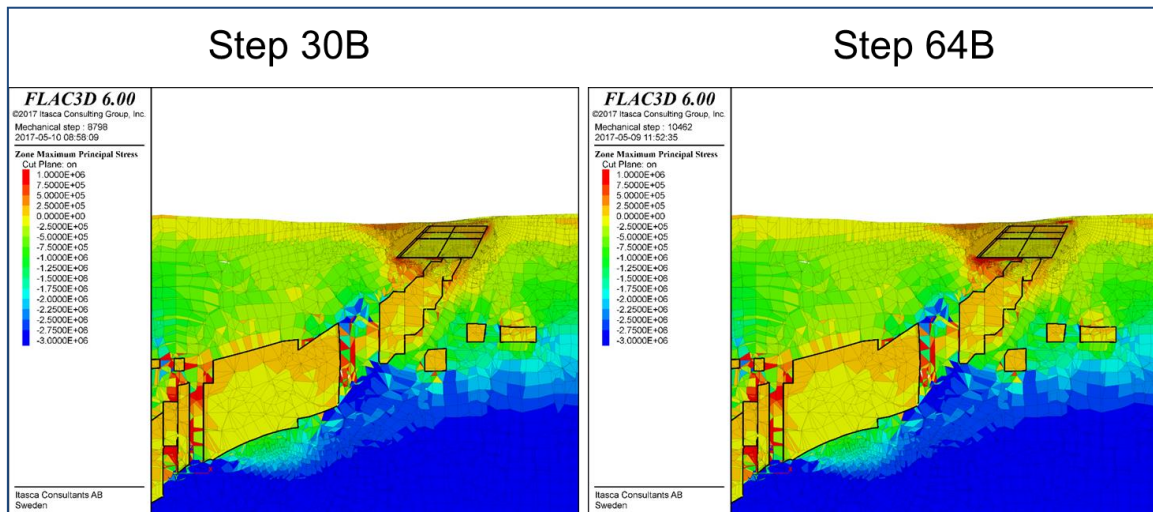


FIGURE 13.31 MINIMUM PRINCIPLE STRESS (σ_3) IN SECTION S7 FOR MINING STEP 30 AND 64. POSITIVE VALUES MEANS TENSILE STRESSES.

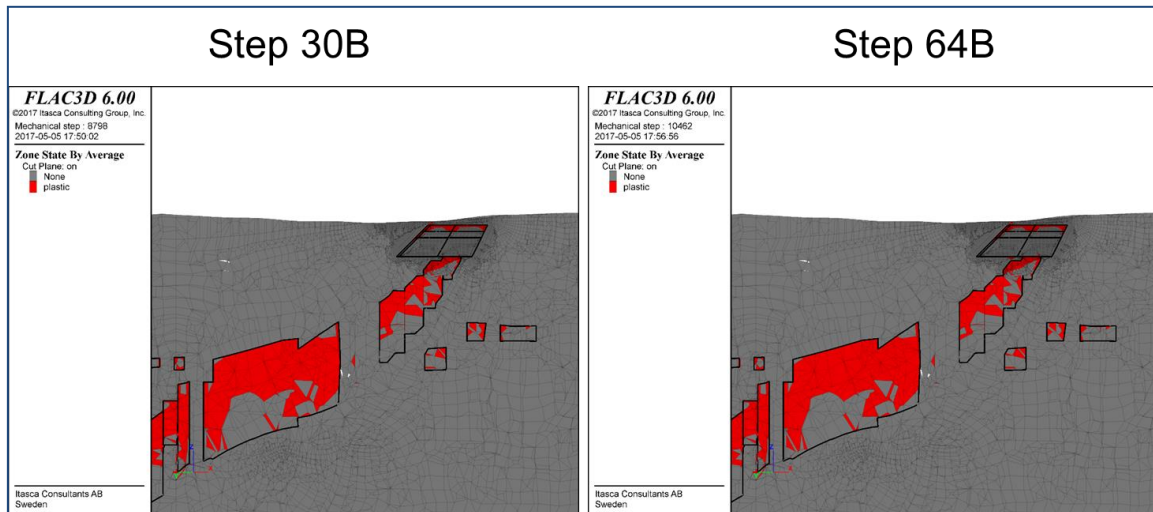


FIGURE 13.32 YIELDING IN SECTION S7 FOR MINING STEP 30 AND 64 SHOWN AS RED.

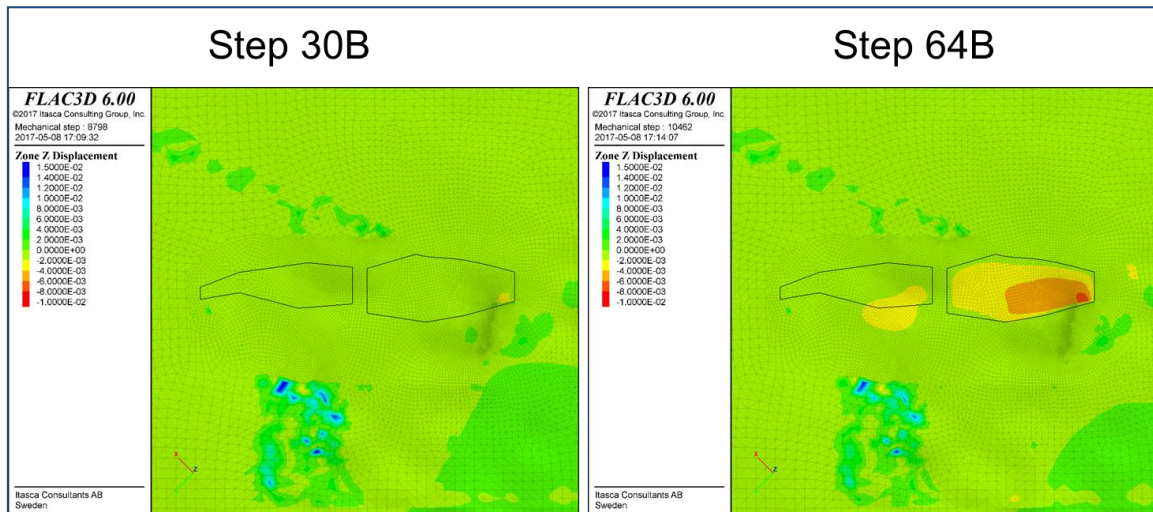


FIGURE 13.33 DISPLACEMENT AT SURFACE IN SECTION S7 FOR MINING STEP 30 AND 64.

13.6.4 RESULTS

The results can be summarized as follows:

- Low stresses (in σ_1) above the crown pillar stopes.
- Tensile stress (in σ_3) above the crown pillar stopes, footwall and hangingwall.
- Yielding in the upper part of the fill, in the Pyrite layer.
- Yielding increases with stope width and height (cross section S21).
- Deformations on the ground surface are less than 1 cm.
- Mining of several stopes at the same time will lead to larger deformations which is shown when mining the whole orebody at the same time where the displacements exceeds 10 cm.

13.6.5 CONCLUSIONS

From the modelling following can be concluded:

- No stability problems in the stopes.
- Stope widths have small impact on stresses and stability.
- Small displacements on surface.
- To limit ground surface deformations, a cautious mining sequence, with few stopes excavated at the same time, is recommended.

13.7 MINING METHOD AND DESIGN

Longhole stope mining will be used for mining of the crown pillar. Access drifts in the centre of the ore (2-4 lens) will be developed and then footwall and hangingwall development drifts for each stope.

This will leave a thin pillar in the 2-4 lens along the access drift that can then be mined. The hangingwall development drifts will be driven at a low angle from horizontal to create a high point in the back of the stopes to ensure tightfilling of the stopes.

The stopes will be mined from south to north (e.g. from river side to north) starting no closer than 30 m from the river Blackwater flood plain and be backfilled as soon as mucking of the ore is complete. Stopes can be blasted when backfill has achieved specified strength for adjacent stopes.

Longhole stoping at the far north of the crown pillar (1-5 lens) can but does not have to be done along strike ("longitudinal"). A flat dipping ore lens, good hanging wall rock quality, Pale Beds, and low grade are considerations that will have to be taken into account for the choice of mining direction of these stopes.

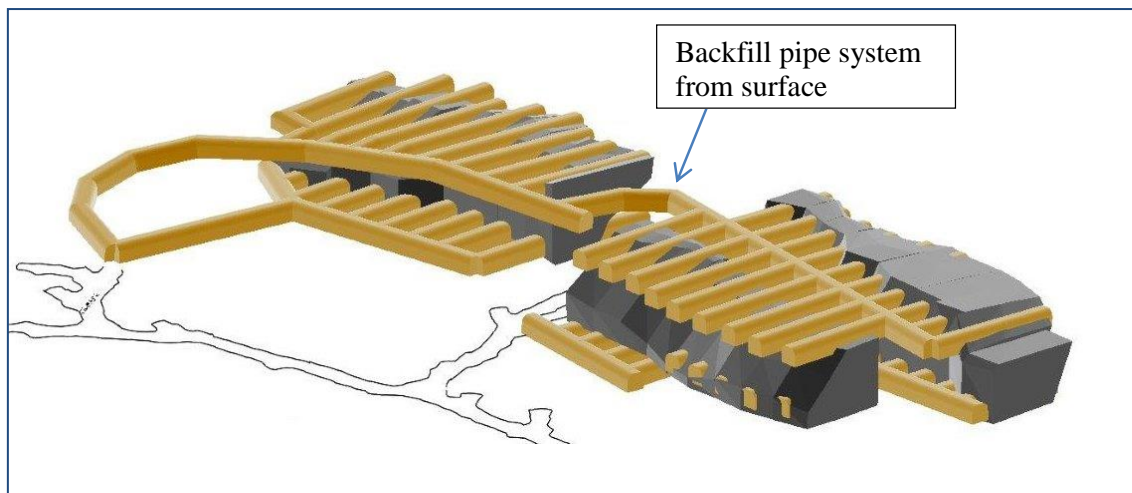


FIGURE 13.34 DEVELOPMENT OF FOOTWALL AND HANGINGWALL DRIFTS IN THE CROWN PILLAR. DRIFT SHOWN AS THIN BLACK LINES IS ALREADY DEVELOPED.

The design of the longhole stopes depends on the width of the stopes and is shown in FIGURE 13.35 and FIGURE 13.3.

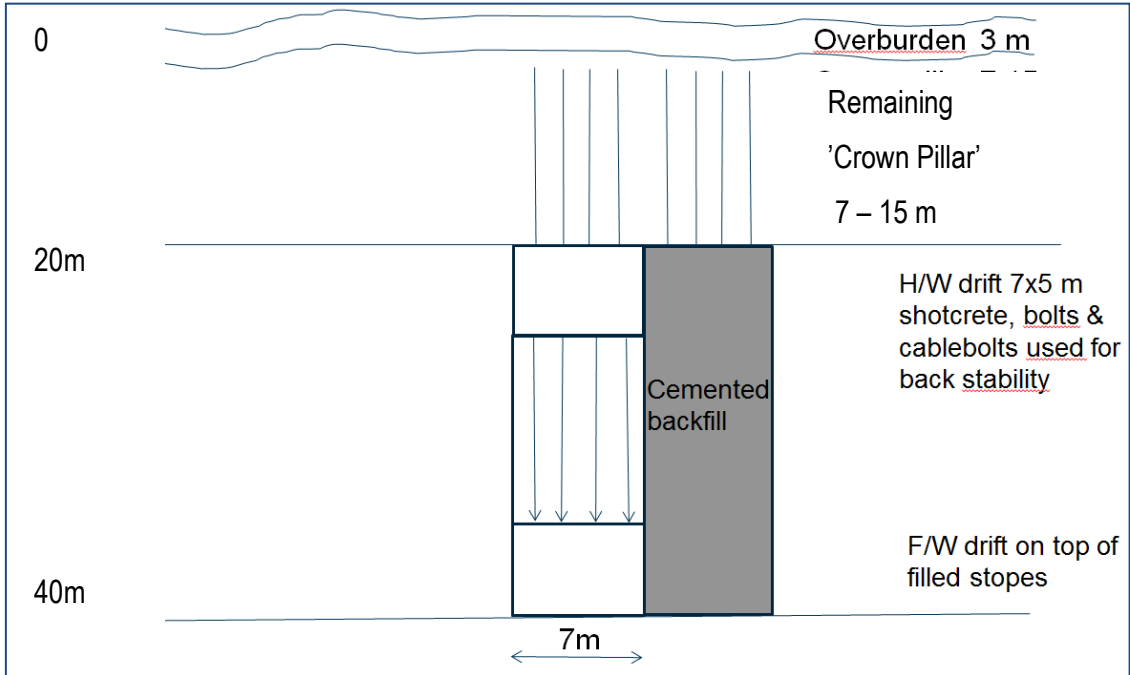


FIGURE 13.35 PRINCIPLE OF STOPE DESIGN FOR UP TO 8 M WIDE STOPES.

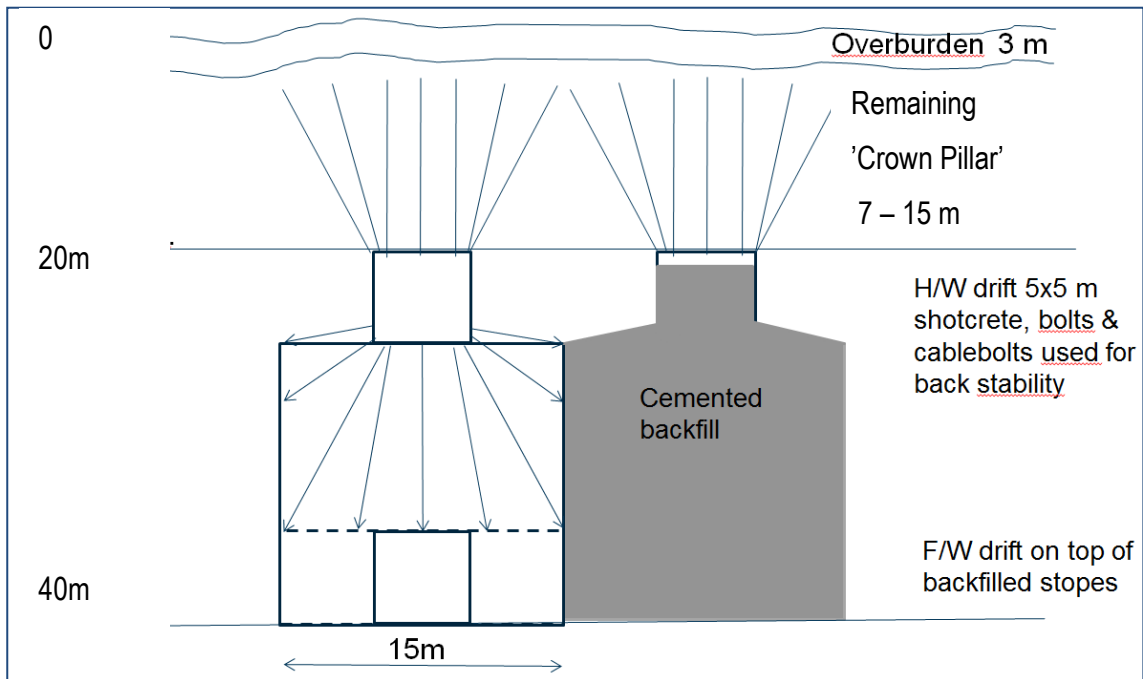


FIGURE 13.36 PRINCIPLE OF STOPE DESIGN FOR >8 M WIDE STOPES.

13.8 ROCK SUPPORT

Amount of rock support for the drifts and stopes can be assessed by empirical methods as shown in Table 13.15 and the Q-system rock support chart shown in Figure 13.3.

TABLE 13.15 SUMMARY OF EMPIRICAL METHODS FOR ROCK BOLT LENGTH ASSESSMENT FOR DIFFERENT STOPE SPANS.

Method	Maximum drift/stope width for the bolt length		
	2,3 m	2,7 m	3,1 m
$L=(0,25-0,33)*W$, (Bergbultning, Bjurström)	7-10 m	8-11 m	9-12 m
$L=0,33*D$, (INCO)	7 m	8 m	9 m
Q-system, ESR=1.6	8 m	13 m	17 m
Q-system, ESR=3	15 m	24 m	30 m
$L=0,4*W+0,45$, RMR 40-60, "fair"	5 m	6 m	7 m
$L=0,3*W+0,30$, RMR 60-80, "good"	7 m	8 m	9 m

L = bolt length, W = width of stope, D = Diameter of span circle, ESR = Equivalent span ratio (1.6 for permanent infrastructure and 3 for temporary mine opening).

The Q-system rock support chart suggests that for temporary mine openings (ESR=3-5) and Q-values from core logging up to 10 m wide stopes can be supported by a layer of 5 cm of fibreshotcrete and 1.8 m systematic bolting pattern with 2.4 m long rock bolts.

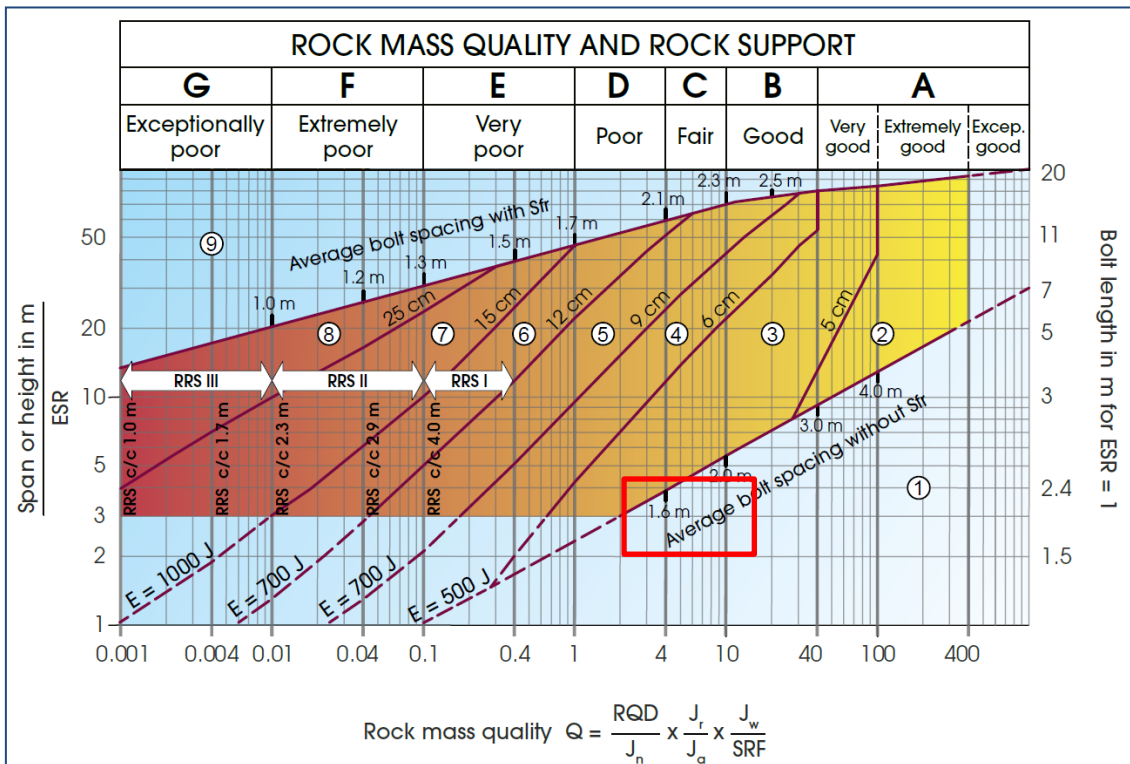


FIGURE 13.37 Q-SYSTEM ROCK SUPPORT CHART (BARTON, 2015). RED RECTANGLE SHOWS SUGGESTED ROCK SUPPORT FOR UP TO 10 M WIDE OPENINGS IN THE CROWN PILLAR.

To increase the stability of the crown pillar cable bolts will be installed in the back of the stopes. Cable length should reach up to 2-3 m below the rock surface and be designed for weight of rock and overburden above the stopes.

13.9 BACKFILLING

Tightfilling of the stopes is essential for successful mining. This can be achieved by hangingwall drifts in the stopes driven at a low angle from horizontal to create a high point in the back of the stopes.

Transportation of the backfill from the backfill facility located in the concentrator plant will be through the existing underground pipe system. The backfill will then flow through a cased drill hole from surface down to the access drift in the 2-4 lens and then through local pipes into the different stopes.

To minimize span each stope after blasting and mucking will have to be backfilled. The strength of the backfill should be in the order of 1 MPa.

13.10 GROUND MOVEMENT MONITORING

For monitoring of ground movement extensometers from surface through the crown pillar will be installed before mining. The extensometers will be connected to an on-line network for continuous logging to be able to give momentarily readings if necessary.

13.11 POTENTIAL IMPACTS

13.11.1 SURFACE SETTLEMENT

surface settlement has been monitored since mining commenced in the 1970s, with an array of ≈ 270 surface precise leveling stations over the mine area. To date mining operations have resulted to date in a maximum of only 70mm of surface settlement, centered over the main mining area. This is in part testament to the competence of the rocks overlying the ore, but also reflects the contribution made by long-term rock pillars, and the appropriateness of the longhole-stopping-with-backfill mining method.

Surface settlement is controlled principally by two measures;

- (i) the leaving of permanent (yielding) pillars in strategic locations, which provide direct support to the hangingwall (roof) rockmass, and
- (ii) the use of backfill in each mined stope, the backfill being placed as tight as possible against the stope roof.

Settlement potential above future Nevinstown mining will be minimised through the use of permanent yield pillars, and tight backfilling.

The key to managing surface settlement is to minimise the potential for any differential displacement to occur. This is generally only possible where major structures are present. The analysis suggests that major faults such as the A-Fault will only have a very minor effect on settlement, and that these structures will be stable close to surface. This must be confirmed with detailed monitoring of fault behaviour during implementation. In the area of interest, only the A-Fault extends up through the UDL rocks. A basalt dyke extends to surface to the east of the A-Fault, but is not likely to have a significant influence on settlement behaviour. Consequently, it is the behaviour of the A-Fault which has been the focus of attention regarding surface settlement in the Study.

The only surface infrastructure at Nevinstown that may be affected by surface settlement is the uninhabited Nevinstown House, owned by Tara Mines, in the centre of the mining area. The extent of the effect depends largely upon whether any small differential settlement occurs.

In the longer term, surface settlement will continue to occur for a period after mine closure, although at a gradually reducing rate. This is due to the mine backfill gradually providing increased resistance to continued hangingwall relaxation, until a state of equilibrium is reached. The return of groundwater levels to their pre-mining state will also provide further resistance to continued settlement. The period over which this may occur is very difficult to estimate, but it may last for 2-3 years, though at a progressively reducing settlement rate.

13.11.2 UNDERGROUND MINE STABILITY

Stability of the underground workings is governed by the stability of the stopes. Mine development (tunnels) is small compared to the scale of the mining activity, and though the stability of each opening is crucial from an operations standpoint, development stability does not impact on the large scale stability with which the Study is concerned.

Additional conservatism is warranted when mining close to surface, and beneath the river.

Key factors in achieving stable stoping, and this applies especially to the surface crown pillar area, are as follows:

- The longhole stoping process is sequential, ie. each stope is mined and filled before mining of the immediately adjacent stope commences.
- Each individual stope is uniquely designed for stability. This is the current practice at Tara Mine. In general, the need for additional rockmass reinforcement is determined on a case-by-case basis, but for those stopes close to surface (stope backs above $\approx 1500\text{mRL}$) AMC recommends the hangingwall is routinely strengthened with cement grouted cablebolts¹¹, as an additional precautionary measure.
- As noted above, Tara Mines have reduced stope dimensions close to surface, from 20m wide to 15m wide. The stope length varies according to ore geometry, but it is the

¹¹ Cablebolts are commonly used in the mining industry. They typically comprise 7-strand steel cable tendons, each with a peak load-bearing capacity of 25 tonnes. One or two cables can be installed in a single borehole, using cement grout.

minimum stope dimension that has the greatest impact on stope stability. AMC has confirmed the chosen stope dimensions are appropriate.

- Backfill is placed as tight as possible into each stope after mining. Cemented backfill is recommended for all stopes close to surface. Near-total tight-filling of each stope is achieved by 'shaping' of the stopes to promote tight backfilling, and further 'top-up' filling which follows the initial placement. This is possible from the hangingwall development access available. Also, any minor separation of the backfill from the hangingwall that occurs in primary stopes is further tight-filled during the filling of secondary stopes.

13.12 MITIGATION MEASURES

The proposed mining methods and mine design provide the main mitigation against geotechnical impacts at surface. In addition, a Management Plan is recommended for implementing.

The Plan would comprise a Monitoring Programme, and an Implementation Plan. A robust monitoring programme is central to implementation. It is through monitoring that the Study findings are confirmed, and in particular the results of monitoring provide the basis for reviewing and adjusting designs according to *actual* rather than predicted rockmass and hydrological responses.

The project Implementation Plan encompasses a series of recommended responses to any conditions that don't correspond to predictions. The plan comprises a series of recommended technical responses to conditions arising, such as specific investigations of stope behaviour, determining the causes of elevated stresses in pillars, investigations into higher than expected groundwater inflows to the mine, etc

13.13 GEOTECHNICAL RISK ASSESSMENT

TABLE 13.16 is used for geotechnical risk assessment of mining the crown pillar. The risk assessment shows potential risk areas and necessary actions to be taken to minimize production disturbances. The actions include span, mining sequence, rock support, backfilling, blasting practices and distance from the river Blackwater.

Caused by	Probability ²⁾ for					Hazard	Mitigation
	Falling rock ¹⁾	Waste or fill dilution ¹⁾	Ore loss ¹⁾	Minor production disturbance ¹⁾	Major production disturbance ¹⁾		
Geology and rock conditions (= rock + stress)	3	2	1	2	1	Structurally fall-outs from backs or walls (especially at faults, basalt dikes and TBU.	Geometries based on rock conditions, rock support (Shotcrete); Skin pillars
Varying ore geometry	1	1	3	1	1	Ore losses at the toe of the pillar	None required
Planned layout (length, width, height and angles of backs, walls and pillars)	2	2	2	2	1	Fall-outs from backs ore loss due to pillar thickness	Geometries based on rock conditions, rock support
Surrounding mining or openings	1	2	2	2	1-2	Stress in secondary/retreat stopes	Controlled mining sequence and backfill control
Water, pressure or flow	1	1	1	1	2	Water inflow from the Blackwater through mining induced cracks	Careful blasting, keep distance from river (30m) and/or CAF closest to the river
Fill	1	2	1	1	1	Fill from adjacent stopes flowing or falling into the stope.	Cemented backfill, skin pillars
total assessment	2	2	2	1-2	1-2		

TABLE 13.16 GEOTECHNICAL RISK ASSESSMENT.

1) Falling rock = rock , block or concrete falling without control. Waste rock/fill inclusion = more than expected for the mining method. Ore loss = not planned . Minor production disturbance = disturbances in the mining cycle, disturbance time ≤ 1 week. Major production disturbance = no production, disturbance time > 1 week.

2) Assessment of probability: 1 = small, 2 = medium, 3 = high, - = Not applicable. The assessment is based on current mining plans and conditions for each stope, and current standards and practices for the chosen mining method.

Comment: Generally geometries and the presence of large structures are seen as the major risk factor, the risk increases with increased extraction ratio. The risks are manageable through adaption of the plans to the mining conditions in each ore body.

13.14 RECOMMENDATIONS

Based on the empirical and numerical studies on stable stope dimensions and effective use of available ore resources an 8 m thick crown pillar will be left above the stopes. Proposed stope dimensions are 10 m wide, up to 30 m long and approx. 22 m high stopes (FIGURE 13.3).

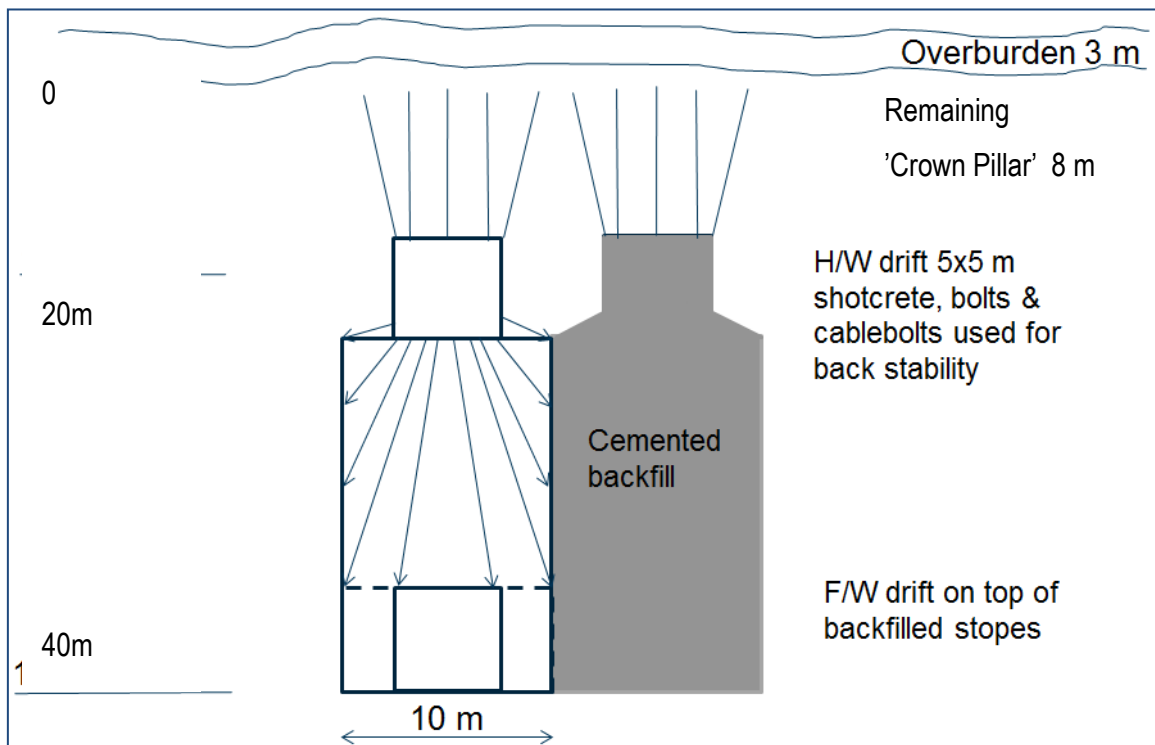


FIGURE 13.38 STOPE DIMENSIONS PROPOSED FOR AN 8 METER THICK CROWN PILLAR.

Other recommendations are given below:

- From start of mining only single stopes should be mined and backfilled in a “side by side” pattern, i.e. when a stope is backfilled adjacent stope will be mined. When more experience of mining the crown pillar is gained the mining sequence may be changed.
- The outcome of mining the stopes will be important as input for risk assessments and possible change of mining strategy. Therefore, stope reconciliation should be done for every stope by geologists, mine planning and geotechnical group.
- Mining of the stopes should start from south to north (e.g. from river to north) and stopes be mined no less than 30 m from the river.

-
- Backfilling should commence immediately after a stope has been mucked out.
 - It is essential that stopes are tightfilled (>90% of the back will be in contact with the backfill). If it is questionable if tightfilling is achieved this must be verified and more backfill poured into the stope if necessary.
 - The mining area at the surface should be fenced off and only be accessible by authorized people.
 - Remotely operated deformation monitoring of the crown pillar should be installed before mining commences. Already installed levelling monitoring stations above the crown pillar will give data of surface settlement through an on-line network.

13.15 CONCLUSIONS

The Geotechnical Study has confirmed that the mining proposals for the proposed mining in Nevinstown are sound, and subject to the establishment of a routine monitoring strategy, and certain recommendations can be implemented without noticeable impact on the surface environment.

The independent review found that regardless of stopes dimensions, surface deformations induced by mining the crown pillar are negligibly small, in the order of millimeters, when stopes are mined one at the time, with subsequent back-filling.

The overall, global, stability of the crown pillar after simulated extraction is satisfactory. Even the largest stope height of 25 m, stability conditions are good and ground surface deformations are insignificant (order of millimeters). A decrease in stope height results in less yielding and smaller deformations, and thus an increased margin of safety.

— Ground support with bolts, shotcrete, and cables, are required to support the low-stress/tensile areas around the crown pillar stopes.

— Further modelling with faults included is recommended to assess their possible influence on the crown pillar stability and ground surface deformations.

— Mining of the stopes within the Z1NEVN area is not judged to cause any significant effects on surrounding areas and the ground surface, given the relatively large distance to the ground surface. This is under the assumption that mining is conducted using normal stope procedures and with cemented backfill. Additional core drilling and geomechanical core logging should, however, be conducted to verify rock conditions before mining starts.

The geotechnical monitoring programmes will be an integral component of the mining activity. The monitoring will confirm the conclusions reached in the Study, and provide valuable on-going information for use by Tara Mines in detailed design and operations.

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