Boliden Tara Mines Limited

Planning Submission to
Meath County Council

Extension of Mining Operations into new areas in Liscartan and Rathaldron

ENVIRONMENTAL IMPACT STATEMENT

NON-TECHNICAL SUMMARY

&

NATURA IMPACT ASSESSMENT

Submitted by:
Boliden Tara Mines Limited
Environmental Department
Knockumber
Navan
Co. Meath

Submitted to:
Meath County Council
Abbey Mall
Abbey Road
Navan
Co. Meath

July 2010

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Introduction

Boliden Tara Mines Limited, the largest operating lead-zinc mine in Europe, is located at Knockumber, 2 km west of Navan in County Meath. It is the most productive zinc mine in Europe and the fifth most productive in the world.

The mine exploits the Navan Zn-Pb deposit, which was discovered in 1970 by the Tara Exploration & Development Company Ltd. Development of the orebody began in 1973 and production of concentrate started in June 1977. On 1st January 2004, the ownership of Tara passed to Boliden. The currently projected mine life extends past 2018.

The mine is currently divided into the following sub-areas for management and planning:

- The Central Area, also known as the Main Mine or Knockumber Mine. This was the first area to be mined. It has largely been mined out.
- South West Extension (SWEX), to the southwest of the Main Mine.
- Nevinstown, to the north of the Main Mine.

SWEX and Nevinstown are currently being developed and mined by trackless underground methods, principally long hole open stoping with backfill. Room and pillar methods are applied where the ore is thinner. Access to the SWEX and Nevinstown is from a portal at the Main Mine site.

An expansion of the mine workings is currently being planned into the Liscartan and Rathaldron application areas, located to the northwest of the Main Mine area. The expansion of the mine workings into the Liscartan & Rathaldron application areas would be accessed from the existing underground workings and would use similar mining methods to those currently being employed.

The current estimated ore reserves are 17.0 million tonnes at 7.2% Zn and 1.8% Pb. However the total reserves and resources in Liscartan and Rathaldron are comparatively modest and amount to 1.1 million made up of 0.9 million tonnes of inferred resources grading 7.71% Zn, 1.53% Pb and 0.2 million tonnes of indicated ore reserves grading 6.81% Zn, 1.48% Pb.

Proposed Development

This proposal involves mining in the townlands of Liscartan and Rathaldron, Navan, Co. Meath. The Liscartan/Rathaldron orebody is a small uninterrupted part of the 'Navan orebody' currently being mined.

Mining will exclusively be by underground means, extending the existing mine workings into the adjacent Liscartan/Rathaldron orebody. The surface characteristics and features of the 'mining area' will not be altered by mining activity and there will be no surface development associated with this proposal. The necessary infrastructure 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 Liscartan/Rathaldron section of the orebody dips to the southwest and strikes to the northwest in common with the general characteristics of the main orebody, giving a depth below surface ranging from 150m to 575m, with ore thickness ranging from 4m to 12m.

Appropriate Assessment

An appropriate assessment or 'Natura Impact Statement' has been undertaken in accordance with the European Commission Methodological Guidance on the provision of Article 6(3) and 6(4) of the 'Habitats' Directive 92/43/EEC (EC 2001) and the European Commission Guidance 'Managing Natura 2000 Sites'.

The purpose of this assessment was to determine, the appropriateness or otherwise, of the proposed project in the context of the conservation status of such sites. The report is supported by full technical details contained in the EIS and forms an appendix to the main text of the Environmental Impact Statement (See appendix 1).

It was concluded through the screening process that the proposed project will have no direct or indirect impacts on the overlying River Blackwater and therefore no significant impacts on the qualifying interests of the cSAC are likely. Accordingly, progression to Stage 2 of the Natura Impact Statement process is not considered necessary.

Project Description

Access to the proposed orebody will be via the existing portal access (underground road from surface) on the Knockumber Mine site. This will provide a vehicle route via the existing mine into the new areas of the orebody. Underground drifts from existing mine workings at varying locations and depths will provide access for mining purposes. There will be no additional access to the proposed orebody.

Mine services such as compressed air, water, fuel and communications cables will be carried through the existing mine into Liscartan/Rathaldron. There will be no services into the mine from outside the existing Knockumber mine site.

Mine development is planned to access 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 existing mine crusher and conveyor system.

The selected mining method will generally be longhole open stoping where ore thickness proves to be sufficiently high (up to 12m), together with variations on room and pillar mining in areas of thinner ore (down to 4m). Cemented backfill will be used for initial primary stoping and a mixture of cemented and un-cemented backfill for later (secondary) stoping. This is the current practice in the existing mine. Longhole open stoping is sequential, that is, stopes are mined in sequence and each stope is filled before mining of adjacent stopes can commence. In room and pillar mining the roof stability is achieved through the design of stable rock pillars, provision of roof support where necessary and the use of regional (larger) pillars where the mining spans are large.

Mine production is the generation of large tonnages of ore from stopes and pillars. All ore produced will be transported underground by trucks to the existing mine crushing conveyor system from where it will be hoisted to surface. In a typical year, up to 170,000 tonnes of production ore and 40,000 tonnes of development ore will be scheduled from this area. Waste rock generated from continuing development will be handled as described above. Mining equipment to load and haul both ore and waste is part of the existing fleet. No additional mobile equipment will be necessary to handle ore and waste from the proposed development.

All ventilation requirements will be met by the existing mine ventilation system. Fresh air will enter the mine through existing fresh air routes, including portal entrances and ventilation raises. The air will flow along the main working levels of the mine before rising to upper dedicated (hanging wall) drifts which will return air to existing underground and surface fan stations. Existing fan stations will remain unaltered in terms of their airflow volumes and overall performance so total emissions will continue at current levels. There will be no ventilation-related connections to surface in the Liscartan/Rathaldron area.

Mined-out areas will be backfilled with sand-fraction mill tailings mixed with cement. Backfill will flow through new underground pipelines that will be connected to the existing mine backfilling facilities. Stopes and pillars will be backfilled through holes drilled down into the roof of the excavation and backfill poured down into the void over an extended period until the stope is filled. There will be no backfilling-related connections to surface in the Liscartan/Rathaldron or adjacent areas. In addition, and whenever feasible, waste rock from development will be placed in stopes, prior to backfilling

Processing tailings are pumped to the Randalstown Tailings Storage Facility (TSF) where aeration is provided and suspended solids are allowed to settle out to leave clear water for recirculation and reuse. Planning Permission for an extension of the TSF (Stage 5) has been granted (Ref: NA901452 Meath County Council, June 16th 2010). The 1.1 million tonnes of ore to be mined from the Liscartan/Rathaldron application area will require the deposition in the TSF of about 0.5 million tonnes of tailings for which there is adequate capacity. The orebody section under application is a continuation to the northwest of the same geological structures currently being mined at Knockumber and Nevinstown therefore the characteristics of the tailings will not change.

Groundwater inflowing to the mine workings will be collected at a central underground pumping station. All dewatering flows will pass through a large settling sump at this pumping station, where suspended solids settle out, prior to being pumped via the production shaft to the second stage of settlement/clarification in the Mine/Reclaim Water Ponds. There are no plans for additional water management facilities on surface.

The total pumping capacity of the mine is 21,600 m^3/d while the current total inflow to the mine is 11,979 m^3 / day.

It is anticipated that the proposed development could lead to an increase of between 15-30% of the current inflow to the entire mine. There is sufficient flexibility and storage in the current water management system to accommodate all anticipated additional water collected and pumped from underground.

SCOPING AND CONSULTATION

The scoping process for the proposed mine extension was entered into in the early stages of the EIA. The scope of work emerged both formally and informally from discourse between Tara Mines' staff, the Competent Authority (Meath County Council), Specialist Agencies / Consultants and the Public. All of these sources provided invaluable information while identifying and clarifying the nature and detail of key issues to be contained in this EIS.

HUMAN BEINGS

A desk study was carried out in order to examine all relevant information pertaining to planning and socio economic activity in the study area. The relevant national, regional and local planning guidelines were examined along with the Meath County Development Plan 2007-2013.

Economic Issues under Consideration

The principal economic consequence of the proposed development will result from its effect on the future life of the mine. These consequences are estimated in terms of employment and income to the local region and the country including:

Direct effects, such as the employment and capital investment in the mine over its expected lifetime.

Indirect effects, such as employment and income effects in enterprises supplying goods and services to the mine.

Induced (knock-on) effects, which are additional to the indirect effects since they arise from the establishment of new enterprises or from increased levels of economic activity supported by the mine.

Employment is an important indicator of the economic standing of an area. Unemployment levels, employment status and industrial groups within the Navan area were studied. Quarterly National Household Survey (QNHS) provides details of unemployment on a regional level. Navan is located in the Mid East Region therefore this Region will be used to illustrate unemployment in the area. The Mid East Region consists of counties Kildare, Meath and Wicklow. The unemployment rate is the number of unemployed persons expressed as a percentage of the total labour force. The unemployment rate for the State was 12.4% while the unemployment rate for the Mid East Region, which contains the study area, was 11.4%.

Government published statistics clearly indicated a sharp rise in the rate of unemployment in the Navan region.

Boliden Tara Mines Limited is Europe's largest zinc and lead mine and currently produces between 2.6 and 2.7 million tonnes of ore per annum and 0.4 Mt of zinc and lead concentrate. The Company currently employs a total of 680 employees and it is estimated that there are 3 additional jobs indirectly supporting each Tara job.

The townlands of Liscartan and Rathaldron although situated on the periphery of Navan town are sparsely populated. Land in Liscartan and Rathaldron is zoned as Agricultural and any future mining in this area will not affect farming productivity or practices.

There will be no loss of rights of way of existing amenities, conflicts or other changes likely to alter the character and use of the surroundings and the traditional right of anglers to pass along the river bank will not be restricted.
The Meath County Development Plan 2007-2013 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 development plan also provides policies in relation to extractive industries which include.

Boliden Tara Mines Limited currently employs a total of 680 employees and it is estimated that there are 3 additional jobs indirectly supporting each job. The proposed development will underpin the future operation of Tara Mines. The current Life of Mine Plan extends to 2018. The effect of wages and salaries generated by Tara being spent in the local and greater Navan areas are considerable. Currently, the annual wage bill is €58 million, of which approximately €50 million is the gross payroll cost, and €8 million is the employer costs. In addition an average of €1.6 million is paid, annually, to the local authority in rates, water rates and planning charges.

The proposed mine extension is an essential component of the mine plan and therefore to the sustainability of the mine. The continued operation of the Company will be of major economic importance at local and national level.

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 net positive contribution to the Balance of Payments is in the region of €140 million.

GEOTECHNICAL

The geology of the Navan region and Tara Mines orebody is described in detail in Ashton et al (2003), and numerous other prior references. The main feature of the geology in the area is the Castle-Liscartan Fault Zone or complex, the eastern edge of which represents the western boundary of the current Tara Mines operations. As a consequence of normal displacement on this fault zone some rock units stratigraphically above the Navan Group beds are now present, but they occur a significant distance above the 1-5 Lens. Given these units are far above the orebody.

The total reserves and resources in Liscartan and Rathaldron amount to 1.1 million made up of 0.9 million tonnes of inferred resources grading 7.71% Zn, 1.53% Pb and 0.2 million tonnes of indicated ore reserves grading 6.81% Zn, 1.48% Pb.

Tara Mines anticipate that surface and underground diamond drilling will upgrade the Inferred Resources to Indicated status and may allow better discrimination of low / high ore grades and thereby allow slightly more tonnage to be scheduled. It is considered unlikely, given the geology of the area, that there will be any significant increase in the scheduled tonnages (J Ashton pers.comm.). All resources at Rathaldron are currently inferred, but this may be modified or upgraded with further drilling and evaluation.

The geological and geotechnical conditions in both Liscartan and Rathaldron are very similar to those in the main areas of the existing mine, including the Nevinstown area (which lies immediately adjacent and to the east of Rathaldron). The only significant differences are associated with the Liscartan – Castle Fault Complex which passes through the centre of Liscartan. The characteristics of this fault complex have been discussed above.

Potential Surface Impacts

The land overlying the Liscartan area is mostly farm land, but with a public road and overhead power line passing over the eastern portion. The land overlying the Rathaldron area is farm land, also with an overhead power line passing through the centre of the area.

As noted above, a number of factors combine to make it very unlikely that underground mining would result in any discernable surface subsidence impact in the Liscartan and Rathaldron areas. These include:

- The proposed depth of mining
- The limited ore thicknesses.
- The limited areal extent of individual stopes.
- The use of tight backfilling and a primary / secondary sequence in open stoping extraction.
- The limited stoping spans and use of sequential backfilling in thin ores where "drift and slash" methods will be used.
- The use of cable bolt support in areas of poorer stope roof conditions.

HYDROLOGY

The area around the Tara Mine comprises flat to gently undulating farmland, with some relatively recent residential development. Ground surface elevation along the River Blackwater is around 62 metres above Ordnance Survey Datum (maOD) as it flows through the area of the Liscartan/Rathaldron application area. The elevation of the land surface rises away from the River Blackwater, attaining around 75 maOD in the centre of Rathaldron, and around 93 maOD in the southwest of Liscartan.

The River Blackwater defines the boundary between the Liscartan and Rathaldron land holdings, and also separates Nevinstown from the Main Mine area. The River Blackwater is a major tributary of the River Boyne. The source of the Blackwater is Lough Ramor, County Cavan, from where the Blackwater flows about 30 km SE to join the Boyne at Navan

The Navan orebody extends to within a few metres of ground surface in the Nevinstown area and to 150 metres of ground surface in the Liscartan and Rathaldron area, where it is covered by variable glacial drift. The orebody dips to the southwest. In the extreme southwest of the SWEX area, known as SWEX B, it is around 900 m below ground level. The mineable ore thickness ranges from 4 m, the height of a drift, to 80 m. The thicker ore is generally found in the east of the deposit. The plan view dimensions of the orebody as currently defined are 5.7 km (NE-SW) by 1.9 km (NW-SE).

The deposit is hosted in limestones and dolomites of Lower Carboniferous age. The Pale Beds are often permeable and cavities are present in certain areas. Drill holes may lose water to fractures when penetrating the Pale Beds due to the presence of a vadose zone within the Pale Beds resulting from dewatering of the mine workings. The principal unit overlying the Pale Beds is the Upper Dark Limestones (UDL), which tend to be strongly bedded and contain abundant shaley horizons. In general, the UDL is considered to form a low permeability "roof" to the Pale Beds.

Most of the economic mineralisation occurs within the Pale Beds as complex, strata bound tabular lenses. The lenses strike between NE and ENE, roughly parallel to the major faults. The lenses are frequently dislocated by faulting. The ore occurs within the lenses as high grade massive sulphides or lower grade disseminated sulphides. The degree of mineralisation is generally greatest close to the base of the Pale Beds, within a basal micrite and associated dolomites.

A reference to groundwater levels, and references to other data which have an elevation associated with them, are reported in both metres above or below Ordnance Datum (mAOD/mBOD) and metres above Mine Datum (mAMD).

Sources of groundwater inflow to the mine

Groundwater inflows to the Tara workings are derived from the following sources:

- District-scale lateral groundwater flow in the Pale Beds.
- Downward leakage of groundwater from the UDL.
- Recharge derived from precipitation
- Leakage from the River Blackwater.

Most of the inflow to the workings occurs via discrete, fracture-controlled inflow zones. Their location is determined by a combination of structure, local jointing and lithology contrasts. The highest groundwater inflow rates occur from the Pale Beds in Nevinstown and the Main Mine. The UDL sequence tends to inhibit the downward movement of groundwater into the Pale Beds over these areas.

Groundwater conditions in the SWEX area are somewhat different to those in the Main Mine and Nevinstown areas. Significant rates of inflow have occurred via old "Navi" drill holes extending into SWEX from the surface. Deeper zones of weathering are present within the upper part of the UDL above SWEX, and it is considered that most of the SWEX inflows are derived from groundwater in the upper weathered UDL flowing downwards through old drill holes. A grouting programme was initiated in late 2005 to plug the old drill holes from ground surface and to pressure-grout fracture systems from the SWEX workings. This programme has resulted in a significant reduction in the rate of inflow to SWEX.

The solid geology at Liscartan/Rathaldron comprises Lower Carboniferous rocks, cut by NE to ENE trending faults and fault zones. Variable thicknesses of glacial till and alluvial deposits blanket the area. The superficial deposits attain thicknesses in excess of 30 m in the buried Whistlemount Channel to the south of Rathaldron. Recent alluvium occurs along the course of the River Blackwater.

A variable thickness of overburden covers the Liscartan and Rathaldron areas:

- The thickness of the overburden varies from 5 to 15 m over Liscartan, with most areas covered with 7 to 10 m of overburden
- The thickness of the overburden generally varies from 10 to 30 m over Rathaldron
- The Whistlemount Channel, a buried channel, can be distinguished to the south of the Liscartan/Rathaldron area as linear region where the thickness of overburden is generally in excess of 20 m and may approach 35 m.

Sources of water flowing to the mine

Extensive monitoring of the Nevinstown and Main Mine inflows and water chemistry over the past 3-4 years has confirmed that most of the water entering the Main Mine and Nevinstown workings is the result of district-scale groundwater flow within the

Pale Beds. As inflows have been encountered due to opening up of the Nevinstown workings so there has been a general decrease in the magnitude of inflows down-dip in the Main Mine. Current inflows are virtually all derived from district-scale flow rather than from storage removal.

Available monitoring data indicate that the Pale Beds is the main groundwater bearing unit in the Main Mine, Nevinstown, and the Liscartan and Rathaldron application areas. The overlying UDL contributes a minor amount of water, but mostly as a result of vertical downward leakage as the underlying Pale Beds become dewatered.

Dewatering of the Liscartan/Rathaldron application area will be carried out in a similar manner to the current dewatering system. It is expected that all new inflows will be collected and managed in development and haulage headings, similar to present operations. Given the current dataset, there is no benefit in trying to carry out any dewatering using surface wells. It can be estimated that about 2-3 million m^3 of groundwater may need to be removed to allow mining of the planned extension. If this water were to be removed over a period of 3-4 years, the incremental flow rate to the mine would be within the range 15-30 l/second, which represents about a 15-30% increase on the current inflow rate to the entire mine. There is sufficient flexibility and storage in the current water management system to accommodate all anticipated additional water collected and pumped from underground.

Groundwater levels in available surface holes will be monitored throughout mining. Predicted groundwater inflow chemistry for the Liscartan/Rathaldron application area is similar to the current Main Mine and Nevinstown inflow chemistry. In the Main Mine and Nevinstown, virtually all of the underground water makes are representative of very young calcium-bicarbonate type water flowing within the Pale Beds. There is virtually no chemical signature of river water in the underground water makes.

Under the current water management system, water from underground is pumped to the tailings management facility where it is reclaimed for use in the mine and mill. Surplus water is discharged to the River Boyne through a storage pond under the Tara IPPC (Integrated Pollution Prevention and Control) licence. The quality of the water is monitored to ensure IPPC compliance. No significant changes to water quality are anticipated following expansion of the workings into the Rathaldron/Liscartan application area.

Assessment of potential impacts

Based on the currently available dataset, the potential impacts that may result from mining the application area are expected to be very similar to current conditions. No significant incremental impacts are currently anticipated. However, the following areas will have to be addressed by the operational monitoring programme:

- The potential for increased drawdown to influence the district-wide groundwater system.
- The potential for impacts to the River Blackwater floodplain area.
- Potential changes to the moisture balance of the alluvial soils lying above the planned area of the extension.
- Possible development of sink holes at the surface.

The Pale Beds unit in the immediate vicinity of the Tara Mine is classified as a poor to locally productive aquifer according to the criteria developed by the Geological Survey of Ireland (Knight Piésold, 1996). Areas of sands and gravels within the superficial deposits are also water-bearing and may constitute superficial aquifers of local importance. A survey of groundwater users was carried out in 2002 and identified only one potential user of bedrock groundwater in the Tara district (the deep borehole at Rathaldron Castle).

The Liscartan/Rathaldron application area is in an area that has already become dewatered. A considerable amount of drawdown is already observed on west side of Castle-Liscartan Fault Complex. It is considered unlikely that the extent of district-scale drawdown will change greatly from current conditions. Currently, it is not anticipated that mining of the application area will cross any bounding structures that are not already dewatered on their footwall side.

Additional drawdown will occur locally to the west of Castle-Liscartan Fault Complex (to the east of the Randalstown Fault Zone). The potential for additional drawdown to the west of the Randalstown Fault Zone is considered to be low, but this should be confirmed by operational monitoring. If additional drawdown on west side of Randalstown Fault were to occur, it is currently expected that the incremental increase from current conditions would be marginal.

The current monitoring data indicate that drawdown in the Pale Beds unit in the vicinity of the River Blackwater at Rathaldron is of the order of 30 m. It is therefore expected that losses from the river and the flood plain alluvial deposits will be controlled by the permeability of the superficial deposits, rather than by ongoing drawdown in the Pale Beds.

Observations at Nevinstown indicate that the fine-grained nature of the overburden and river-bed materials have minimised downward leakage of river water. Virtually no leakage from the shallow alluvium, the flood plain deposits or the river itself has been observed to date in response to mining beneath the river at Nevinstown. Current losses from flood plain and river are negligible (1.5 l/second or less).

Mining at Tara has been carried out close to, or beneath, the River Blackwater for over 30 years. Virtually all stope blocks located in the vicinity of the river are mined with no significant leakage of water from the river or the shallow alluvial water table of the floodplain.

Given the current dataset, there is no indication that conditions beneath the river will be any different for the Liscartan/Rathaldron extension. However, it should be appreciated that mining below or adjacent to any surface water body needs to be carried out with great care. As mining is extended beneath the River Blackwater, the inflow chemistry should be monitored to detect any chemical signatures similar to river water or shallow alluvial groundwater.

Soil moisture balance

Surface observations above the area of the Main Mine and Nevinstown have indicated that soil moisture conditions have not altered significantly as a result of dewatering the underlying Carboniferous strata. The observations to date support the study on soil moisture carried out in 2002 by Dr J Mulqueen of the Teagasc Land & Water Management Unit, Department of Civil Engineering, National University of Ireland. The study indicated that additional water level reductions in the Carboniferous strata would be unlikely to affect soil moisture conditions.
The soil moisture store is unlikely to be adversely impacted by drawdown in the Carboniferous strata.

When the underground dewatering pumps are finally shut down, all of the mine workings (SWEX, the Main Mine, Nevinstown and the Liscartan and Rathaldron application areas) will progressively fill with water. An inward hydraulic gradient to the workings will be maintained throughout the active filling period, so there will be minimal risk of any potential contaminants entering the surrounding groundwater system.

Following full recovery of the groundwater system, it is anticipated that there will be an inward hydraulic gradient towards the river. It is expected that the shallow groundwater flow system in the alluvium and shallow bedrock will be very similar to pre-mining conditions. This will comprise recharge from infiltration of precipitation and subsequent upward discharge to the flood plan deposits along the line of the river. Groundwater discharge rates via the river flood plain deposits following closure are expected to be similar to pre-mining rates.

Following post-closure stabilisation of conditions, deeper groundwater levels within the Pale Beds at Liscartan will recover to a depth of approximately 2-8 m below ground level. The post-closure shallow groundwater table in the alluvium and shallow bedrock will roughly follow topography. The groundwater gradient will be towards the river, and the water table is expected to be similar to the pre-mining water table. It is anticipated that the groundwater system in the Whistlemount Channel will fully recover following recovery of heads in the UDL.

GROUND VIBRATION AND AIR-OVERPRESURE NOISE

Ground vibration is caused by the imperfect utilisation of the explosive energy released during blasting operations. The energy that is unused in the fragmentation of rock propagates as an elastic disturbance away from the shot area as seismic waves. These waves, which radiate in a complex manner, diminish in strength with distance from the source. The theory relative to this motion is based on an idealised (sinusoidal) vibratory motion. When these waves come into contact with a free face, physical motion results as the energy induces oscillation in the ground surface. Blasting vibration is a surface wave type, which incorporates components of both body and surface motion.

Ground vibration itself is inaudible, however air vibrations both audible and sub-audible usually accompany it. The resulting impacts of blasting vibration are often characterised as being impulsive and of short duration, usually less than 6 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.

Ground vibration from blasting at any receptor point is influenced in the main by:
- maximum instantaneous charge of explosives
- medium between blast source and receptor point and,
- 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. Tara Mines applies the most up to date technology in their mine blasting operation. Ground vibration is currently being recorded continuously and simultaneously for each blast at four permanent locations and five temporary locations. The ground vibration limit at the nearest relevant monitoring stations has not been exceeded since 1985.

The environmental department liaises on a routine basis with the blast engineer in the mine planning department to ensure maximum vibration control. Comparing the planned blast layout with the actual recorded ground vibration waveform and modifying blast designs if deemed necessary achieve this.

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 40 and 900 meters from the surface and as close as 75m to a Tara residential property (almost directly under a Tara occupied house in the most easterly area of mining close to the Blackwater River). Historically the eastern most area of the mine which is the higher elevation of mining has generated the lowest levels of ground vibration at residences (and this is due to a fault structure).

Air Overpressure (Air Blast) Noise

In surface blasting (which Tara does not propose to carry out) the significant pulse of energy that gives rise to an air blast, travels from the source on surface directly through the air. The much smaller pulse of energy that is derived from ground transmission/movement at the receiver is generally insignificant. In underground blasting the air blast that is generated from the movement of the ground at the receiver is insignificant and generally at such a low level that it becomes difficult to measure accurately. Air overpressure (air blasts) is difficult to record accurately below 110 dB and this is due to existing similar levels derived from typical low wind velocities.

Blasting Vibration Impacts

The Liscartan / Rathaldron orebody forms the uninterrupted northwest extension of the existing main orebody. A 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 Liscartan / Rathaldron are essentially identical to those that occur in the 'Nevinstown orebody' which forms part of the same structure.

The proposal for underground mining methods is similar to the existing methods being used. Blasting will be carried out at greater distances from residential property than that already experienced in the existing main mine. The mining development progression northwest will increase the distances from blasting vibration sources for the more populated residential areas on the east and south-east of the mine. The level of ground vibration predicted should be no more intense than that experienced over the last 30 years. Blasting ground vibration will be controlled by adhering to a control regime currently in place - sequential detonation, control of maximum instantaneous charge of explosives used and continuous measurement of ground vibration to ensure compliance.

For 'future Tara development / production blasting', the vibration / noise limits will be similar to those existing and given in the EPA IPPC Licence No 01- 516 Condition 8. Noise: '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

'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

Daytime is defined as 08.00 hrs to 22.00 hrs and night-time is 22.00 hrs to 08.00 hrs

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 that the maximum amount of explosive on any one delay, the maximum instantaneous charge is controlled so that the ground vibration levels are maintained below that specified in the IPPC Licence
- 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 continuous monitoring stations and by additional portable ground vibration monitoring as the need arises. The measures which control ground vibration generated from underground blasting will also control air overpressure noise.

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 study review and analysis of over 30 years of vibration monitoring data has shown that Tara's ground vibration limit compliance has exceeded 99.9%.

SURFACE WATER

The groundwater inflows to the Liscartan/Rathaldron extension (including all groundwater inflow / backfill water / service water) will be collected at a central underground pumping station. All dewatering flows will continue to pass through a large settling sump at this pumping station, where suspended solids settle out, prior to being pumped via the production shaft to the second stage of settlement/clarification in the Minewater/Reclaim Water Ponds. There are no plans for additional water management facilities on surface.

The additional dewatering flow from the proposed orebody is estimated to be approximately 2,642 m^3/d. This amounts to a maximum increase of 22% of the inflow to the mine and 12% of the maximum pumping capacity. There is sufficient flexibility and storage in the water management system to accommodate all additional water collected and pumped from underground.

All minewater (groundwater inflow / backfill water / service water) is collected at a central underground pumping station. It passes through a large settling sump at this pumping station, where suspended solids settle out, prior to being pumped via the production shaft to the second stage of settlement/clarification in the Minewater/Reclaim Water Pond.

No significant changes to water quality are anticipated following expansion of the workings into the Rathaldron/Liscartan application area.

Surface runoff is collected by a system of drainage ditches which feed into the Main Site Drainage Water Pond, where suspended solids settle out prior to the water being pumped to the Reclaim Water Pond.

The waste water from the process plant is pumped to the Tailings storage facility (TSF). The TSF is designed to operate as a large sedimentation/aeration pond where solids settle to the bottom and clear water at the surface is drawn off for recirculation to the Reclaim Water Pond. The limestone in the tailings maintains the water at an alkaline pH, which precipitates all but traces of the metals remaining in solution from the milling process. The large surface area of the facility provides adequate aeration for aerobic degradation of the organic reagents, so as to assure a low B.O.D. level in the water.

The second and third stages of water processing (the Reclaim Water Pond and the Clear Water Pond, respectively) are common to all three water sources. The Reclaim Water Pond is divided into two sections to facilitate cleanout as required. Water from the reclaim pond is either pumped to the processing plant for reuse or is discharged to the River Boyne. The water to be discharged to the River Boyne overflows from the Reclaim Water Pond into a Clear Water Pond.

A weir structure at the pond outlet measures the discharge volume to the River. The discharge is recorded and controlled from the Mill Central Control room which is manned 24 hours per day, 7 days per week. Excess water is discharged under strict quality conditions prescribed in the Company's Integrated Pollution Prevention Control Licence (IPPCL) P0 516-01. Water is discharged at a dilution ratio of 100: 1, so for every cubic meter of water discharged there must be a flow of 100 cubic meters in the river.

Monitoring data indicate that drawdown in the Pale Beds unit in the vicinity of the River Blackwater at Rathaldron is of the order of 30 m. It is therefore expected that losses from the river and the flood plain alluvial deposits will be controlled by the permeability of the superficial deposits, rather than by ongoing drawdown in the Pale Beds.

Observations at *Nevinstown* indicate that the fine-grained nature of the overburden and river-bed materials have minimised downward leakage of river water. Virtually no leakage from the shallow alluvium, the flood plain deposits or the river itself has been observed to date in response to mining beneath the river at Nevinstown. Current losses from flood plain and river are negligible (1.5 l/second or less). Except for hole N00022 (on the floodplain), and the Nevinstown exploration decline (1500NDEX2), both of which are now dry, there has been no chemical indication of river water inflow to the Main Mine or the Nevinstown workings.

Mining at Tara has been carried out close to, or beneath, the River Blackwater for over 30 years. Virtually all stope blocks located in the vicinity of the river are mined with no significant leakage of water from the river or the shallow alluvial water table of the floodplain.

Following mine closure pumping will cease and the mine will fill with groundwater. This process is likely to take a number of years. Afterwards, the pre-existing groundwater drainage pattern will be re-established.

FLORA AND FAUNA

A baseline habitat, flora and fauna survey of lands in the vicinity of the town-lands of Liscartan and Rathaldron, Navan, Co. Meath, was carried out.

A desk study was undertaken to determine if there were any designated habitats or protected species recorded within this 10 km square (N86). Data held by the National Parks and Wildlife Service was examined in relation to the survey area.

Two field surveys were undertaken; the initial over two days in January 2010, the second walk-over survey was carried out over two days and two nights in June 2010. The survey methodology consisted of systematically walking the site area and recording on a large scale, habitats and vegetation types present. The primary aim of the initial survey was to broadly identify habitats, and to observe indications of fauna not easily seen during the growth season (for example trails through vegetation are easier to follow at this time of year). All observations of fauna (or signs thereof such as scat, prey remains, holes, fur etc.) were recorded and any setts, dens, etc. were recorded. The purpose of the second survey was to more accurately identify vegetation types, and any rare/protected flora, in addition to fauna not observed during the January survey – most importantly bats. Bats were surveyed over 2 warm, humid nights from 30 minutes before sunset until 90 minutes after sunset.

A review of data held by the National Parks and Wildlife Service indicated that there is a significant area of the site covered by a designated conservation area which makes up a component of the River Boyne and River Blackwater SAC (site code 002299) and this area is indicated in Appendix I. This site is a candidate SAC for alkaline fen and alluvial woodlands, both of which are habitats listed on Annex I of the EU Habitats Directive. The site is also selected for Atlantic Salmon, Otter and River Lamprey – all of which are listed on Annex II of the Habitats Directive. The survey area comprises largely of semi-improved agricultural grassland (GA1) and tillage (BC3) with associated hedgerow (WL1) and treeline (WL2) habitat. No rare/protected species of flora was observed during the course of the surveys. The most significant ecological feature of the survey site is the river corridor.

The mammal diversity observed was typical of that one would expect to occur in a largely agricultural setting, with Fox (*Vulpes vulpes*), Badger (*Meles meles*) Brown Rat (*Rattus norvegicus*) and Rabbit (*Oryctolagus cuniculus*) all abundant, with plentiful faeces and/or burrows observed of all four species in the hedgerows and small areas of woodland associated with field boundaries. Numerous Badger setts were located throughout the survey area. It is likely that other Irish mammals common throughout this part of the country such as Hedgehog, Pygmy Shrew, Hare and Grey Squirrel are also present throughout the survey area. Bat surveys were carried out on the nights on the 10th and 17th of June and five species of bat were recorded – Daubentons, Soprano Pippistrelle, Common Pippistrelle, Brown Long-eared and Leislers bat. There were particularly high numbers present foraging around the various wooded areas and there was a high concentration of bat-activity along the river corridor as would be expected. Otter spraint was located within the survey area on both sides of the river – Otter is one of the species for which the Boyne and Blackwater SAC is designated.

The vast majority of the site consists of semi-improved agricultural grassland and tillage, and is of limited ecological value. The associated hedgerows and tree-lines are of relatively high ecological significance given the intensively farmed land in the area. Species composition of both flora and fauna are typical for hedgerows in the County and for the most part the hedgerows are intact and well developed. The small pockets of semi-natural woodland scattered throughout the site are of high ecological significance, providing islands of semi-natural habitat in an intensively farmed landscape.

The ore extraction will take place deep below ground, there will be no above-ground structures and there will be no impact on local hydrology (please see hydrologists report). The proposed development will not result in any disturbance to the surface of the site, and operations will take place far below the zone of biological interaction with the surface. It is therefore concluded that there will be no significant impacts on the ecological interests of the survey area.

Visual Impacts on the Existing Landscape

Since there is no surface structures / infrastructure required for the extension into Liscartan/Rathaldron it was deemed appropriate not to extend the impact assessment past the scoping stage of the EIS.

Air

There is no surface development associated with the planned extension as all air intake / output required for the extension of mining works will be from existing facilities there will be no additional surface structures, or air emission sources. All access to the proposed development will be underground via the Knockumber Mine site. Accordingly, no likely impacts on air quality are anticipated. Furthermore, no odour sources are anticipated.

Ambient air quality and dust deposition have been monitored extensively in the environs of the existing mine site, since development commenced in 1973. The monitoring protocol in place as part of the Company's IPPC Licence will continue.

Material Assets

An archeological assessment was undertaken to assess the impact of the proposed extension of mining operations. The development site is located in an area that is rich in archaeological monuments ranging in date from the Neolithic to the Post-Medieval periods. There is one Recorded Monument within the application area, a mound (ME025-012), though this is not situated directly over the orebody. Between 1975 and 2004 archaeological excavation have taken place in the adjacent townlands of Nevinstown, Simonstown and Randalstown on sites affected by earlier stages of the mine development. There is also a strong likelihood of the existence of further archaeological sites in the area of which there are no surface indications.

The proposed extension to the existing mining operations into Rathaldron and Liscartan will be solely by underground means with no associated surface developments. Therefore, the development should not have any impact on the archaeological heritage of Rathaldron and Liscartan.

The archaeological study comprises the results of desk-based research and a field survey of the proposed development site.

The proposed development, confined entirely to underground mining operations, will not have any impact on the recorded archaeological sites and monuments in Liscartan and Rathaldron townlands.

The development as proposed should 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 ground surface, Tara Mines Ltd should be prepared to be advised by the Heritage and Planning Division of the Department of the Environment, Heritage and Local Government with regard to any necessary mitigating action.

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 Section, DEHLG, of any work proposed at such monuments or places.

ROADS AND TRAFFIC

Access to the Liscartan and Rathaldron orebody will be from within the existing main mine plant site. There will be no other access point from surface to the new development. No additional transportation infrastructure is therefore required. The new development will not lead to any additional surface traffic.

BOLIDEN TARA MINES LIMITED

Environmental Impact Statement

Extension of existing mining operations
into new areas in Liscartan & Rathaldron

SECTION 1 INTRODUCTION

1.1 Background

Boliden Tara Mines Limited, the largest operating lead-zinc mine in Europe, is located at Knockumber, 2 km west of Navan in County Meath. It is the most productive zinc mine in Europe and the fifth most productive in the world.

The mine exploits the Navan Zn-Pb deposit, which was discovered in 1970 by the Tara Exploration & Development Company Ltd. Development of the orebody began in 1973 and production of concentrate started in June 1977. On 1st January 2004, the ownership of Tara passed to Boliden. The currently projected mine life extends past 2018.

The mine is currently divided into the following sub-areas for management and planning:

- The Central Area, also known as the Main Mine or Knockumber Mine. This was the first area to be mined. It has largely been mined out.
- The South West Extension (SWEX), to the southwest of the Main Mine.
- Nevinstown, to the north of the Main Mine.

SWEX and Nevinstown are currently being developed and mined by trackless underground methods, principally long hole open stoping with backfill. Room and pillar methods are applied where the ore is thinner. Access to the SWEX and Nevinstown is from a portal at the Main Mine site.

An expansion of the mine workings is currently being planned into the Liscartan and Rathaldron application areas, located to the northwest of the Main Mine area, as shown in Figure 1.1. The expansion of the mine workings into the Liscartan & Rathaldron application areas would be accessed from the existing underground workings and would use similar mining methods to those currently being employed.

The original ore reserves (calculated in 1971) in the entire orebody amounted to 69.9 million tonnes grading 10.09% Zn, 2.63% Pb. The estimated current (end December, 2009 known Joint Ore Reserves Committee (JORC)) classified mineral resources including the Liscartan/Rathaldron orebody are 11.8 million tonnes grading 7.1% Zn and 1.8% Pb.

The current estimated ore reserves are 17.0 million tonnes at 7.2% Zn and 1.8% Pb. However the total reserves and resources in Liscartan and Rathaldron are comparatively modest and amount to 1.1 million made up of 0.9 million tonnes of inferred resources grading 7.71% Zn, 1.53% Pb and 0.2 million tonnes of indicated ore reserves grading 6.81% Zn, 1.48% Pb.

1.2 Proposed Development

This proposal involves mining in the townlands of Liscartan and Rathaldron, Navan, Co. Meath. The Liscartan/Rathaldron orebody is a small uninterrupted part of the 'Navan orebody' currently being mined.

Mining will exclusively be by underground means, extending the existing mine workings into the adjacent Liscartan/Rathaldron orebody. The surface characteristics and features of the 'mining area' will not be altered by mining activity and there will be no surface development associated with this proposal. The necessary infrastructure 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 Liscartan/Rathaldron section of the orebody dips to the southwest and strikes to the northwest in common with the general characteristics of the main orebody, giving a depth below surface ranging from 150m to 575m, with ore thickness ranging from 4m to 12m.

1.3 E.I.A. Regulations

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. 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 extension of mining operations into the new area of Liscartan and Rathaldron constitutes a project as prescribed in Schedule 5 of the 2001 regulations.

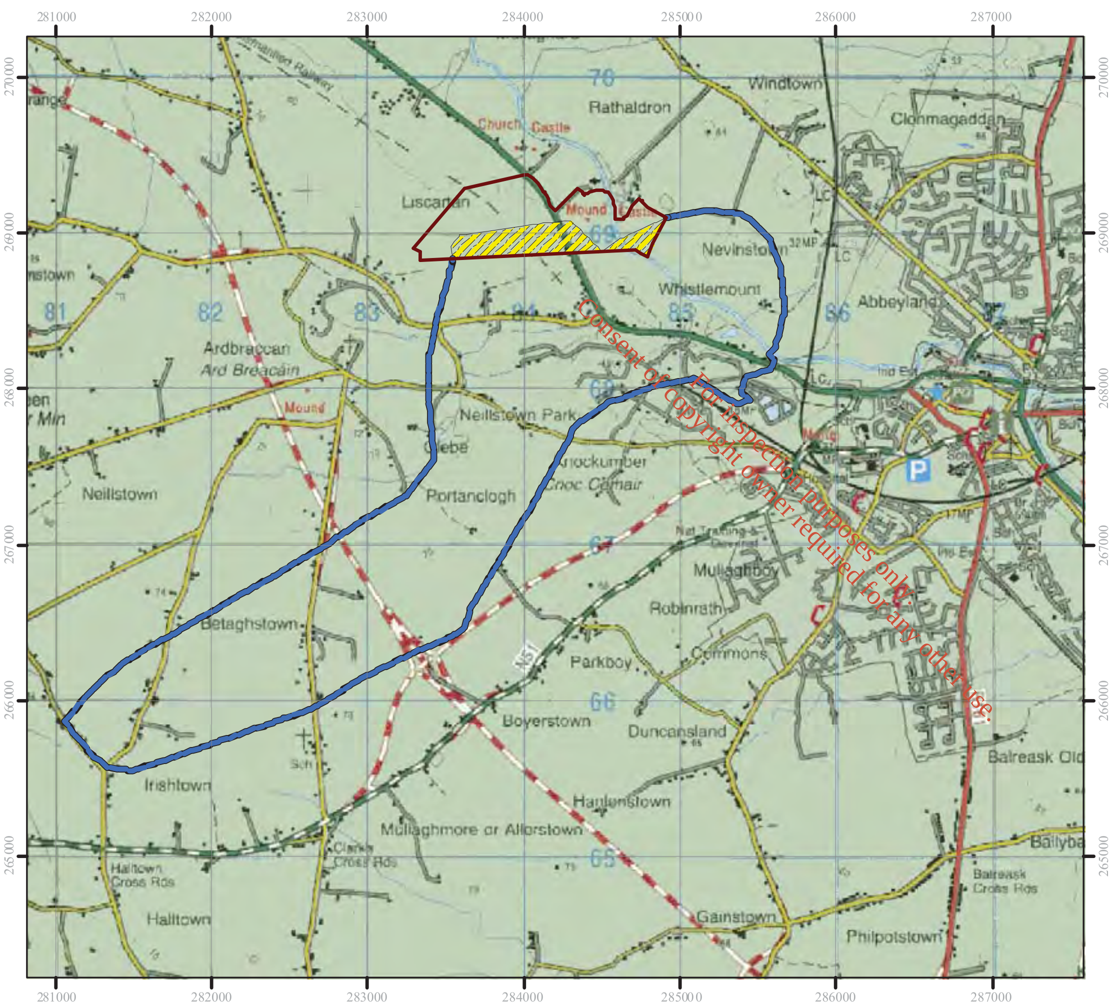


Figure 1.1 Location map

Legend

- Application area
- Navan Orebody outline
- Liscartan/Rathaldron orebody

1:35,000

Map reproduced from O.S. digital maps by permission of The Ordnance Survey Ireland.

1.4 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 the Environment, Heritage and Local Government. Other Government departments, statutory bodies and special interest groups also exercise important control functions. The responsibility for further regulation in the natural resource sector, including mining, is currently administered by the Department of Communications, Marine and Natural Resources who also, though not directly, have responsibility for environmental control through the Central and Regional Fisheries Boards. Within the Department of the Environment, Heritage and Local Government, the Heritage Service, *Dúchas*, 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 immense regulatory power is the Planning Appeals Board, An *Bord Pleanala*, which determines first and third party appeals *inter alia* against planning decisions. Other bodies with responsibilities in relation to mining development are the Health Boards 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. A lesser participatory role in planning decisions has been played by Bord Failte Eireann, the National Tourist Board.

1.5 Appropriate Assessment

An appropriate assessment or Natura Impact Statement has been undertaken in accordance with the European Commission Methodological Guidance on the provision of Article 6(3) and 6(4) of the 'Habitats' Directive 92/43/EEC (EC 2001) and the European Commission Guidance 'Managing Natura 2000 Sites'. The Guidance for Planning Authorities issued by the Department of Environment, Heritage and Local Government is also adhered to.

This assessment was undertaken to determine the potential impacts, if any, of the plan for an extension of mining activities on nearby sites with European conservation designations (i.e. Natura 2000 sites). The purpose of this assessment was to determine, the appropriateness or otherwise, of the proposed project in the context of the conservation status of such sites. The report is supported by full technical details contained in the EIS and forms an appendix to the main text of the Environmental Impact Statement (See appendix 1).

1.6 Content of the Environmental Impact Statement

An Environmental Impact Statement (EIS) is a key component of the EIA procedure and its content is specified in Annex III of the EC Directive and is defined in Article 25 of S.I. No. 349 of 1989 as follows:

> " *A statement of the effects, if any, which proposed development, if carried out, would have on the environment"*

This EIS has been prepared following a "Grouped Format Structure", and examines each aspect of the environment in a separate section referring to the existing environment, the proposed development, likely impacts and mitigation measures. Boliden Tara Mine Limited has developed an extensive environmental monitoring programme around the existing Randalstown tailings facility partly in response to conditions attached to Planning Conditions and latterly in response to requirements of the Company's IPPC Licence No. P0516-01. 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 an expanded development.

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

- Guidance on the Information to be Contained in Environmental Impact Statements (March 2002)
- Advice Notes on Current Practice in the Preparation of Environmental Impact Statements (March 2003)

1.7 The Project Team

The Environmental Impact Statement has been prepared by Tara Mines Environmental Department staff with assistance of the following specialists:

- Geotechnical - M.A. Struthers
- Groundwater - Geoff Beale, Slumberger Water Services (UK) Ltd.
- Blast Vibration and Air-overpressure Noise – Brendan O' Reilly, Boliden Tara Mines Ltd.
- Flora And Fauna - Dr. Patrick Moran, Forest Environmental Research and Services Ltd.
- Archaeology, Heritage and Cultural - Kieran Campbell, Drogheda, Co. Louth
- Appropriate/Natura Assessment. Dr. Brian Madden of Biosphere Environmental Services

The following Tara Mines Environmental Department personnel contributed to the preparation of the EIS:

Eric Brady MSc, IAH
Oliver Fitzsimons, B. Env. Sc. (Hons)
Ailish Mc Cabe, B. Ag. Sc. (Hons)
Brendan O' Reilly, MSc, ISEE, SFA, EAA

SECTION 2 PROJECT DESCRIPTION

2.1 Introduction

The proposed development involves the mining of proven ore reserves in the townlands of Liscartan and Rathaldron (Figures 2.1 and 2.2). The surface characteristics and features of the 'mining area' will not be altered by mining activity and there will be no surface infrastructure facilities in this area.

The Liscartan/Rathaldron section of the 'Navan orebody' is an uninterrupted extension of existing mine workings that are currently being mined by Boliden Tara Mines Limited (Tara Mines). The Liscartan/Rathaldron section of the orebody dips to the southwest and strikes to the northwest in common with the general characteristics of the orebody, giving a depth below surface ranging from 150m to 575m with ore thickness ranging from 4m to 12m. Mining follows a cyclic pattern resulting in the removal of ore underground followed by the filling of the voids using cement and waste sand material that remains after the ore treatment process. The surface characteristics and features of the Liscartan / Rathaldron townlands will not be altered by mining activity and there will be no surface structure / infrastructure facilities in the area.

2.2 Mining and Processing Operation

2.2.1 Access

Access to the proposed orebody will be via the existing portal access (underground road from surface) on the Knockumber Mine site. This will provide a vehicle route via the existing mine into the new areas of the orebody. Underground drifts from existing mine workings at varying locations and depths will provide access for mining purposes. There will be no additional access to the proposed orebody.

2.2.2 Underground Infrastructure

Mine services such as compressed air, water, fuel and communications cables will be carried through the existing mine into Liscartan/Rathaldron. There will be no services into the mine from outside the existing Knockumber mine site.

2.2.3 Mine development

Mine development is planned to access 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 existing mine crusher and conveyor system.

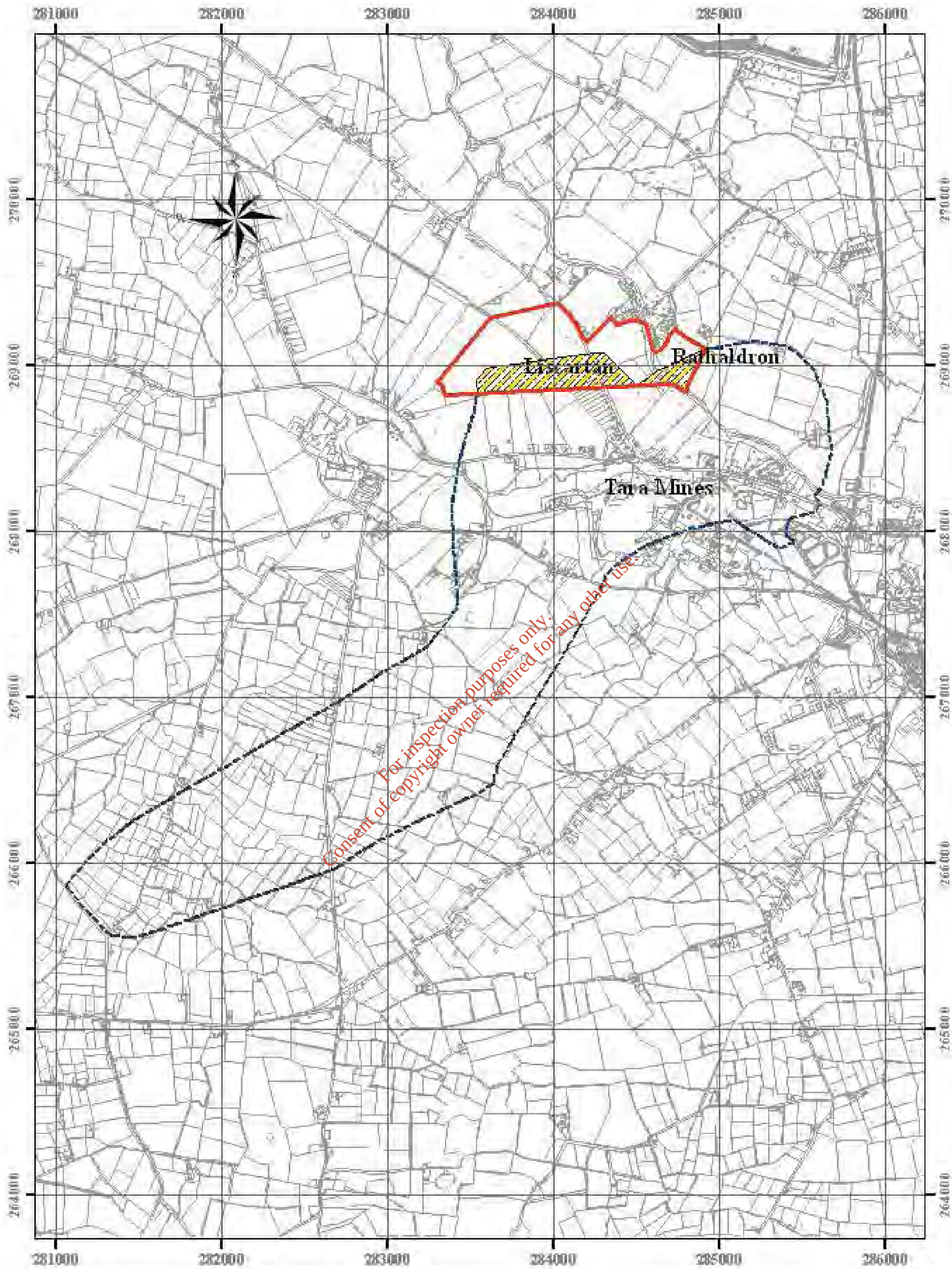


Figure 2.1 Liscartan/Rathaldron orebody with respect to the Navan orebody

Legend

Application area

Known Orebody outline

Liscartan Rathaldron orebody

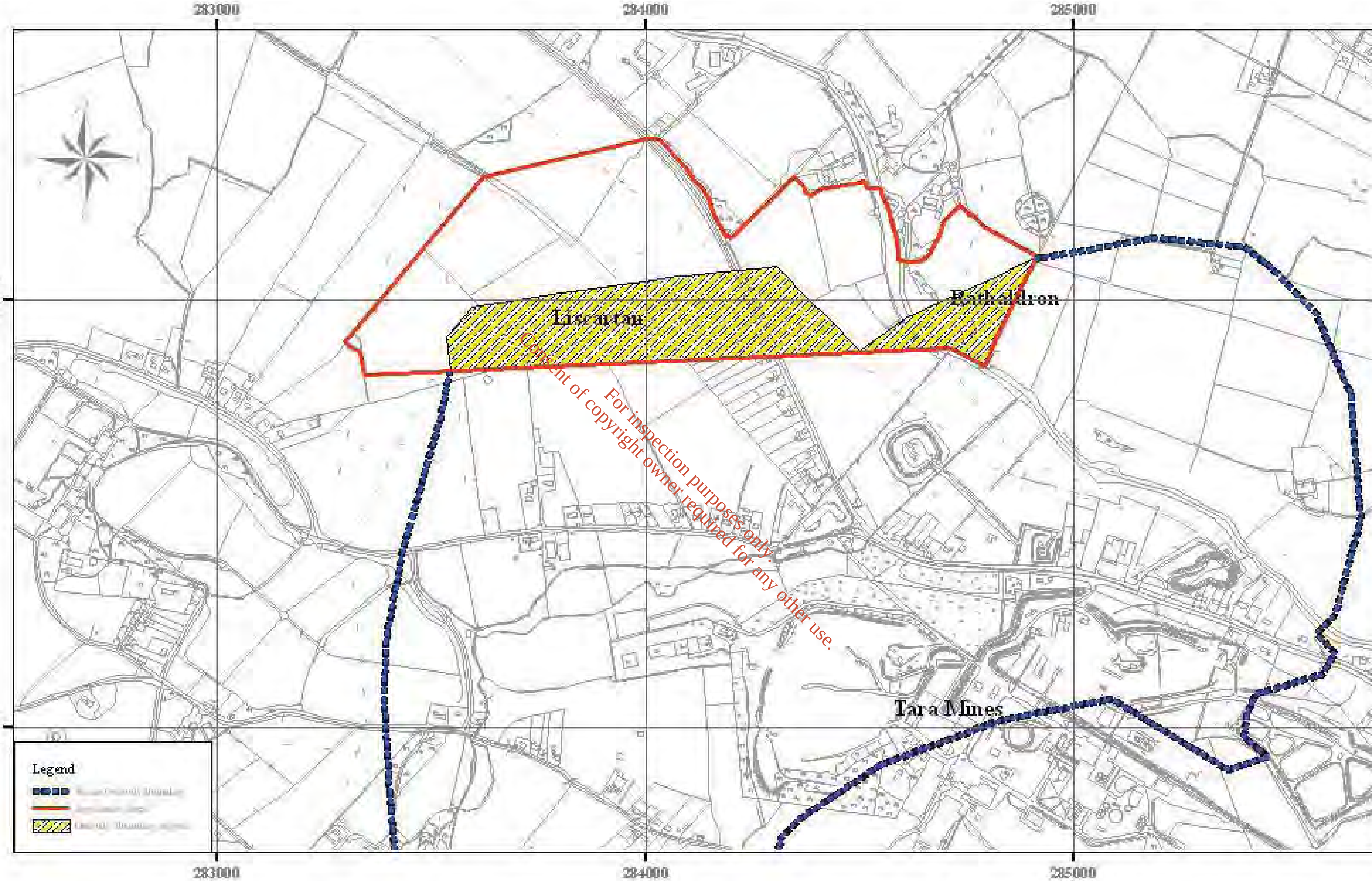


Figure 2.2 Liscartan and Rathaldron application area

1:12,500

2.2.4 Mining Methods

The selected mining method will generally be longhole open stoping where ore thickness proves to be sufficiently high (up to 12m), together with variations on room and pillar mining in areas of thinner ore (down to 4m). Cemented backfill will be used for initial primary stoping and a mixture of cemented and un-cemented backfill for later (secondary) stoping. This is the current practice in the existing mine. Longhole open stoping is sequential, that is, stopes are mined in sequence and each stope is filled before mining of adjacent stopes can commence. In room and pillar mining the roof stability is achieved through the design of stable rock pillars, provision of roof support where necessary and the use of regional (larger) pillars where the mining spans are large.

Hangingwall drifts will be driven some 40-50m above the orebody to facilitate exploratory diamond drilling, ventilation and backfill functions

2.2.5 Mine Production

Mine production is the generation of large tonnages of ore from stopes and pillars. All ore produced will be transported underground by trucks to the existing mine crushing conveyor system from where it will be hoisted to surface. In a typical year, up to 170,000 tonnes of production ore and 40,000 tonnes of development ore will be scheduled from this area. Waste rock generated from continuing development will be handled as described above. Mining equipment to load and haul both ore and waste is part of the existing fleet. No additional mobile equipment will be necessary to handle ore and waste from the proposed development.

2.2.6 Ventilation

All ventilation requirements will be met by the existing mine ventilation system. Fresh air will enter the mine through existing fresh air routes, including portal entrances and ventilation raises. The air will flow along the main working levels of the mine before rising to upper dedicated (hanging wall) drifts which will return air to existing underground and surface fan stations. Existing fan stations will remain unaltered in terms of their airflow volumes and overall performance so total emissions will continue at current levels. There will be no ventilation-related connections to surface in the Liscartan/Rathaldron area.

2.2.7 Backfilling

Mined-out areas will be backfilled with sand-fraction mill tailings mixed with cement. Backfill will flow through new underground pipelines that will be connected to the existing mine backfilling facilities. Stopes and pillars will be backfilled through holes drilled down into the roof of the excavation and backfill poured down into the void over an extended period until the stope is filled. There will be no backfilling-related connections to surface in the Liscartan/Rathaldron or adjacent areas. In addition, and whenever feasible, waste rock from development will be placed in stopes, prior to backfilling

2.2.8 Tailings management

Processing tailings are pumped to the Randalstown Tailings Storage Facility (TSF) where aeration is provided and suspended solids are allowed to settle out to leave clear water for recirculation and reuse. In June 1998 Meath County Council granted planning permission (P96/919) for an extension of the Tailings Management Facility. The second cell of this extension project, titled Stage 4B, was completed in 2006 and the first tailings material was deposited in November 2006. Planning Permission for a further extension (Stage 5) has been granted (Ref: NA901452 Meath County Council, June 16th 2010).

At the end of 2009 a total of 3.08 million tonnes of tailings had been placed in Stage 4B of the TSF leaving a remaining capacity of 3.66 million tonnes. The 'Stage 5 extension' will provide capacity to accommodate an additional 7.9 million tonnes of tailings giving a total combined capacity of 11.5 million tonnes. The current Life of Mine plan requires storage capacity for up to 9 million tonnes. The 1.1 million tonnes of ore to be mined from the Liscartan / Rathaldron application area will require the deposition in the TSF of about 0.5 million tonnes of tailings for which there is adequate capacity. The orebody section under application is a continuation to the northwest of the same geological structures currently being mined at Knockumber and Nevinstown therefore the characteristics of the tailings will not change.

2.2.9 Mine dewatering

Groundwater inflowing to the mine workings will be collected at a central underground pumping station. All dewatering flows will pass through a large settling sump at this pumping station, where suspended solids settle out, prior to being pumped via the production shaft to the second stage of settlement/clarification in the Mine/Reclaim Water Ponds. There are no plans for additional water management facilities on surface.

The total pumping capacity of the mine is 21,600 m^3/d while the current total inflow to the mine is 11,979 m^3 / day.

It is anticipated that the proposed development could lead to an increase of between 15-30% of the current inflow to the entire mine. There is sufficient flexibility and storage in the current water management system to accommodate all anticipated additional water collected and pumped from underground (ref Section 6).

SECTION 3 SCOPING AND CONSULTATION

3.1 Introduction

The scoping phase assists in identifying those issues and risks that are likely to be important during the EIA and which, therefore, must be adequately addressed in the EIS.

The scoping process for this EIS involved

- Consultation (both formal and informal) with the planning authority and statutory consultees to identify relevant issues and agree appropriate methodologies (see Appendix B).
- Meeting with local residents and landowners

In addition, the scoping process afforded due regard to the information gained as a result of:

- Consultations and meetings that took place during Environmental Impact Assessments for previous mine extensions
- Monitoring records and technical reports available for current mine development.
- Potential changes to the characteristics of the surrounding environment.
- Potential changes in the regulatory requirements and policy.

3.2 Guidance

Neither EC Directive 85/337 nor the Regulations transposing it into Irish law refer specifically to scoping. However, the scoping process has become an established and integral part of an EIA and this is reflected in many recent publications (eg. *Advice Notes on current practice in the Preparation of Environmental Impact Statements and Guidelines on the Information to be Contained in Environmental Impact Statements, Environmental Protection Agency, March 2002)*.

3.3 Scoping for Development

During the scooping process for the Liscartan/Rathaldron development particular focus was placed on issues and impacts that were;

(i) Environmentally based
(ii) Likely to occur
(iii) Significant or adverse

The scope emerged from dialogue between;

- *Tara's Environmental Department* who proposed the initial outline based on a knowledge of the project and the site;

- *The Competent Authority* (Meath County Council) who have a detailed knowledge of the procedural and legal requirements as well as an extensive knowledge of both the context and local issues and concerns;

- *Specialist Agencies / Consultants* who have a detailed understanding of a particular aspect of the environment affected

- *The Public and local businesses*, who provided views on both thematic and area-specific concerns.

Scoping continued throughout the duration of the EIA and involved feedback and further consultation with relevant parties. This was achieved by reviewing environmental criteria emerging from an assessment of the specific receiving environment.

Table 3.1 gives a list of the individuals and representative bodies contacted for consultation.

TABLE 3.1 PROJECT SCOPING – LISTED ORGANISATIONS

Mr. Shane Donnelly Town Clerk Navan Town Council Town Hall Watergate Street Navan Co. Meath	Ms. Mary Saddler Chairwoman Navan Chamber of Commerce Church Hill Navan Co. Meath	Mr. Gerry Lynn Senior Environmental Engineer Meath County Council County Hall Railway Street Navan Co. Meath
Mr. Fergal O'Bric Planning Officer Meath County Council Abbey Mall Abbey Road Navan Co. Meath	Mr. Pat Gallagher Senior Planner Meath County Council Abbey Mall Abbey Road Navan Co. Meath	Ms. Loreto Guinan Heritage Officer Meath County Council Abbey Mall Abbey Road Navan Co. Meath
Mr. Kevin Stewart Director of Services Meath County Council County Hall Railway Street Navan Co. Meath	Mr. Charlie Mc Carthy Senior Roads Engineer Meath County Council County Hall Railway Street Navan Co. Meath	Mr. Ian Lumley Heritage Officer An Taisce Tailors Hall Back Lane Dublin 8
Divisional Manager Developments Applications Unit Heritage Division DoEHGL Dun Sceine Harcourt Lane Dublin 2	Mr. Brian Breslin Assistant Principal Exploration and Mining Division Department of Communications, Marine & Natural Resources Beggars Bush Haddington Road Dublin 4	Ms. Ann Mc Manus Regional Manager Department of Agriculture, Fisheries & Food District Veterinary Office Naas Co. Kildare
Mr. Dominic Mullaney Principal Advisor Department of Transport Roads Division Block 7, Floor 2 Irish Life Center Lower Abbey Street Dublin 1	Regional Manager National Roads Authority St. Martins House Waterloo Road Ballsbridge Dublin 4	Mr. Frank Clinton Licensing Unit Environmental Protection Agency Headquarters PO Box 3000 Johnstown Castle Estate Co. Wexford
Mr. Niall Horgan Regional Inspectorate Environmental Protection Agency Mc Cumiskey House Richview Clonskeagh Road Dublin 14	Mr. Noel Mc Gloin Local Officer Eastern Regional Fisheries Board 15a Main Street Blackrock Co. Dublin	Mr. Pat Doherty Chief Executive Officer Eastern Regional Fisheries Board 15a Main Street Blackrock Co. Dublin

TABLE 3.1 PROJECT SCOPING – LISTED ORGANISATIONS		
Mr. Pat Griffin Senior Inspector Health & Safety Authority Metropolitan Building James Joyce Street Dublin 1	Mr. Donal Daly The Geological Survey of Ireland Headquarters Beggars Bush Haddington Road Dublin 4	Mr. Seamus O'Shea Senior Executive Officer Department of Agriculture, Fisheries & Food Athlumney, Kilcarn Navan Co. Meath
Mr. Oliver Dillon Area Manager Teagasc Dublin Road Dundalk Co. Louth	Mr. Anthony Clinton Irish Farmers Association Bective Street Kells Co. Meath	Mr. John Murphy Regional Engineer Office of Public Works Newtown Trim Co. Meath
Mr. Al Donnelly Principal Environmental Health Officer Health Service Executive County Clinic Navan Co. Meath	Mr. Eugene Cummins Navan Town Manager Meath County Council County Hall Railway Street Navan Co. Meath	
Local residents		
Mr. James O'Brien, Whistlemount, Kells Rd, Navan		
Mr. Fergus Halpin, Whistlemount, Kells Rd, Navan		
Mr Michael Kelly, 6 Liscarton, Kells Rd, Navan		
Mr Noel Foley Liscartan Navan Co Meath		
Mrs Anne Kelly Rathaldron Castle Navan		
Mr Brady Navan Water Works Kells Road Navan		
Mr. Jack Leahy, Liscartan, Kells road Navan		
Mr. Sweeney Liscartan House Kells Road Navan		

SECTION 4 HUMAN BEINGS

4.1 Introduction

A desk study was carried out in order to examine all relevant information pertaining to planning and socio economic activity in the study area. The relevant national, regional and local planning guidelines were examined along with the Meath County Development Plan 2007-2013.

The effects of noise, dust, traffic, air and water quality on the surrounding environment will be dealt with individually in those relevant sections of the EIS.

4.1.1 Scope of Economic Issues under Consideration

The principal economic consequence of the proposed development will result from its effect on the future life of the mine. These consequences are estimated in terms of employment and income to the local region and the country including:

> *Direct effects*, such as the employment and capital investment in the mine over its expected lifetime.
>
> *Indirect effects*, such as employment and income effects in enterprises supplying goods and services to the mine.
>
> *Induced (knock-on) effects*, which are additional to the indirect effects since they arise from the establishment of new enterprises or from increased levels of economic activity supported by the mine.

There is no doubt that the proposed extension to the mine will be a project of major economic significance at local, regional and national levels.

4.2 Existing Environment

Boliden Tara Mines Limited, the largest operating lead-zinc mine in Europe, is located at Knockumber, 2 km west of Navan in County Meath. Originally sited in a rural area, expansion of Navan urban area has resulted in the development of residential areas nearer to the mine although much of its surroundings remain flat sparsely populated agricultural land, see figure 4.1. The River Blackwater which flows into the River Boyne passes over the orebody and forms a surface intersection feature between what is now referred to as the 'Main orebody' and the 'Nevinstown orebody' to the northeast. To the southwest lies the SWEX and SWEXB orebody. The Liscartan/Rathaldron ore represents the north and north-western limit of the main Navan orebody.

4.2.1 Settlement and social pattern

The townlands of Liscartan and Rathaldron although situated on the periphery of Navan town are sparsely populated. Figure 4.1 shows the area of the proposed orebody with respect to residential dwellings in the area.

The development of the Liscartan/Rathaldron orebody will not entail any surface structures, roads etc. The orebody lies at a depth below surface ranging from 150m to 575m.

Table 4.1 Residential dwellings in area

House ID	Owner	TOWNLAND
R1	O Brien	WHISTLEMOUNT
R2	Halpin	WHISTLEMOUNT
R3	Leahy	LISCARTAN
R4	Tara	LISCARTAN
R5	Keogan	LISCARTAN
R6	Tara	LISCARTAN
R7	Tara	LISCARTAN
R8	Keogan	LISCARTAN
R9	Tara	LISCARTAN
R10	Tara	LISCARTAN
R11	Kelly J	LISCARTAN
R12	Duffy	LISCARTAN
R13	Tara	LISCARTAN
R14	Keogan	LISCARTAN
R15	Keogan S	LISCARTAN
R16	Tara	LISCARTAN
R17	O Rourke	LISCARTAN
R18	Dolan	LISCARTAN
R19	Kelly m	LISCARTAN
R20	Rathaldron Farm	RATHALDRON
R21	Rathaldron castle	RATHALDRON
R22	Liscartan house	LISCARTAN
R23	Brady	LISCARTAN
R24	Foley	LISCARTAN

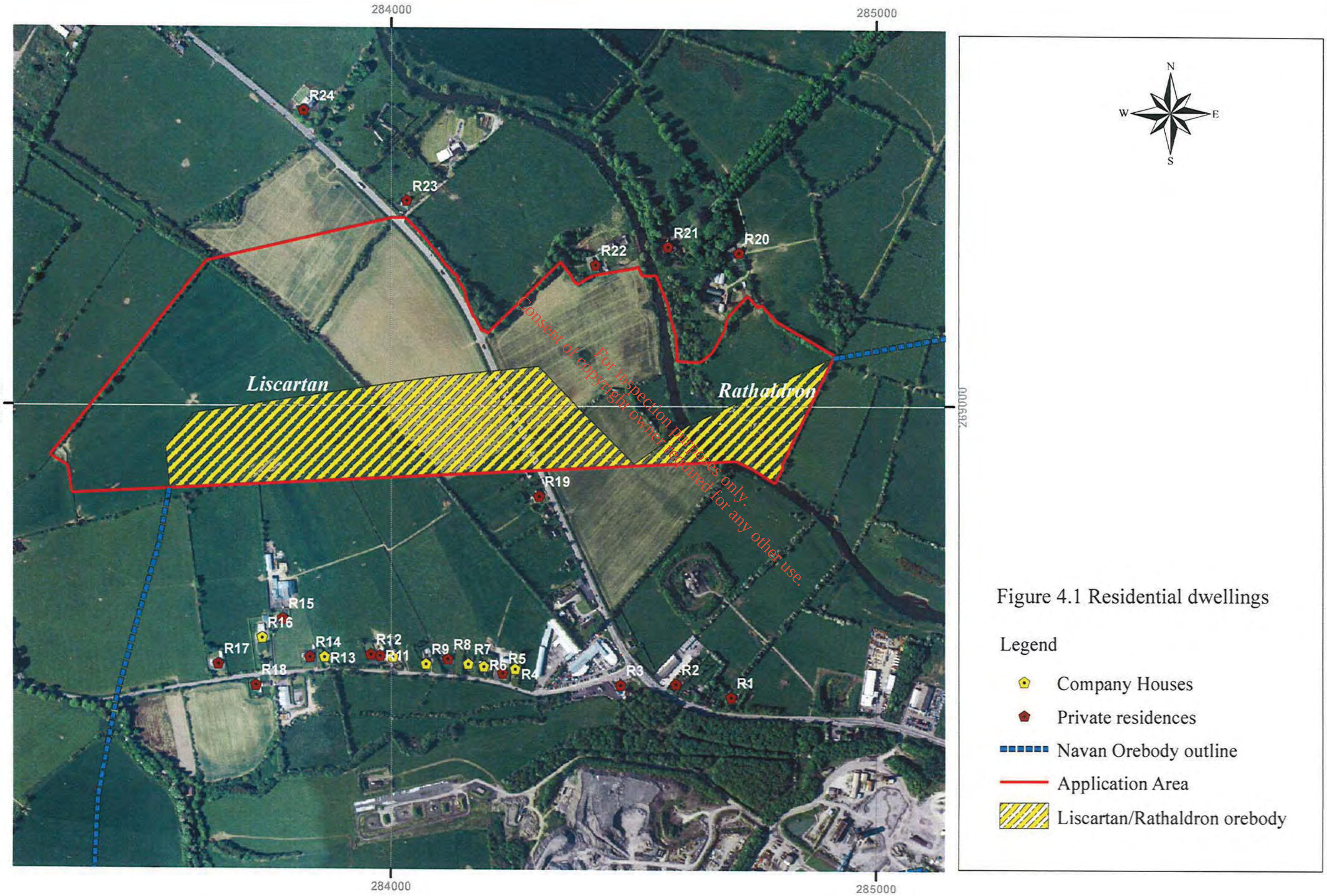


Figure 4.1 Residential dwellings

4.2.2 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 Navan area. Quarterly National Household Survey (QNHS) provides details of unemployment on a regional level. Navan is located in the Mid East Region therefore this Region will be used to illustrate unemployment in the area. The Mid East Region consists of counties Kildare, Meath and Wicklow.

Table 4.2 Quarterly National Household Survey (Q4 2009)

	Unemployment Rate	Participation Rate
State	12.4	61.2
Mid east Region	11.4	65.8

Source: CSO, 2010

Table 4.2 illustrates the findings from the most recent QNHS quarter four (September to November 2009). The unemployment rate is the number of unemployed persons expressed as a percentage of the total labour force. The unemployment rate for the State was 12.4% while the unemployment rate for the Mid East Region, which contains the study area, was 11.4%.

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). Currently the participation rate in the State is 61.2%. The Mid East Region's participation rate is 65.8%, which are lower then that of the State.

The Central Statistics Office (CSO) publishes figures relating to the live register. These figures are not strictly a measure of unemployment as they include persons who are legitimately working part time and signing on part time. However they can be used to provide an overall trend within an area.

Table 4.3 Live Register 2008-2010

	April 2008	April 2010	% Change
State	195,598	432,657	121
Mid East Region	17,056	41,445	143
Meath	4,511	11,556	156
Navan	2,401	5,988	149

Source: CSO 2010

The figures in table 4.3 show that over the period April 2008 – April 2010 the number of persons on the live register increased in all regions. The figures clearly indicated a sharp rise in the rate of unemployment in the Navan region.

Boliden Tara Mines Limited is Europe's largest zinc and lead mine and currently produces between 2.6 and 2.7 million tonnes of ore per annum and 0.4 Mt of zinc and lead concentrate. Based on current ore reserves, Tara Mines needs to increase the storage capacity of the TSF to allow the processing of ore beyond the year 2013. The Stage 5 proposal will extend the Life of Mine Plan beyond 2018.

Tara Mines currently employs a total of 680 employees and it is estimated that there are 3 additional jobs indirectly supporting each Tara job.

Table 4.4 illustrates the industrial groups of persons living in the State, Meath and Navan. It can be seen in these figures that the percentage of workers in the mining, quarrying and turf production sector is higher in Meath than in the state as a whole. The percentage of these workers is also significantly higher for the town of Navan. This indicates the importance of this sector to the town. These statistics outline direct mining employment figures only and do not convey the other industrial groups that benefit from operations at Tara Mines such as construction, manufacturing etc.

Table 4.4 Industrial Groups (Employment Numbers)

Occupational Group	State	Meath	Navan
Agriculture, Farming and Fishing	1.11%	1.52%	1.41%
Mining, quarrying and turf production	0.09%	0.22%	2.01%
Manufacturing industries	9.04%	8.98%	13.70%
Electricity, gas and water supply	0.27%	0.26%	0.29%
Construction	1.44%	2.15%	12.78%
Wholesale and retail	15.04%	16.04%	14.50%
Hotels and Restaurants	6.82%	5.23%	4.65%
Transport, storage and communications	3.30%	4.19%	5.51%
Banking and Financial services	6.02%	6.65%	4.43%
Real estate, renting and business activities	9.83%	9.37%	8.82%
Public administration and defence	5.35%	5.92%	5.18%
Education	10.88%	10.25%	5.60%
Health and Social work	18.92%	17.96%	9.15%
Other community, social and personal service activities	5.71%	6.29%	4.28%
Industry not stated	6.16%	4.98%	7.71%

Source: CSO

4.2.4 Land use

Land in Liscartan and Rathaldron is zoned as Agricultural and any future mining in this area will not effect farming productivity or practices.

Theory and experimental measurements show that soil moisture is influenced by rainfall, evapotranspiration and recharge to the groundwater table. Since soil moisture content is not influenced by the height of the watertable, grass and crop growth and production likewise are not influenced when the watertable is deep. This has been the case at Tara Mines since development began in 1973 and will continue to be the case as mining is extended outwards from the existing boundaries.

There will be no loss of rights of way of existing amenities, conflicts or other changes likely to alter the character and use of the surroundings and the traditional right of anglers to pass along the river bank will not be restricted.

4.2.7 Extractive Industry

The Meath County Development Plan 2007-2013 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;

RD POL 11 '*To facilitate the exploitation of the county's natural resources and to exercise control over the types of development taking place in areas containing proven or potential deposits, whilst also ensuring that such industries are carried out in a manner which would not unduly impinge on the visual amenity or environment quality of the area.'*

RD POL 12 '*To protect the finite aggregate resources, in such areas of known or potential aggregate sources, whereby only development compatible with mining or quarrying activities shall be permitted in areas being or likely to be used for these purposes.'*

RD POL 13 '*To ensure that extractive industries do not adversely affect the environment or adjoining existing land uses.'*

RD POL 17 '*To ensure that development for aggregates / mineral extraction, processing and associated concrete production does not significantly impact on the following areas:*
1) Existing & Proposed Special Areas of Conservation (SACs);
2) Special Protection Areas (SPAs);
3) Existing & Proposed Natural Heritage Areas (pNHAs);
4) Other areas of importance for the conservation of flora and fauna;
5) Areas of significant archaeological potential;
6) In the vicinity of a recorded monument, and;
7) Sensitive landscapes'.

4.3 Potential Impacts

4.3.1 Effects on Employment and Economy

Boliden Tara Mines Limited currently employs a total of 680 employees and it is estimated that there are 3 additional jobs indirectly supporting each job. The proposed development will underpin the future operation of Tara Mines. The current Life of Mine Plan extends to 2018.

The effect of wages and salaries generated by Tara being spent in the local and greater Navan areas are considerable. Currently, the annual wage bill is €58 million, of which approximately €50 million is the gross payroll cost, and €8 million is the employer costs. In addition an average of €1.6 million is paid, annually, to the local authority in rates, water rates and planning charges.

The proposed mine extension is an essential component of the mine plan and therefore to the sustainability of the mine. The continued operation of the Company will be of major economic importance at local and national level.

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 net positive contribution to the Balance of Payments is in the region of €140 million.

4.4 Conclusion

In summary the extension of the mining operation will extend the life of mine plan thus supporting the continued success of the mining operation. The success of the mining operation has a significant, positive impact on the socio-economic standing of the local community.

SECTION 5 GEOTECHNICAL

5.1 Introduction

The Liscartan and Rathaldron portion of the Navan orebody is an uninterrupted extension of ore currently being mined by Boliden Tara Mines Limited (Tara Mines). The Liscartan and Rathaldron section of the orebody dips to the southwest and strikes to the northwest in common with the general characteristics of the orebody, giving a depth below surface ranging from 150-575m within the Liscartan section, from 150-200m below surface in the Rathaldron section, and with an ore thickness ranging from 4m to 12m.

The proposal involves mining in the Townlands, or parts of, the Liscartan and Rathaldron leases. The surface features of the mining area will not be altered by mining activity and there will be no surface structures or infrastructure facilities in this area.

AMC Consultants (UK) Limited ("AMC") were requested to prepare a report covering the mining geotechnical aspects of the proposed extension to mining operations. The report focuses on considerations of regional (large-scale) stability arising from the mining activity, and not on details of the design of individual excavations. This is beyond both the scope of this report, and the information available at this time. Comment is made however on the nature of future investigations by Tara Mines that would be expected to ensure the mining operations are conducted in a safe and stable manner.
Water Management Consultants Ltd (WMC) is preparing a separate report into the hydrological aspects of the Liscartan & Rathaldron areas.

5.2 Geology

5.2.1 Geological Summary

The geology of the Navan region and Tara Mines orebody is described in detail in Ashton et al (2003), and numerous other prior references. The geology of the Liscartan and Rathaldron areas can be summarised as follows:

- Economic mineralisation in the Liscartan and Rathaldron areas is restricted to the 1-5 Lens.
- As in the main Tara Mines orebody, the mineralisation in these areas is stratabound.
- Mineralisation in these areas ranges from 150m - 575m below surface in the Liscartan section, from 150-200m below surface in the Rathaldron section, and with ore thickness ranging from 4m to 12m.

Figure 5.1 shows the plan limits of the two areas. The limits of Inferred and Indicated Resources (as defined by Tara Mines) are also shown, along with the positions of cross-sections listed below.

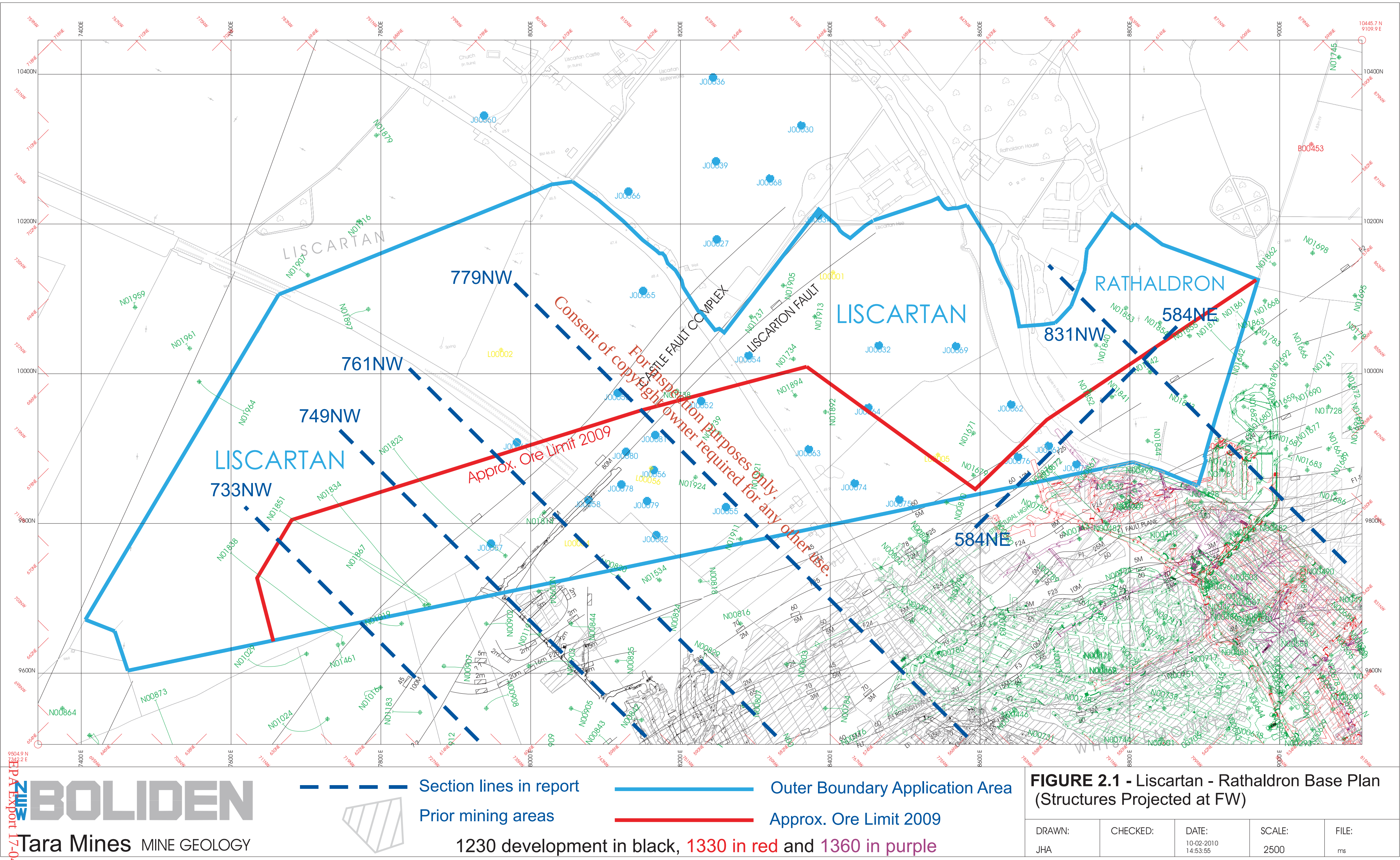


Figure 5.1 Liscartan/Rathaldron Base Plan (Structures Projected at FW)

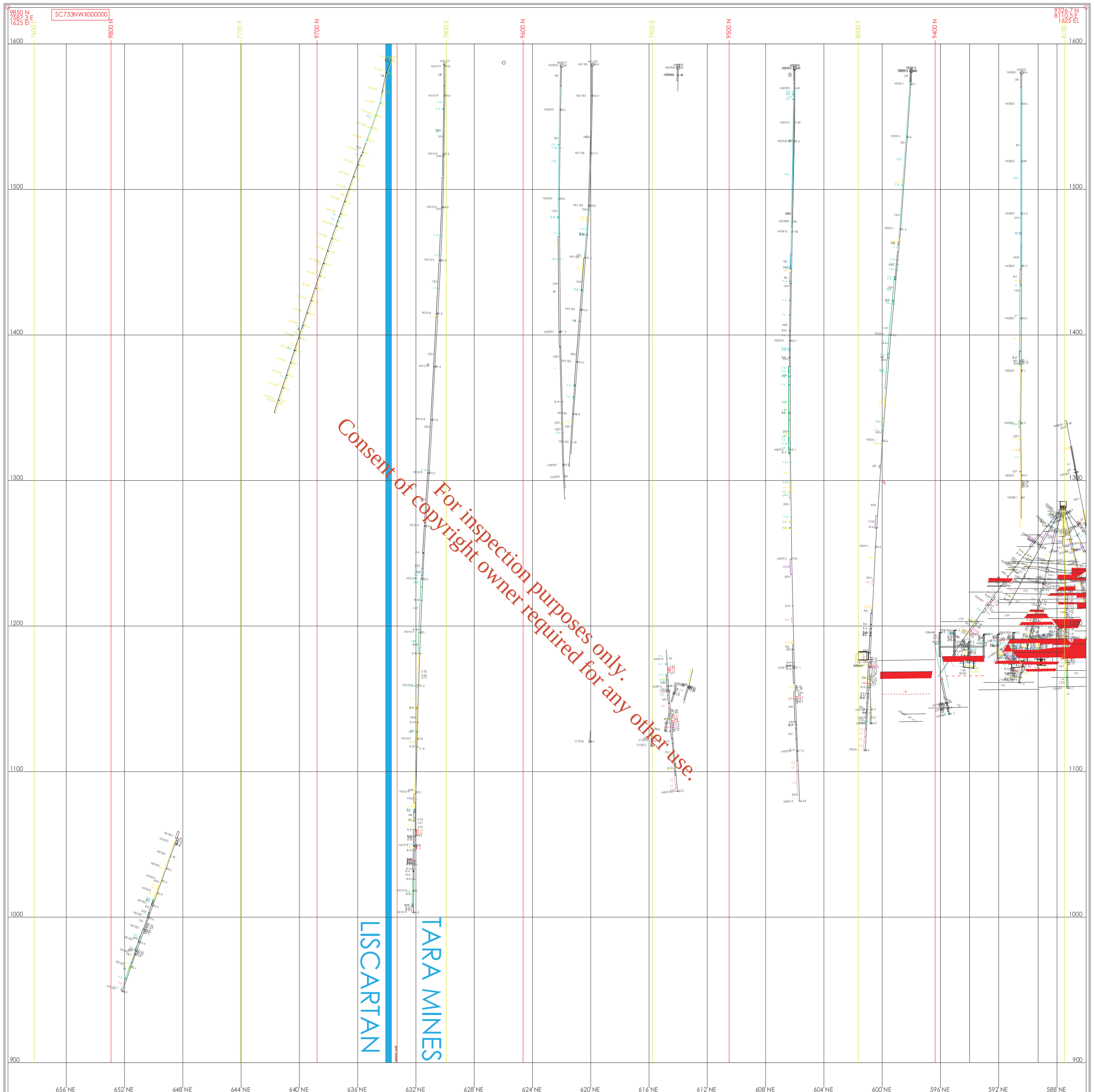
Figures 5.2 to 5.5 are vertical cross-sections through the Liscartan mineralisation. Figures 5.6 and 5.7 are vertical cross-sections through the Rathaldron mineralisation.

The main feature of the geology in the area is the Castle-Liscartan Fault Zone or complex, the eastern edge of which represents the western boundary of the current Tara Mines operations. As a consequence of normal displacement on this fault zone some rock units stratigraphically above the Navan Group beds are now present, but they occur a significant distance above the 1-5 Lens. Given these units are far above the orebodies, they will not impact on large-scale stability around stoping, and therefore will not be considered in any detail here.

The main rock units that host the 1-5 Lens mineralisation are the same as occur in other areas of the mine. These are described briefly 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 metres thick, which form recognisable "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.
- **Shaley Pales:** Thinly bedded limestones and calcareous sandstones, and interbedded shales. The latter often contain highly polished bedding surfaces. The NW-trending joint set found in the Pale Beds is also present. Ground conditions vary from 'poor' (where shales dominate), to 'good' in the limestones (refer Barton et al 1974 for definitions of 'poor' and 'good').
- **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.
- **Thinly-Bedded Unit (TBU):** The TBU comprises thinly-bedded (<10cm) calcareous sandstone and mudstones, often with laminae of fine pyrite. Again bedding planes are polished, especially close to faults.

With the exception of the major Castle-Liscartan Fault, all other geological characteristics of these areas are the same as elsewhere in the current Tara Mine.

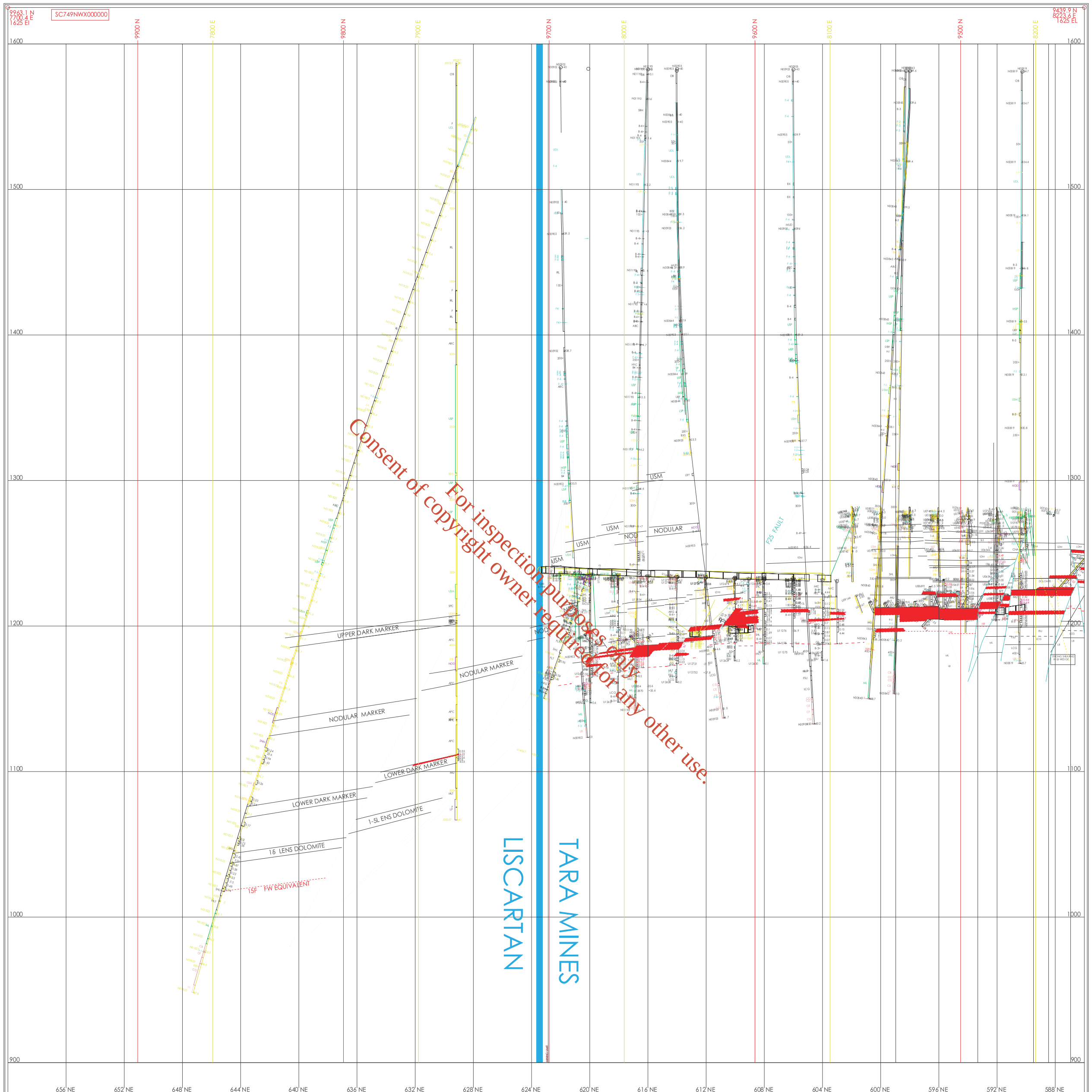


NEW BOLIDEN
Tara Mines MINE GEOLOGY

Figure 5.2 - Section 733 Liscartan

NW SECTION - 733
LISCARTAN

DRAWN	DATE	SCALE	RANGE (ddh)	RANGE (drifts)
E.HYLAND	19-02-2007	1250	40	5



BOLIDEN
Tara Mines MINE GEOLOGY

Figure 5.3 - Section 749 Liscartan

NW SECTION - 749
LISCARTAN

DRAWN	DATE	SCALE	RANGE (ddh)	RANGE (drifts)
EH		1250	40	5

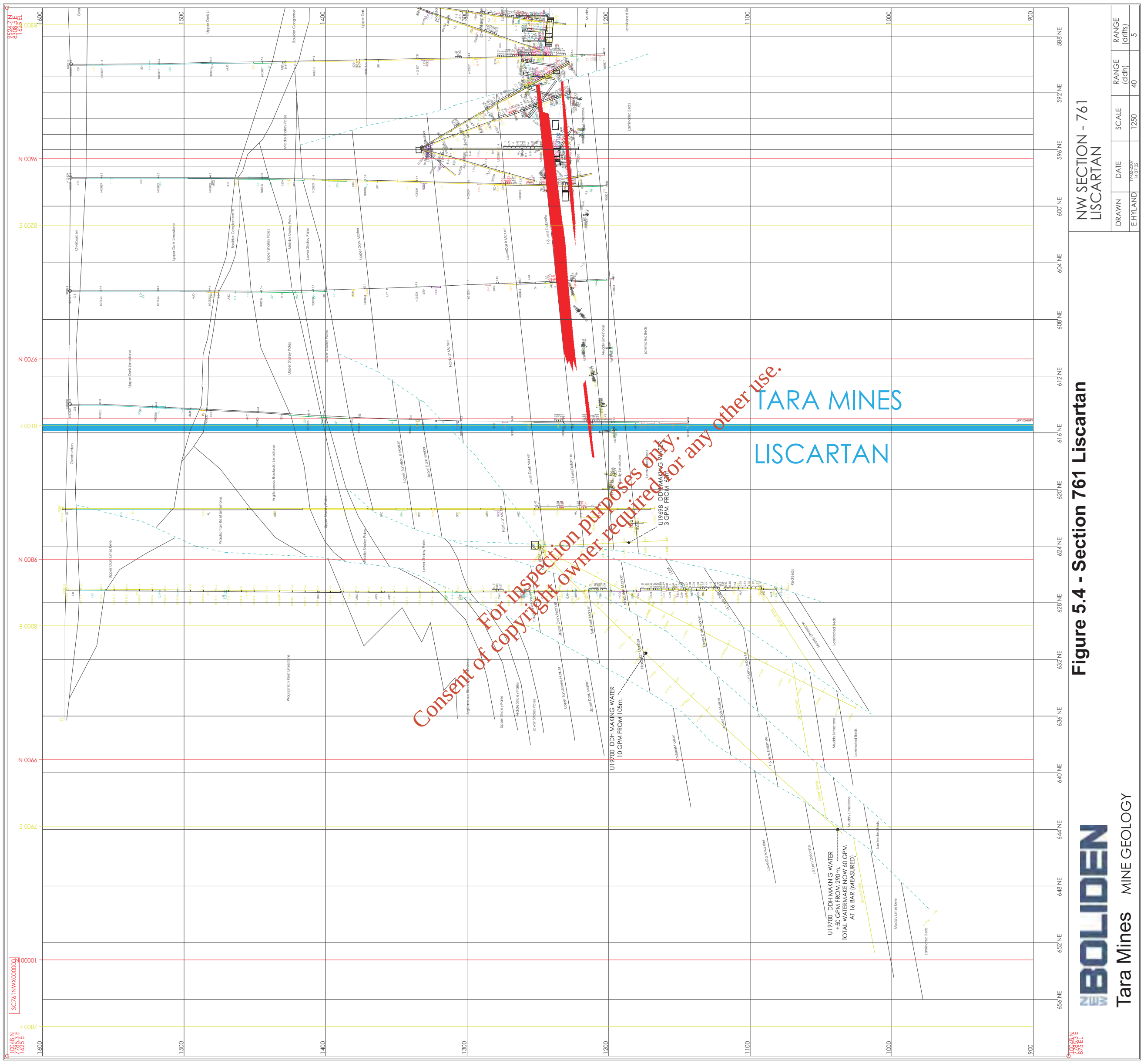


Figure 5.4 - Section 761 Liscartan

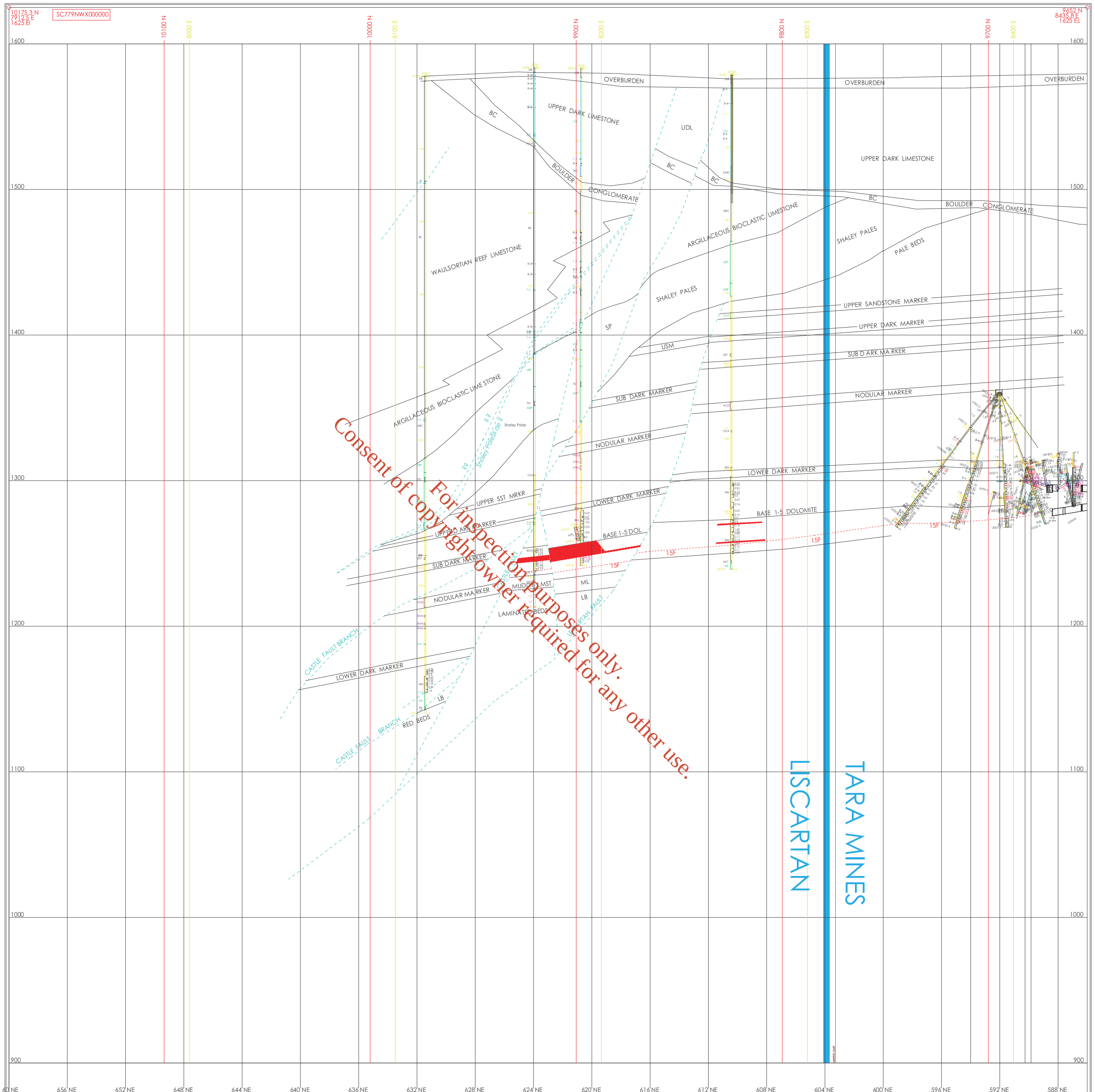


Figure 5.5 - Section 779 Liscartan

BOLIDEN
Tara Mines MINE GEOLOGY

NW SECTION - 779
LISCARTAN

DRAWN	DATE	SCALE	RANGE (ddh)	RANGE (drifts)
EH	17-02-2007 17:37:27	1250	40	5

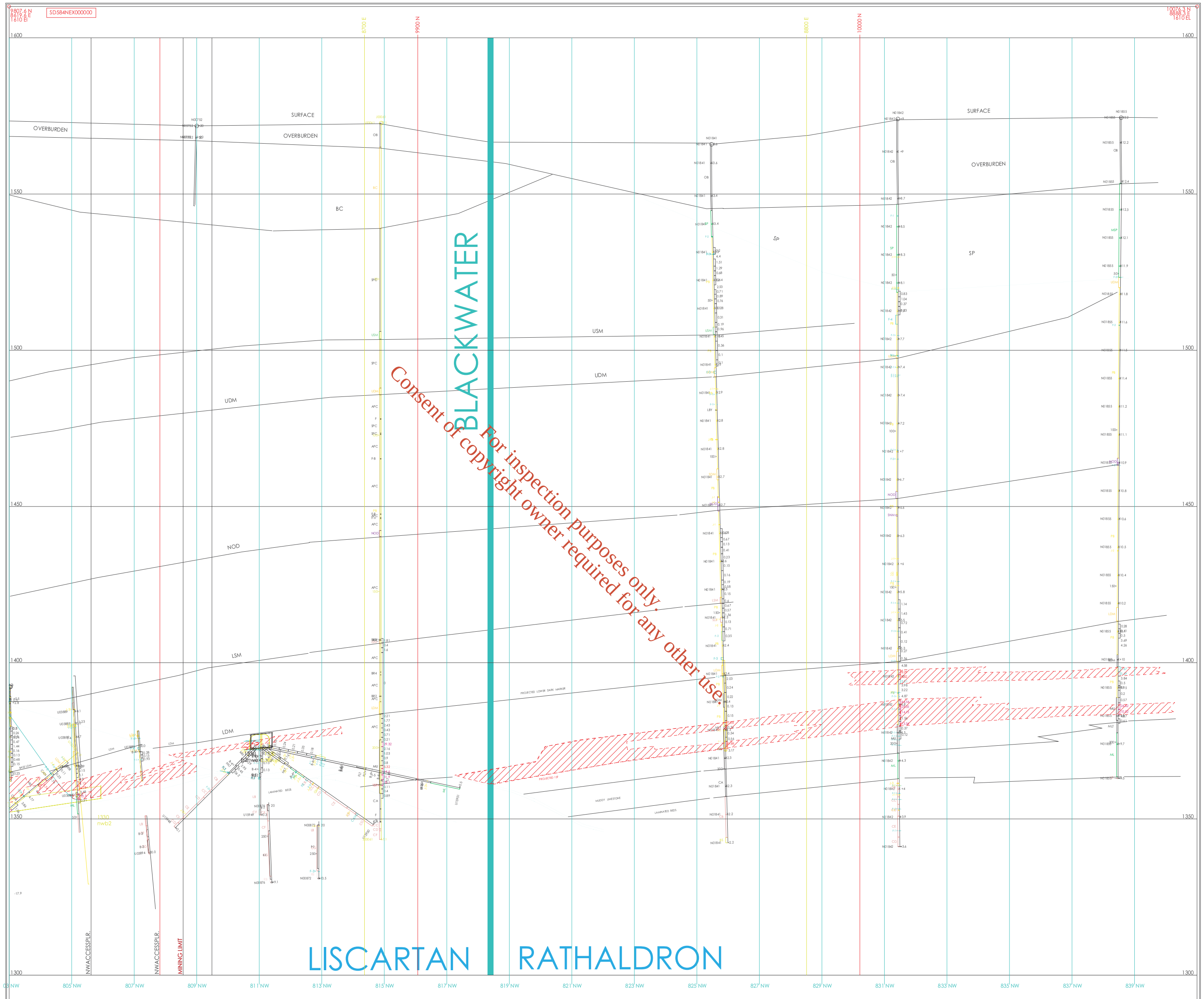


Figure 2.6 - Section 584 - Rathaldron

BOLIDEN Tara Mines MINE GEOLOGY

NE SECTION - 584
NON STANDARD

DRAWN	DATE	SCALE	RANGE (ddh)	RANGE (drifts)
E.HYLAND	19.02.2007	500	20	5

Figure 5.6 Section 584 Rathaldron

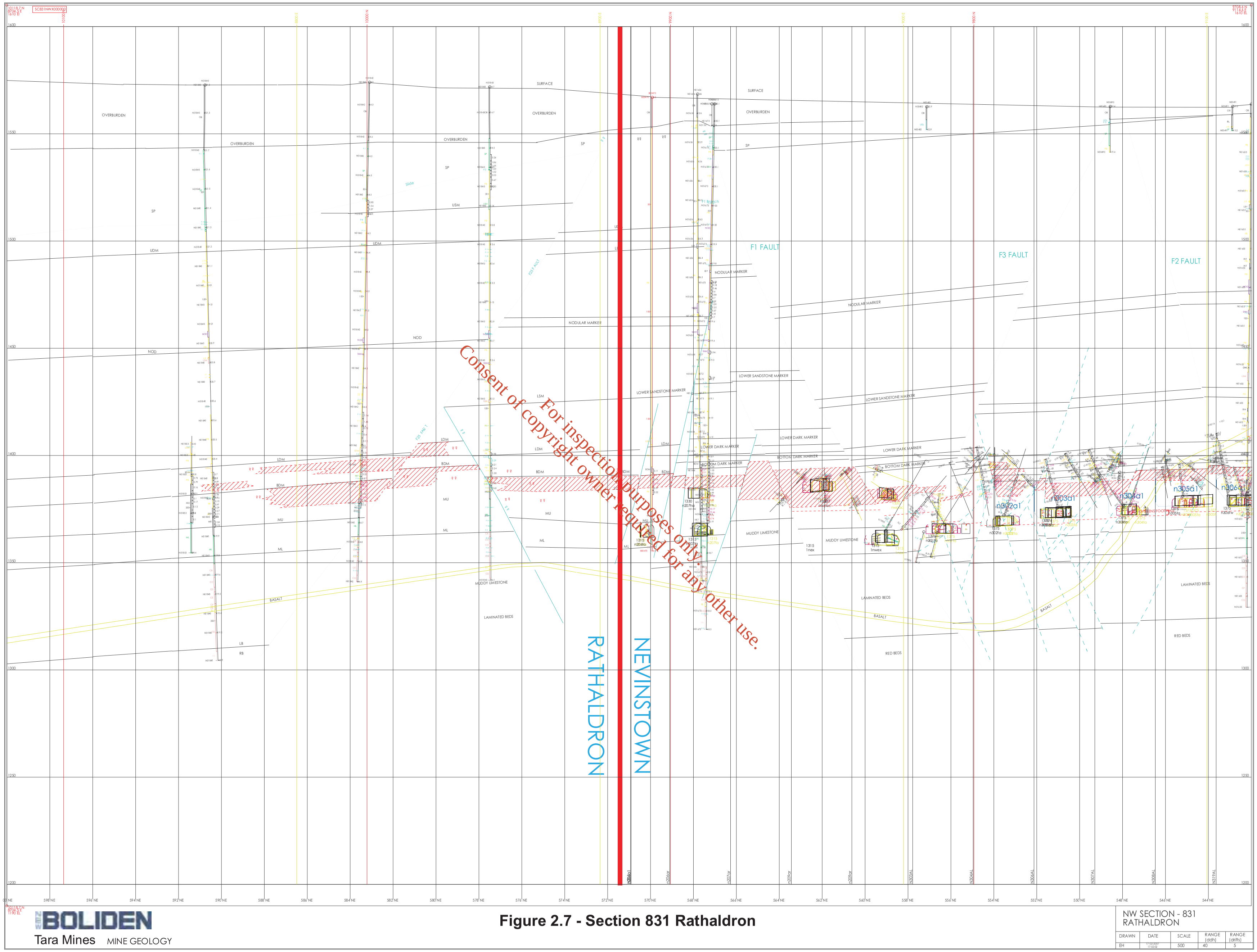


Figure 2.7 - Section 831 Rathaldron

Figure 5.7 Section 831 Rathaldron

5.3 Resources

The total reserves and resources in Liscartan and Rathaldron amount to 1.1 million made up of 0.9 million tonnes of inferred resources grading 7.71% Zn, 1.53% Pb and 0.2 million tonnes of indicated ore reserves grading 6.81% Zn, 1.48% Pb.

Tara Mines anticipate that surface and underground diamond drilling will upgrade the Inferred Resources to Indicated status and may allow better discrimination of low / high ore grades and thereby allow slightly more tonnage to be scheduled. It is considered unlikely, given the geology of the area, that there will be any significant increase in the scheduled tonnages (J Ashton pers.comm.).

All resources at Rathaldron are currently *inferred*, but this may be modified or upgraded with further drilling and evaluation.

5.4 Major Structures

Figure 5.8 is a plan showing the major structures through the areas of interest. Tara Mines provided the following descriptions of major structures in the area:

5.4.1 Castle - Liscartan Fault Complex

The Castle-Liscartan Fault Complex dips moderately to steeply northwest, and defines the north-western boundary to the horst that hosts the Navan Orebody. This fault complex apparently splays from the Randalstown Fault to the west of the current mining operations. The geometry of the fault complex is understood from surface drill-core intersections and limited underground exposure (see individual descriptions below). The Castle Fault accommodates the major component of normal displacement while the Liscartan Fault forms a persistent footwall branch perhaps representing an earlier expression of extensional movement in the area. Complex sliding within the Shaley Pales in association with these two faults indicates that these structures are at least Courceyan in age.

Liscartan Fault Zone: Striking northeast and sub-parallel to the Castle Fault system, the Liscartan Fault shows a normal displacement to the northwest. The throw is variable and is interpreted as ranging from 30m on section 729NW decreasing to10m on section 779NW. The dip of the fault varies from ~ 45 - 65^{o}. Where intersected underground in 1230 B17EX, mapping shows the Liscartan Fault as a 20m zone of at least 10 distinct branches. At its northeast end, the dips are sub-vertical. Overall throw across this zone is >50m. When first intersected in 1230 B17EX (in 1998) the Liscartan Fault Zone yielded approximately 0.4 litres/sec of groundwater. This water make has since dried up but the zone remains damp.

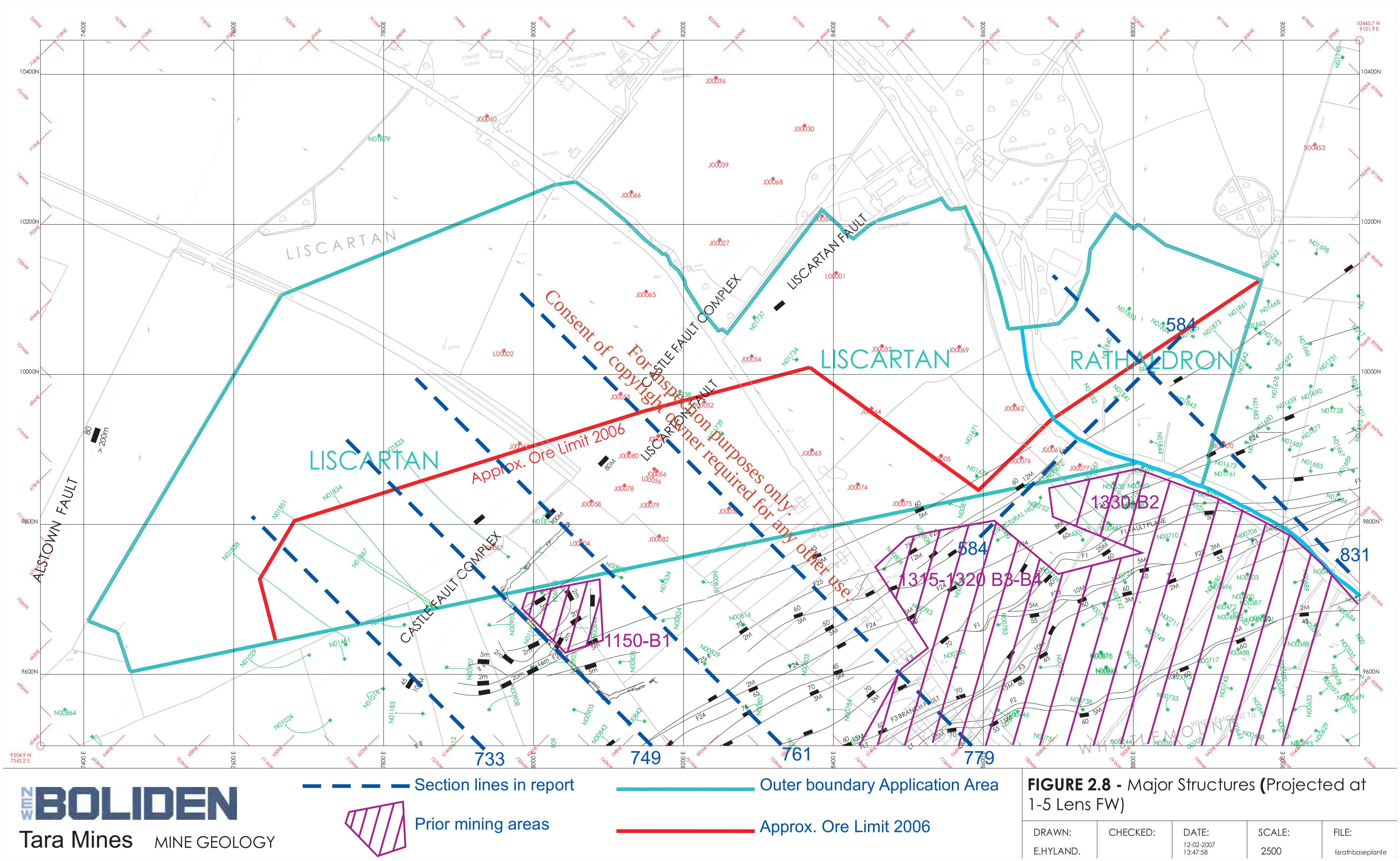


Figure 5.8 Major Structures (Projected at 1-5 Lens FW)

Castle Fault Zone: With the exception of the interpreted branch faults noted above there are no underground exposures of the Castle Fault system. The system strikes northeast and is interpreted to have normal throws to the northwest in the order of 80 to >100m. At least six distinct branches have been interpreted and at the 1-5 lens ore footwall the fault system may splay laterally over a distance in excess of 100m. Recent underground delineation diamond drilling in December 2006 hit water in two of the three holes drilled. Borehole U19700 drilled at -45^o through the fault system continues to yield 4.5 litres/sec at 16 bar.

5.4.2 F24 – F25 Faults

F24 occurs approx. 30-50m northwest of F1 at the 1-5 lens ore footwall (Figure 5.5). It strikes sub-parallel to the ore, and dips 45-70^o to the southeast. It has a maximum normal displacement of 8m and is often leached and wet. No major or continuous water makes have been recorded from its underground exposures. It branches into at least two distinct components where mapped at the western end of the 1315 190N River Pillar development.

F25 is located approximately 70-100m northwest of F1 at the 1-5 lens footwall, and strikes ENE sub-parallel to F1 (Figure 5.5). It is distinguished from the remainder of the ENE trending suite of faults by its opposite dip towards the northwest, between 45-65^o. Average normal displacement to the northwest is in the region of 10m.F25 is calcitic and locally vughy along its mapped length. It was always wet when intersected in Block 4W and Block 15W development. In Block 17W, together with its associated structures, F25 continues to make water at a rate of 5.3 – 6.0 litres/sec.

5.4.3 Randalstown Fault

The Randalstown Fault is a major, late, northeast to NNE trending sinistral-reverse fault that dips steeply northwest. The reverse component of motion is of the order of 200m and the fault is suspected of having a significant sinistral wrench component. The fault outcrops in the western part of the Liscartan area but dips away from the area of the Application and does not intersect the resource area. It is not known whether or not this fault carries groundwater but holes drilled in the northwest part of Zone 1 suggest that, like the A and C faults, it is a tight shear zone rather than an open fissure. It will not be intersected during mining.

5.4.4 Discussion

The numbered faults above are essentially small structures identified by underground mapping and drilling at the ore horizon. Surface drillhole spacing is often inadequate to ascertain whether these faults penetrate the hangingwall rocks above the Pale Beds. It is considered unlikely that these faults extend into the Upper Dark Limestones (UDL) since the principal extensional phase of movement at Navan occurred before these rocks were deposited. However, it is highly likely that parts of the Castle and Liscartan faults extend through the hangingwall rocks (Shaley Pales, ABL, Waulsortian Reef Limestone, Boulder Conglomerate and Upper Dark Limestones) to surface. Some older interpretations of this fault complex placed a later reverse/wrench movement on the Castle Fault. It does seem likely that this fault had some compressional movement at this time.

5.5 Mining

5.5.1 General Description

Access to the Liscartan and Rathaldron orebody will be exclusively via underground development from the existing operations of Tara Mines. Underground drifts from existing mine workings at varying locations and depths will provide access for mining purposes. All mine services such as compressed air, water, ventilation etc will be carried through the existing mine into Liscartan and Rathaldron.

All mine development is to be accessed from the existing mine, and all ore resulting from development will be transported to the existing mine crusher and conveyor system. Waste rock will be either dumped into suitable openings underground, when these are available, hauled to surface for temporary storage, or directed to a crusher for later hoisting to surface.

Hangingwall drifts will be driven some 20-50m above the orebody to facilitate exploratory diamond drilling, ventilation and backfill functions.

Ore thicknesses are limited in the areas of interest, hence mining in the area will be development intensive. The selected mining method will generally be longhole open stoping where ore thickness proves to be sufficiently high, together with variations on room-and-pillar mining in areas of thinner ore (down to 4m). Open stoping will utilise a primary / secondary extraction sequence as per current practice in the main mine. Cemented backfill will be used for initial primary stoping and a mixture of cemented and uncemented backfill for later (secondary) stoping. This is also the current practice in the existing mine. Longhole open stoping is sequential, that is, stopes are mined in sequence and each stope is filled before mining of adjacent stopes can commence.

In room-and-pillar mining roof stability is achieved through the design of stable rock pillars, provision of roof support, and the use of larger regional pillars where the gross mining spans are large. Geotechnical aspects of these methods are described below.

All ventilation requirements will be met by the existing mine ventilation system. Further description of the proposed ventilation scheme is provided elsewhere in the Tara Mines' submission documents. There will be no ventilation-related connections to surface in the Liscartan and Rathaldron or adjacent areas.

Mined-out areas will be backfilled with sand-fraction mill tailings with added cement when required, that will flow through an extensive underground pipeline network connected to the existing mine backfilling facilities. Stopes and pillars will be backfilled through holes drilled down into the roof of the excavation and backfill poured down into the void over an extended period until the stope is filled. There will be no backfilling-related connections to surface in the Liscartan and Rathaldron or adjacent areas. In addition, and whenever feasible, waste rock from development will be placed in stopes, prior to backfilling.

5.5.2 Extraction Areas

The extent of planned extraction in the two areas is shown in Figure 5.1. The approximate area defined by the current Inferred Resources (outer boundary) at Liscartan is 17 hectares, and that at Rathaldron is 3 hectares. This report assumes that the current areas of Inferred Resources will be mostly upgraded to Indicated Resources by further drilling, and hence be incorporated into the mine production schedules, although this is a conservative assumption and the actual upgraded tonnage may be significantly lower.

5.6 Prior Mining Activity

Liscartan

The closest prior stoping to the Liscartan area is in the 1315-1320 B3-B4, 1320-B2 and 1150 B1 areas, at the western extremities of the main Tara Mine (refer Figure 5.1). Each of these involved the mining of small uphole open stopes, with minor room-and-pillar stoping. Stoping was successful, with no particular stability issues.

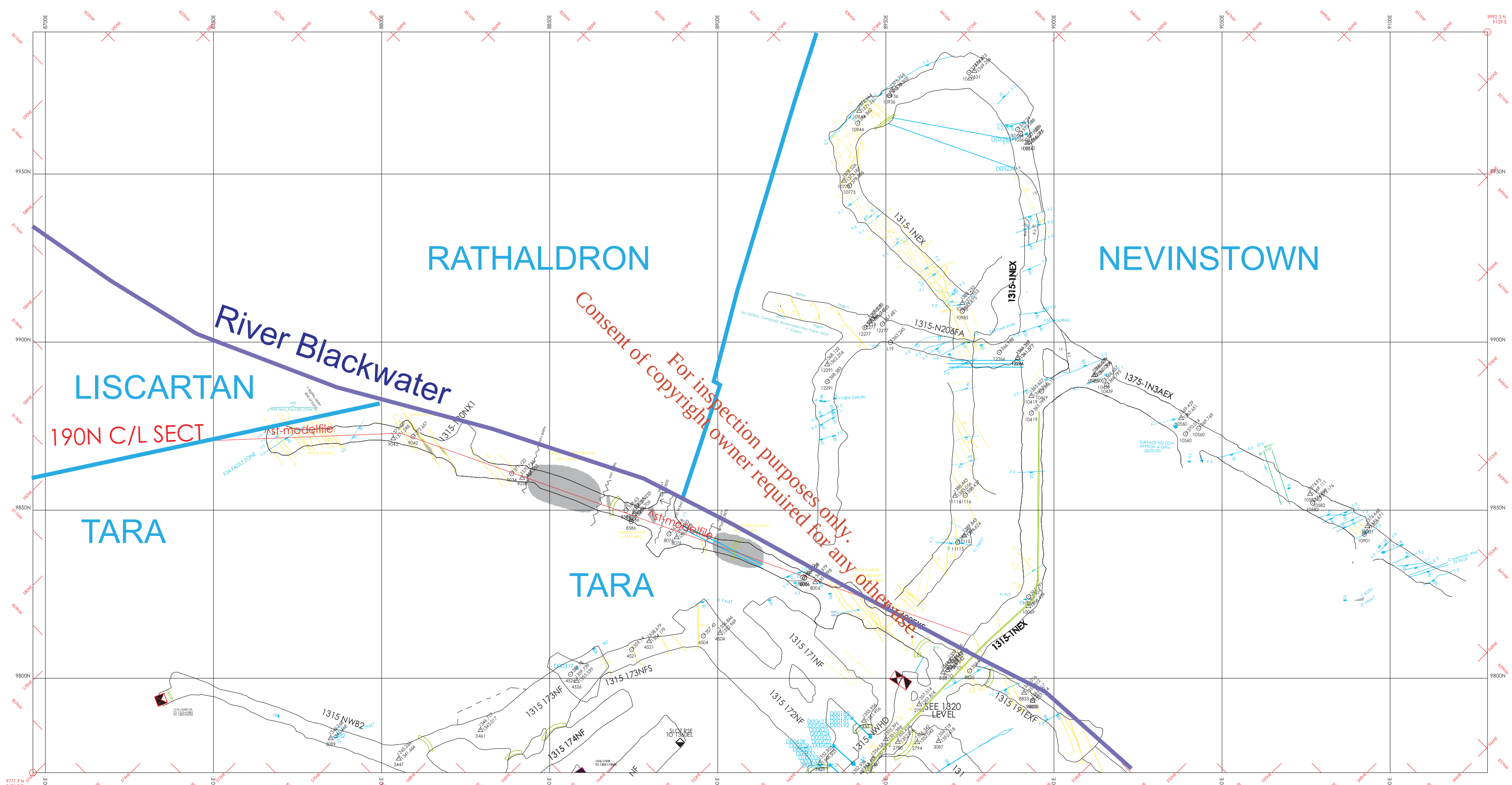
Rathaldron

The Rathaldron resource is a straightforward western extension of the Nevinstown orebody, and is expected to have generally very similar characteristics. Stoping in Nevinstown has not yet approached the boundary with Rathaldron.

However, prior stoping has occurred south of the River Blackwater, against the south-eastern corner of the Rathaldron area, and the eastern extremity of the Liscartan area. Figure 5.9 shows a plan view of the 1315 mL and 1375 mL development in the 1330-B2 area (and to the east), together with the 190N section line for Figure 5.10 (the 1330 B2 area is also shown on Figure 5.1). The section shows a series of short uphole stopes along 190N, some of which experienced hangingwall overbreak, mainly due to the local influence of the F1-F23 fault systems (with associated zones of cavities and leaching), but also partly influenced by the close proximity of the LDM unit in the hangingwall. The concentration of fault splays is very apparent in the centre of the figure.

The cavities and leaching are associated with the F1 fault system, which trends ENE and continues into the Nevinstown area (Figure 5.1). The F1 fault does not pass through either Rathaldron or Liscartan. Nevertheless, an area of poorer ground conditions is recognised in the south-eastern corner of Rathaldron, which is discussed in the following section.

A discussion on cavity development relating to these areas is provided in the companion WMC hydrological report.



NEW BOLIDEN Tara Mines MINE GEOLOGY

Figure 3.1 - 1315 Level

1315 LEVEL NW MAPPING PLAN and 190N C/L SECT LOCATION

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E.HYLAND.		12-02-2007 14:04:39	500	lisrath1315map190

Figure 5.9 - 1315 Level

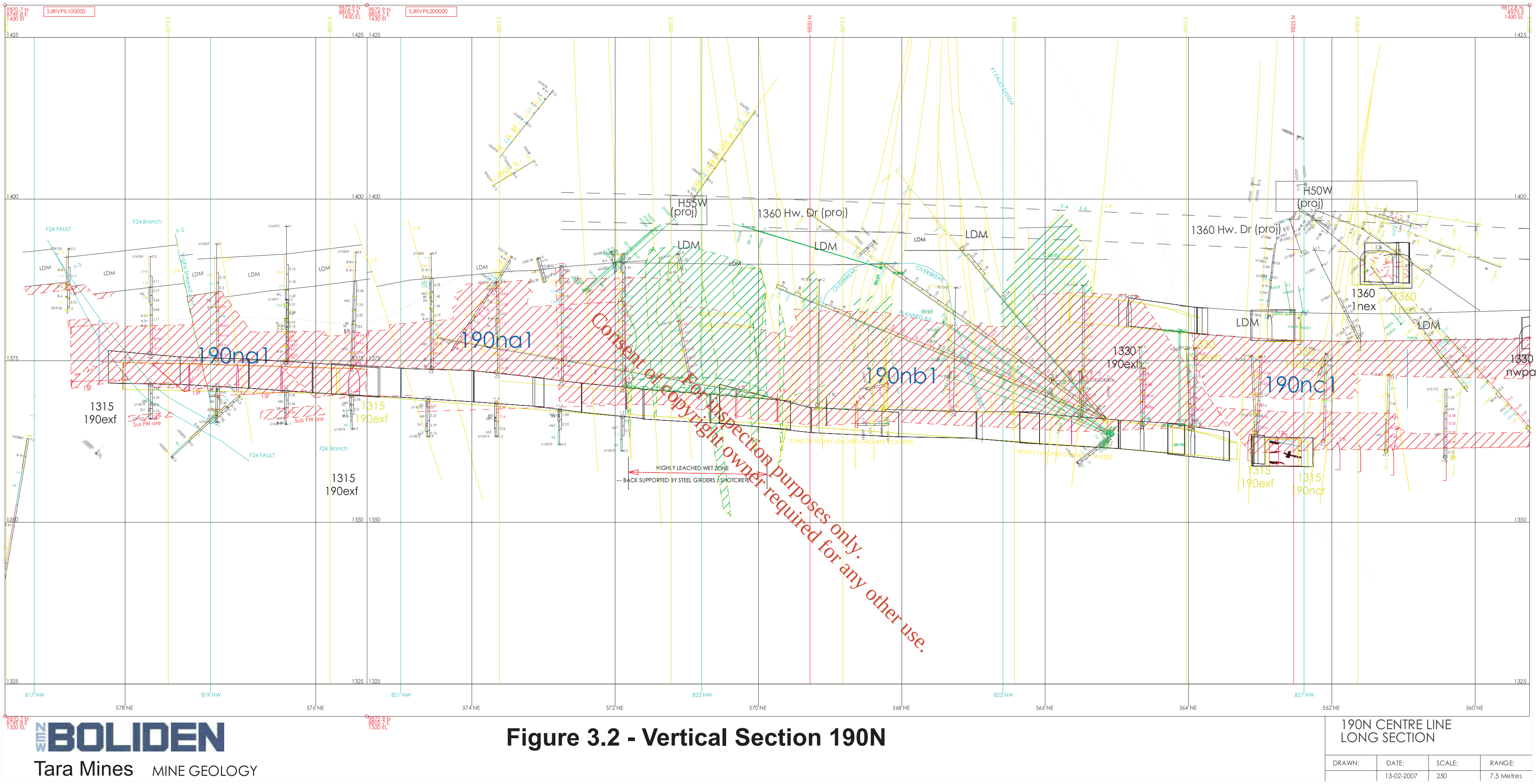

Figure 3.2 - Vertical Section 190N

Figure 5.10 Vertical Section 190N

5.5 Geotechnical STUDY

5.5.1 General Characteristics

The geological and geotechnical conditions in both Liscartan and Rathaldron are very similar to those in the main areas of the existing mine, including the Nevinstown area (which lies immediately adjacent and to the east of Rathaldron). The only significant differences are associated with the Liscartan – Castle Fault Complex which passes through the centre of Liscartan. The characteristics of this fault complex have been discussed above.

As noted, an area of poorer ground conditions also exists in the south-eastern corner of Rathaldron, against the Blackwater River boundary, and associated with the F1 fault system. Examples of stoping difficulties associated with this fault were referred to in the previous section. However, the F1 fault does not pass into Rathaldron, but continues on a ENE strike into the Nevinstown area.

Figure 5.7 (Section 831NW) shows the occurrence of relatively minor cavities and leaching in drillholes in the western areas of Nevinstown, but with no significant similar effects in the central areas of Rathaldron. Again, the companion WMC report addresses cavity development.

The stability of mine workings in relation to possible surface effects is governed largely by the stability of the rockmass directly above the mining areas (often referred to as the hangingwall). In the case of the 1-5 Lens extraction in Liscartan and Rathaldron, the hangingwall comprises the competent Pale Beds, and a micrite sub-unit within the Pale Beds. A stratigraphic marker horizon called the Lower Dark Marker (LDM) may either form the hangingwall to the ore lens, or be up to 25-35m above. This comprises a relatively thin horizon (typically 5m thick) of dark siltstones and shales. If stoping extends up close to the LDM the stope back may be cable bolted, to reduce the risk of hangingwall dilution, or some overbreak may occur. However, the unit is only thin and the Pale Beds above are competent.

A weaker unit called the Shaley Pales occurs approximately 150m above the 1-5 Lens in Liscartan, but is absent in Rathaldron. This unit is too far above the proposed Liscartan stoping to have any impact on large scale stability, and is not considered any further here.

Mine design processes at Tara Mines consider the detailed characteristics of all of the rocks hosting the mineralisation, and this process it outlined in a following section of this report.

5.5.2 Rockmass Characteristics and Rock Strength

A substantial database of rock properties is available at Tara Mine, testwork having been conducted in various campaigns since the 1970's.

Table 5.1 summarises the typical rockmass conditions and intact rock strength for the key lithologies at Tara Mine. The same general characteristics are expected to apply to Liscartan and Rathaldron, but Tara Mine should confirm this is the case during routine drilling and data collection operations.

Table 5.1 Summary Geotechnical Characteristics of Key Lithologies

Lithology	Description	Q-System Typical Range[(1)]	Average UCS_{50} [(4)] (MPa) [subscript = number of samples]
Upper Dark Limestone	Variably but frequently thick-bedded dark limestones, with mudstone interbeds. Polished bedding planes common in shale interbeds. Typically bedding plus one joint set.	0.9 – 3.3 Median 1.9	$172_{(16)}$ S.Dev. 63
Boulder Conglomerate	Debris flow conglomerate, with variable clasts and matrix.	2.3 – 13.2 Median 5.4	94 S. Dev. 44
Pale Beds	Strong, medium to coarse grained limestones, partly dolomitised, commonly thickly bedded, but with minor shale / sandstone layers which may contain polished bedding planes. Typically bedding planes plus two orthogonal joint sets.	8.8 – 30.2 Median 14.0	161 [(2)] $_{(6)}$ S. Dev. 64
Fault Zones	Zones of disturbance with discrete faults which may be tight or partly open, and may contain thin gouge-filled splays.	0.7 – 3.5 [(3)] Median 1.5	N/A

1. Refers to the NGI Q-System of rockmass classification. Range stated as lower and upper quartiles.
2. Mineralised Pale Beds.
3. Applies to fault zones generally – discrete, thin intervals of much poorer condition will occur within each zone.
4. UCS_{50} is the uniaxial compressive strength, normalised to 50mm diameter core.

Tara Mines staff regularly undertake stress analysis modelling of stoping and mine sequences. The *rockmass* properties for Pale Beds used in these analyses (which Tara staff maintain is based on back-analysis of actual behaviour) is:
Young's modulus 40GPa, Poisson's ratio 0.25, UCS_{mass} 60MPa
This has not been independently verified by AMC, but does appear to fit with operations experience in the main mine.

5.5.3 Virgin Stress Field

The in-situ stress has been measured on a number of occasions in different areas of the Tara Mine. The general mine stress field is stated as being (D. Feng, pers.comm.) (dip positive down):

Major principal stress ($\square_1$) =14 MPa, bearing 305^o, dip 20^o
Intermediate principal stress ($\square_2$) = 11 MPa, bearing 135^o, dip 70^o
Minor principal stress ($\square_3$) = 3 MPa, bearing 036^o, dip 03^o
[at a depth of ≈ 270m below surface].

The measurements have consistently shown that the major principal stress ($\square_1$ trends to the NW (ie. parallel to the orebody strike, perpendicular to the trend of the orebody, and perpendicular to the NE-SW trending normal faults); the intermediate stress ($\square_\square$is approx. normal to the bedding in the Pale Beds; and $\square_\square$ (the minor principal stress) is essentially parallel to the bedding in the Pale Beds.

5.5.4 Weathering

Weathering of the rocks at Rathaldron and Liscartan, and over the Navan orebodies as a whole, is remarkably shallow with fresh rocks generally very close to the base of overburden (within 5-10m). The uppermost 3-6m of the UDL (where sub-cropping) is commonly more intensely fractured, with evidence of iron-staining and water migration along fractures. This thin zone has increased permeability compared to the fresh, relatively impermeable UDL below. The Pale Beds also show remarkably little weathering close to surface.

Weathering may extend to greater depth along major structures which connect to surface.

5.6 The Design Process

A detailed design process has evolved at Tara Mines over many years. This has been progressively revised and updated with improved understanding of the various lithologies and their behaviour during and after mining, and with the introduction of new technologies as they have emerged, such as improved surveying instrumentation, and advanced CAD software.

In respect of the use of geotechnical information in the design process for open stoping, there are three stages of drilling; (i) surface, (ii) infill drilling from hangingwall access, and (iii) stope drilling (from footwall stope development), ultimately achieving drillhole coverage in the order of 10x10m within each stope. This provides detailed information on hangingwall conditions, and allows specific stability assessments to be made on a stope-by-stope basis. These assessments also draw on substantial previous experience at the mine, and the results of numerical modelling of rock stresses and displacements around proposed excavations.

Conventional room-and-pillar mining is a man-entry method, that is mine personnel enter the stoping areas. The design process for room-and-pillar mining is similar to that for open stoping, but it is important that attention is focused on back (roof) conditions during initial development, and the design of appropriate ground support to ensure a safe and stable working environment. Current plans by Tara Mines involve a variation on the method (refer below) which does not envisage requiring man-entry into the stoping areas.

Much of the information used for final detailed design of room-and-pillar stoping comes from mapping in development access, but the results of drilling stages (i) and (ii) above are still utilised.

5.7 Open Stoping – Geotechnical Considerations

Where the ore is thicker than approximately 5m, open stoping will be adopted. This is the most common mining method used at Tara Mines.

Stope dimensions will vary, but will be typically 15m wide (maximum of 20m wide), and of variable length depending on the local ore geometry. They will extend to the full height of the ore, but in both Liscartan and Rathaldron the ore is very thin.

The stability of stope backs (roofs) is normally governed by the minimum span, in this case the stope width.

As noted above, the longhole open stoping will follow a primary-secondary sequence, with primary stopes tight-filled with cemented backfill prior to extracting the secondary pillars in between. Secondary stopes will most likely be tight-filled with weakly cemented or uncemented backfill. Experience has shown that this secondary filling also tops up any small voids remaining over the primary stopes.

Hangingwall access drifts will be available throughout the area, for infill drilling, ventilation, backfill, and geotechnical monitoring (as required).

Stope infill drilling provides valuable information on hangingwall ground conditions, in particular the spacing of bedding plane partings, intensity of fracturing generally, faulting, and the presence of any cavities or leached zones. The design of stable stoping spans is based largely on engineering judgement from previous Tara Mine stoping experience. Design techniques exist for these situations (e.g.Voussoir beam theory; empirical stope design methods), but these are not generally applied at Tara Mine.

AMC recommends Tara geotechnical staff undertake further assessments of rock conditions using rockmass classification techniques (e.g. Barton et a, 1974), and plot actual stoping spans on established design charts to compare mining conditions against these empirical guidelines.

Stress analysis may be used to estimate the likely stress conditions around planned stopes, and examine stoping sequences, but the need for this analysis is determined on a case-by-case basis. In AMC's view this is a reasonable approach, and it is common for stress analyses to be undertaken. AMC expects that some stress analysis studies should be undertaken to examine open stope sequencing and pillar stability at a more detailed stage of the design process.

Stope and development support design includes consideration of any significant wedges that may be exposed in stope walls and backs. Stope roof support may include cable bolting, depending on the spacing of weak parting planes.

In respect of potential stope failures, in the very worst case if the hangingwall effectively "caved" [1] above a 20m-wide stope void of maximum height 15m, the failure would arrest (void become filled with failed material) after it had had extended ≈ 100m above the stope back [2]. A series of factors make this a highly unlikely possibility:

- The small size of the stopes.
- The sequential nature of the stoping sequence.
- The presence of hangingwall development (suitable access for filling) 20-50m above the stopes.
- The competent Pale Beds which forms the gross bulk of the hangingwall immediately above the stopes. It is inconceivable that the Pale Beds would "cave" above such small mining spans.

It is incumbent on Tara Mines to appropriately design individual stope spans and stope support to suit local ground conditions, as per standard practices in the existing mine, and to maximise the extent and effectiveness of tight filling in stopes, to keep any unsupported hangingwall spans to a minimum. It is also necessary to maintain

[1] Caving here refers to sustained, uncontrolled failure of the hangingwall rockmass. Over such small spans this could only occur in very weak materials.

[2] Assuming the stope is completely empty, and the failed material has a 15% swell factor, and with the failure extending purely vertically above the stope.

suitable geotechnical monitoring and/or observation of hangingwall behaviour immediately above the mining areas, to ensure that any adverse changes to the response to stope extraction are identified early enough to modify the mining strategy It is expected that this monitoring can be achieved from hangingwall exploration drifts above the stoping areas.

5.8 "Room-and-Pillar" Stoping – Geotechnical Considerations

Conventional room-and-pillar mining involves the extraction of "rooms", the dimensions of which are determined from consideration of the hangingwall ground conditions, but which are typically 8-10m wide. Pillars are left in place between the rooms, usually on a regular chequer-board pattern (if the orebody geometry is regular enough), and pillar dimensions vary but would typically be in the range of 3-5m square, with the larger pillars required at greater depths, or in areas of weaker rockmass. Larger pillars are also usually required where the orebody is thicker to ensure that stable pillar aspect ratios are maintained.

Figure 5.11 shows a schematic illustration of a typical room-and-pillar layout, and a variation of benching in areas of thicker ore.

Conventional room-and-pillar mining, as proposed for the thin areas of the Liscartan and Rathaldron ores, will commonly achieve a maximum recovery of ≈ 85% of the resource, the remainder being left in pillars for permanent support. This level of recovery includes a small amount of pillar mining, usually via stripping of initially larger pillars (e.g. 5x5m pillars reduced down to 4x4m), or occasionally by removal of individual pillars completely.

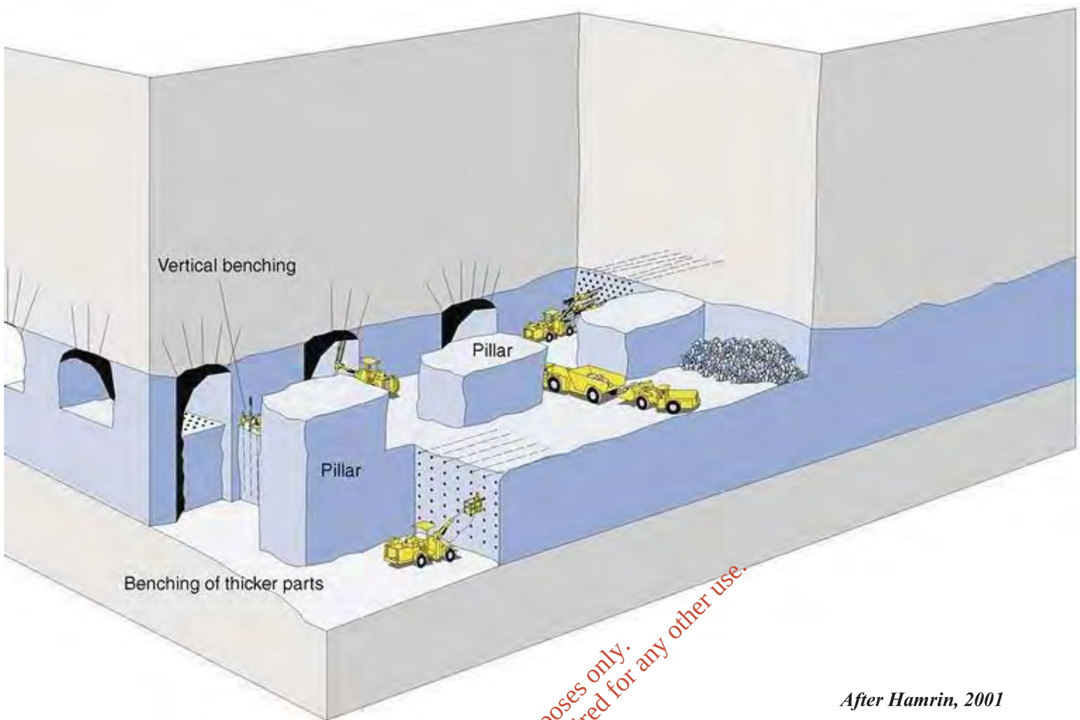

Figure 5.11 Schematic of Room-and-Pillar Mining (From Brady & Brown, 2004)

The pillar recovery phase of a room-and-pillar operation requires careful consideration of the ground conditions, pillar stresses, and hangingwall behaviour. The Cajuput Mine in Western Australia achieved good success from pillar recovery operations, with carefully engineered cable pre-support of backs prior to completely removing targeted pillars in the centre of “dice-five” patterns (Figure 5.12). If this approach was considered for application at Tara, to ensure long-term stability, these areas would need to be tight filled following pillar recovery.

Figure 5.12 is a cross-section of a room-and-pillar stope at the Cajuput Mine in Australia showing the installation of roof monitoring and additional back support (cable bolting) during pillar recovery (unpublished reference material).

It is also common practice, where the orebody covers a large area, to leave barrier pillars between mining districts or panels. The purpose of these large pillars is to arrest any “domino” style pillar failures, should they occur on one area of the mine, to stop the failure spreading to a much larger area. Barrier pillars are also referred to as haulage pillars, since they normally contain routes for main haulages and services. For example, the Lisheen Mine in Ireland has an irregular network or haulage pillars which divide the mining areas into distinct blocks or panels.

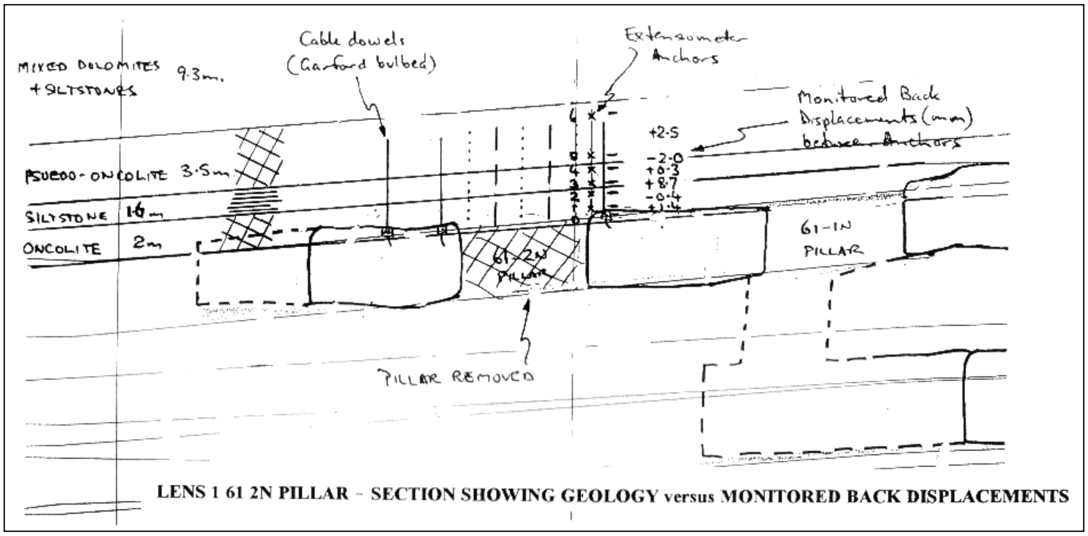

Figure 5.12 Section through Stope at Cadjebut Mine, Australia

However, current plans by Tara Mines are to utilise a "drift and slash" variation, in which initial 6m-wide drifts are later stripped on retreat to 10-15m wide stopes, leaving thin pillars between the drifts, and then subsequently backfilled. Tara Mines do not envisage any personnel entering 'stoping' areas (G. Clear, pers.comm). These plans are currently only conceptual, but are in line with previous practice at Tara Mines in thin ores.

Various empirical, analytical and numerical stress analysis methods can be applied to the design of stable "rooms", pillars, and the specification of appropriate support. Methods of hardrock pillar design are varied, ranging from empirical pillar design formulae through to numerical methods. The same processes can be applied as for the design of open stopes, but higher factors of safety would be applied to cater for the personnel-entry requirement in room-and-pillar mining.

If the final stoping plans for this area differs from the basic description above, it will be necessary to demonstrate that local and regional stability is still assured.

Once again, it is incumbent on Tara Mines to undertake appropriate geotechnical investigations, monitoring and/or observations within and above the stoping areas to ensure local and regional stability is assured.

5.11 Potential Surface Impacts

The land overlying the Liscartan area is mostly farm land, but with a public road and overhead power line passing over the eastern portion. The land overlying the Rathaldron area is farm land, also with an overhead power line passing through the centre of the area (Figure 5.1).

As noted above, a number of factors combine to make it very unlikely that underground mining would result in any discernable surface subsidence impact in the Liscartan and Rathaldron areas. These include:

- The proposed depth of mining.
- The limited ore thicknesses.
- The limited areal extent of individual stopes.
- The use of tight backfilling and a primary / secondary sequence in open stoping extraction.
- The limited stoping spans and use of sequential backfilling in thin ores where "drift and slash" methods will be used.
- The use of cable bolt support in areas of poorer stope roof conditions.

In case a stope does experience some failure, and in the unlikely event that failure is self-propagating, it is important for the mine to respond promptly with stope filling to arrest the failure, the fill being placed from the hangingwall drive up to 50m above.
The hangingwall drives are also good locations from which to install stope hangingwall monitoring instrumentation, such as extensometers. AMC recommends instrumentation is installed in cases where ground conditions are poor in respect of the planned (overall) stoping spans. Extensometers or other displacement monitoring devices would be appropriate, providing suitable access is available from existing development. Where this is not the case, alternative methods such as 'local' seismic monitoring should be considered. This has the advantage of providing monitoring coverage over a larger three-dimensional volume than is possible with conventional methods. Portable seismic stations are available, which can be used stand-alone, or coupled with other units for grater coverage and event resolution.

If the mining method for thin areas is changed to more conventional room-and-pillar stoping, design practices should be modified to those more typical of such operations, with special consideration given to support of stope backs, and the design of stable pillars.

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SECTION 6 HYDROLOGY

6.1 Background

6.1.1 Description of the mining areas

Boliden Tara Mines Limited (Tara Mines) is located about 2 km West of Navan, County Meath, and about 45 km NW of Dublin. It is the most productive zinc mine in Europe and the fifth most productive in the world. Figure 6.1 shows the location of the mine and the application area.

The mine exploits the Navan Zn-Pb deposit, which was discovered in 1970 by the Tara Exploration & Development Company Ltd. Development of the orebody began in 1973 and production of concentrate started in June 1977. On 1st January 2004, the ownership of Tara passed to Boliden. The currently projected mine life extends past 2018.

The mine is currently divided into the following sub-areas for management and planning:

- The Central Area, also known as the Main Mine or Knockumber Mine. This was the first area to be mined. It has largely been mined out.
- The South West Extension (SWEX), to the southwest of the Main Mine.
- Nevinstown, to the north of the Main Mine.

SWEX and Nevinstown are currently being developed and mined by trackless underground methods, principally long hole open stoping with backfill. Room and pillar methods are applied where the ore is thinner. Access to the SWEX and Nevinstown is from a portal at the Main Mine site.

An expansion of the mine workings is currently being planned into the Liscartan and Rathaldron application areas, located to the northwest of the Main Mine area, as shown in Figure 6.2. The expansion of the mine workings into the Liscartan & Rathaldron application areas would be accessed from the existing underground workings and would use similar mining methods to those currently being employed. The hydrogeology of the Liscartan and Rathaldron areas is described in this report.

Elevations relating to Tara mine are measured with reference to the unique Mine Datum which is at 1526.7 m below Ordnance Survey Malin Datum. In this section all reference to groundwater levels, and references to other data which have an elevation associated with them, are reported in both metres above or below Ordnance Datum (mAOD/mBOD) and metres above Mine datum (mAMD).

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Figure 6.1 General location map

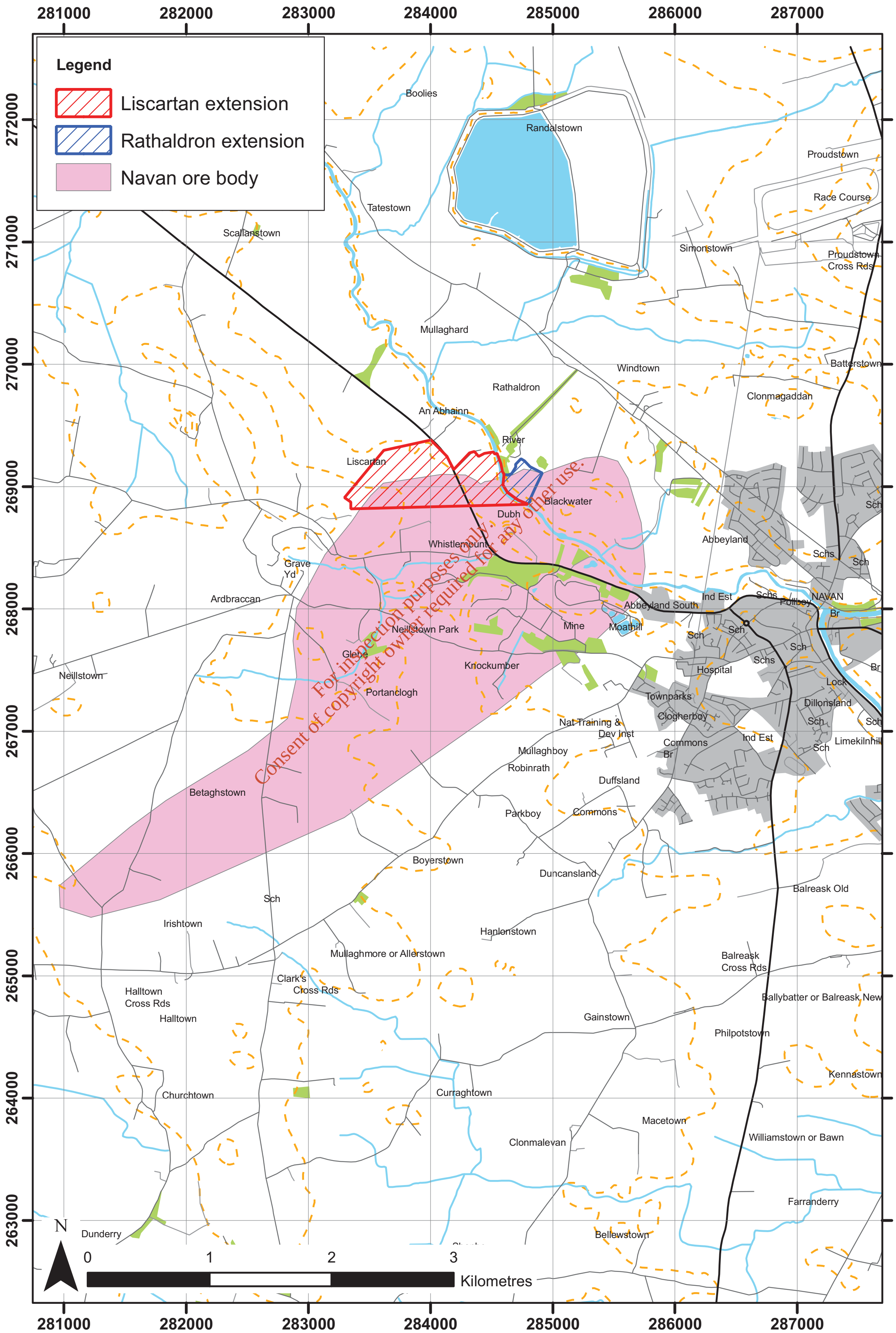

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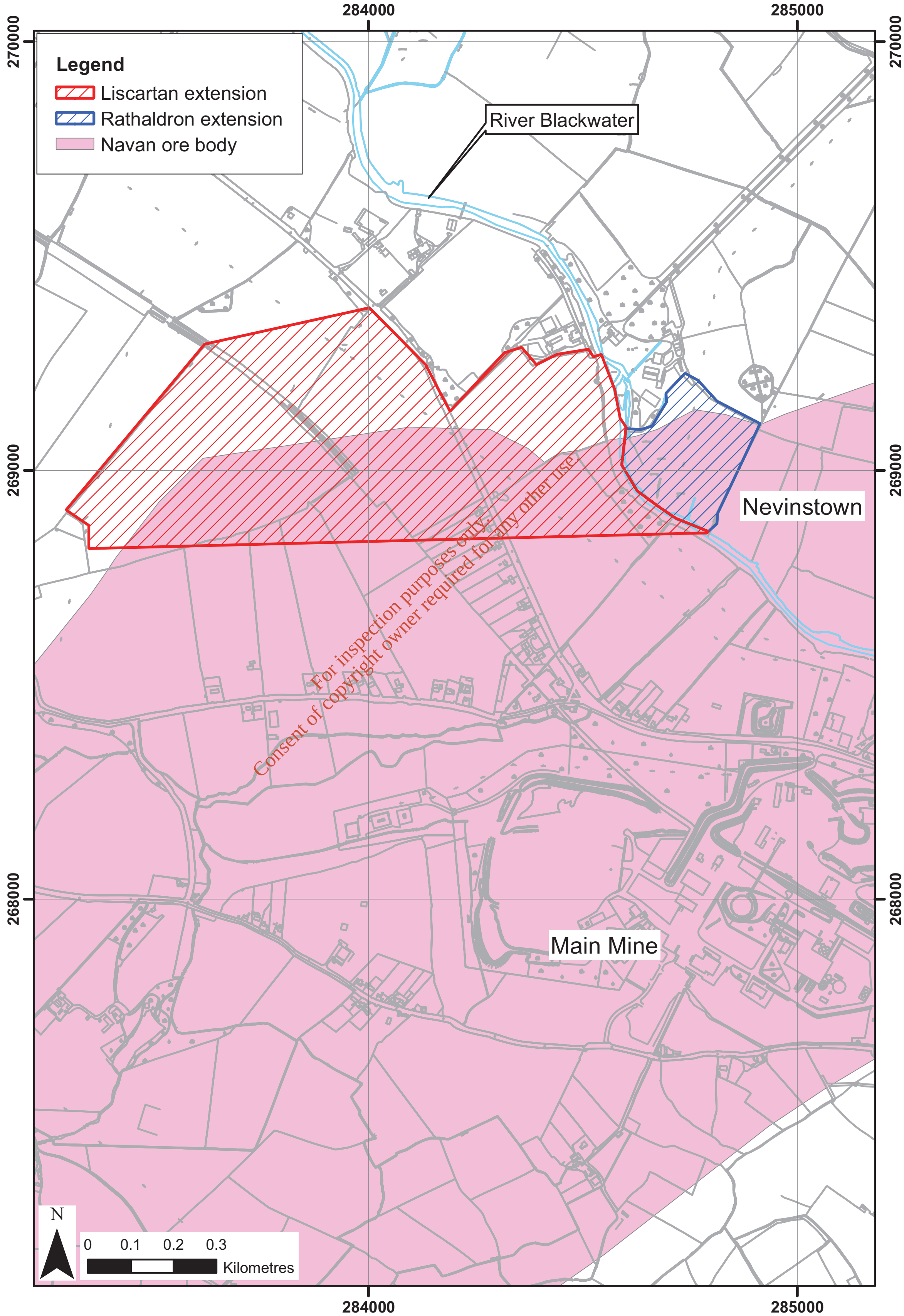
Figure 6.2 Location map of the Liscartan/Rathaldron application area



6.1.2 Physiographic setting

The area around the Tara Mine comprises flat to gently undulating farmland, with some relatively recent residential development. Ground surface elevation along the River Blackwater is around 62 metres above Ordnance Survey Datum (maOD) as it flows through the area of the Liscartan/Rathaldron application area. The elevation of the land surface rises away from the River Blackwater, attaining around 75 maOD in the centre of Rathaldron, and around 93 maOD in the southwest of Liscartan. Figure 6.3 shows the topography of Liscartan and Rathaldron.

The River Blackwater defines the boundary between the Liscartan and Rathaldron land holdings, and also separates Nevinstown from the Main Mine area. The River Blackwater is a major tributary of the River Boyne. The source of the Blackwater is Lough Ramor, County Cavan, from where the Blackwater flows about 30 km SE to join the Boyne at Navan

6.1.3 Navan deposit

The Navan orebody extends to within a few metres of ground surface in the Nevinstown area and to 150 metres of ground surface in the Liscartan and Rathaldron area, where it is covered by variable glacial drift. The orebody dips to the southwest. In the extreme southwest of the SWEX area, known as SWEX B, it is around 900 m below ground level. The mineable ore thickness ranges from 4 m, the height of a drift, to 80 m. The thicker ore is generally found in the east of the deposit. The plan view dimensions of the orebody as currently defined are 5.7 km (NE-SW) by 1.9 km (NW-SE).

Figure 6.4 is a stratigraphic column for the Navan deposit. The deposit is hosted in limestones and dolomites of Lower Carboniferous age. The Pale Beds are often permeable and cavities are present in certain areas. Drill holes may lose water to fractures when penetrating the Pale Beds due to the presence of a vadose zone within the Pale Beds resulting from dewatering of the mine workings. The principal unit overlying the Pale Beds is the Upper Dark Limestones (UDL), which tend to be strongly bedded and contain abundant shaley horizons. In general, the UDL is considered to form a low permeability “roof” to the Pale Beds.

Most of the economic mineralisation occurs within the Pale Beds as complex, strata-bound tabular lenses. The lenses strike between NE and ENE, roughly parallel to the major faults. The lenses are frequently dislocated by faulting. The ore occurs within the lenses as high grade massive sulphides or lower grade disseminated sulphides. The degree of mineralisation is generally greatest close to the base of the Pale Beds, within a basal micrite and associated dolomites.

Laterally, the orebody is divided into three sections, Zones 1, 2, and 3, by faults as shown in Figure 6.6. The Liscartan & Rathaldron application area is part of Zone 1. Stratigraphically, the lenses are numbered from 1 to 5, by reference to the base of the various Pale Beds marker horizons. Lens 5 is the lowest lens in the sequence. The lenses are referenced with a zone-lens number. The lowest lens in Zone 1, for example, is the 1-5 Lens.

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Figure 6.3 Topography of project area

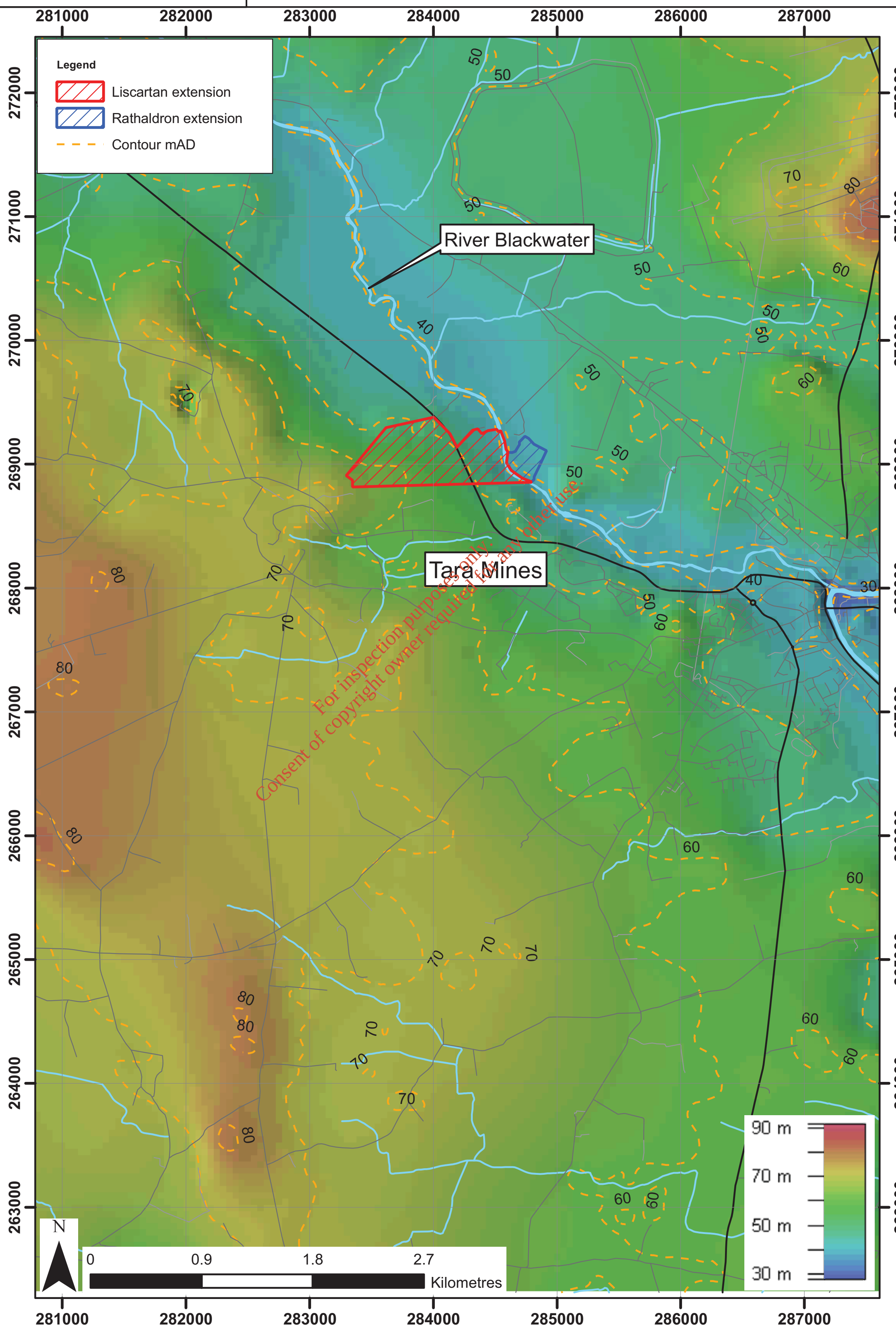

Figure 6.4 Generalised stratigraphy of Tara Mines

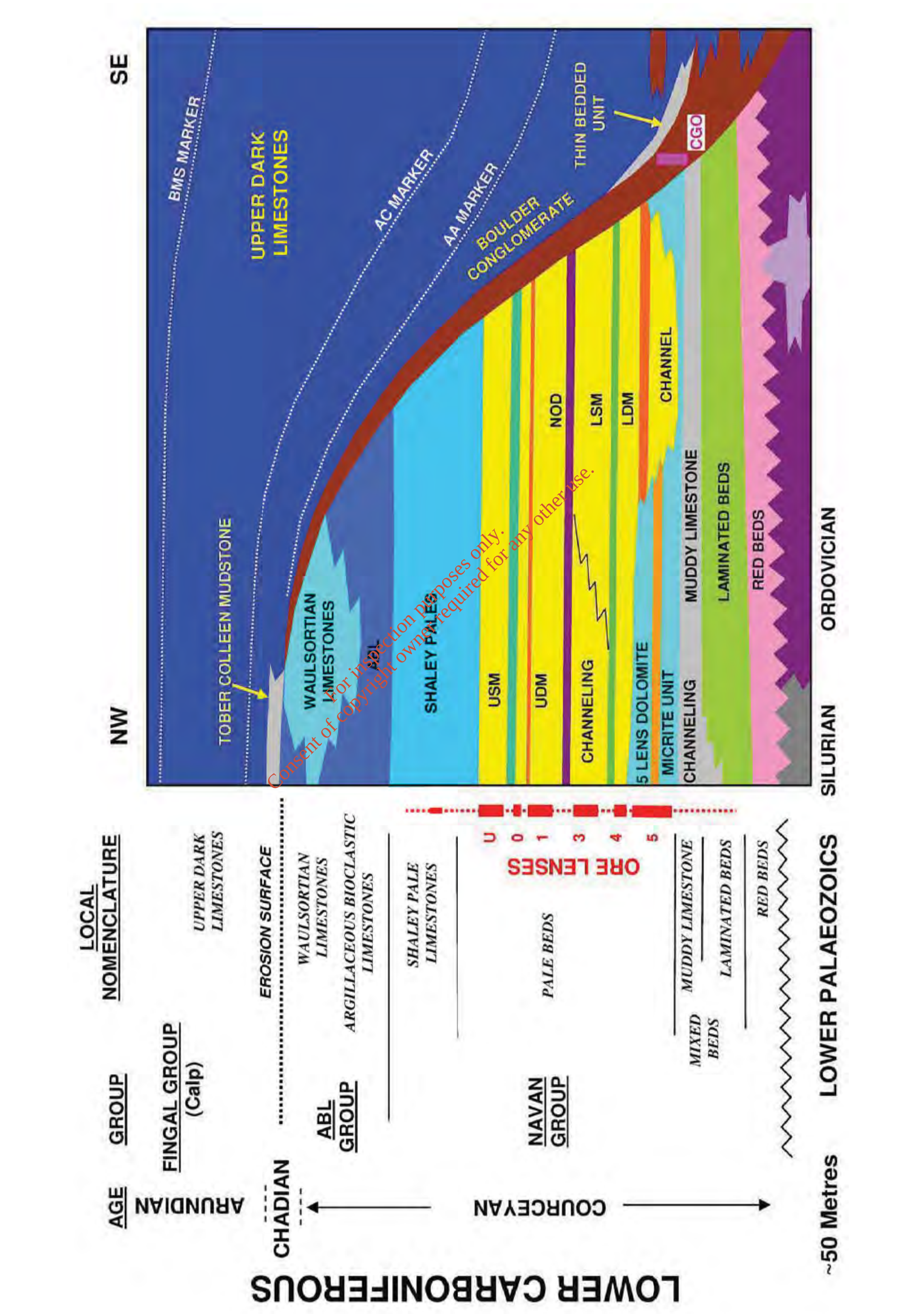

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Figure 6.5 Mean monthly rainfall

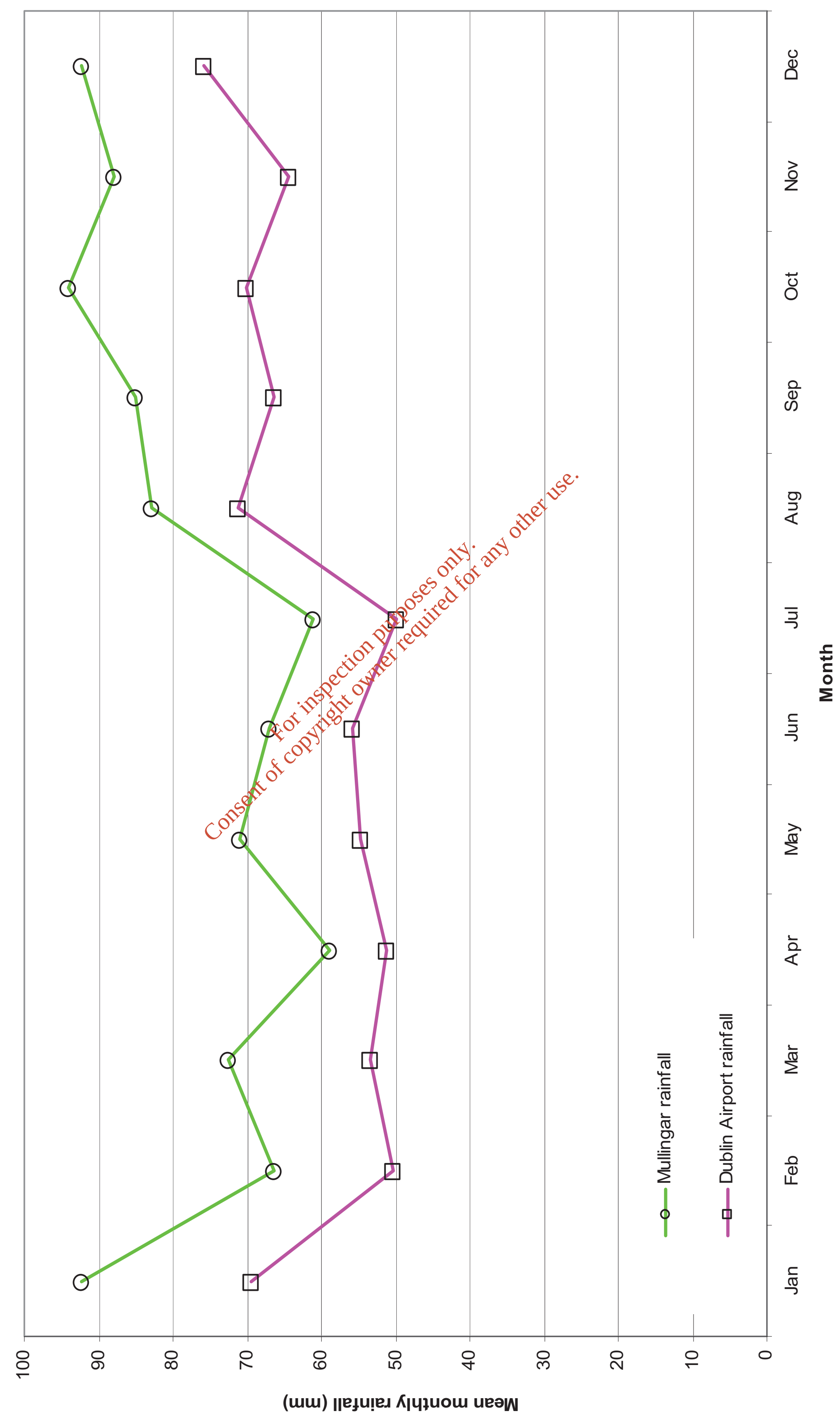

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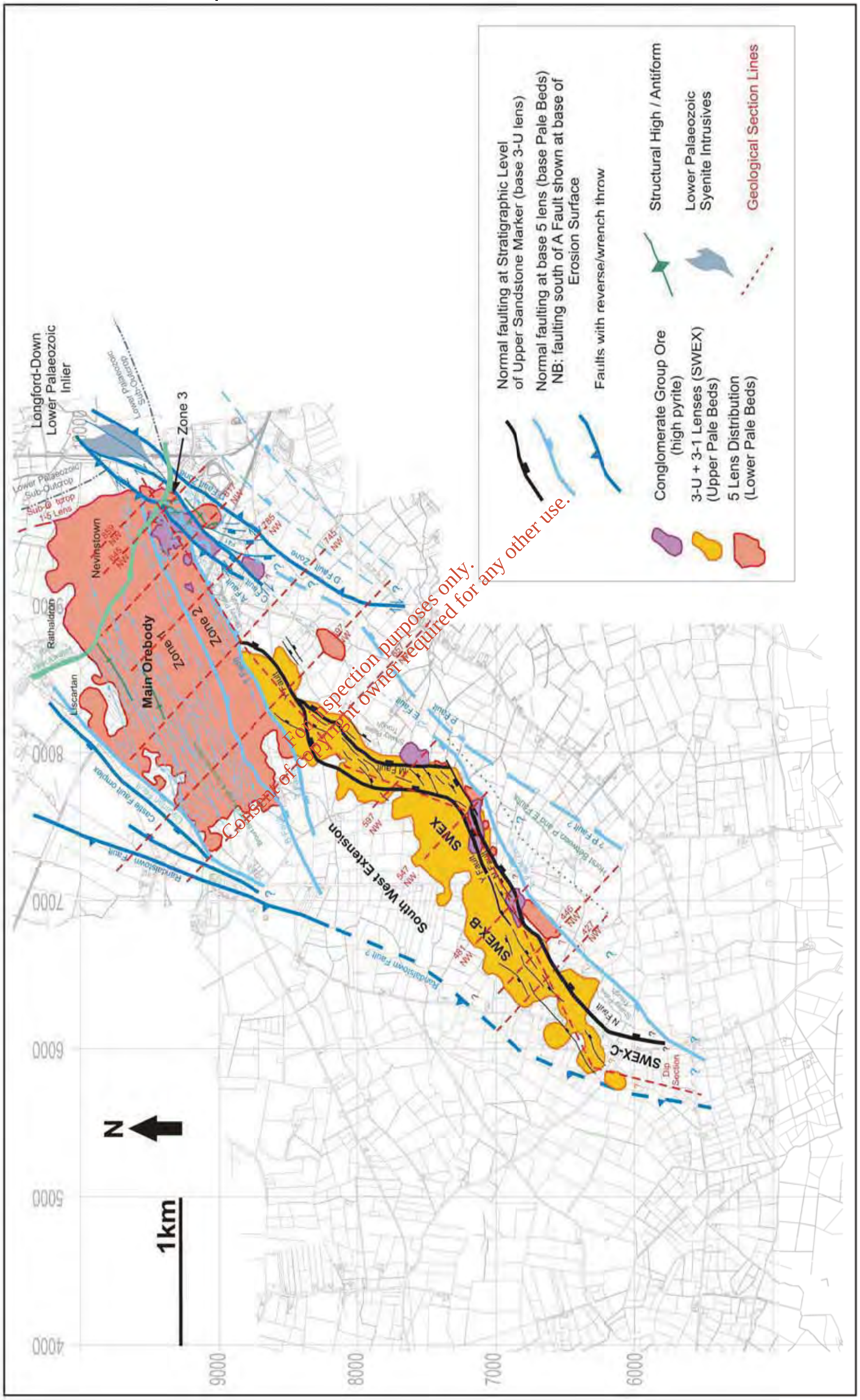
Figure 6.6 The Navan orebody



6.1.5 Mine datum in the Tara workings

A reference to groundwater levels, and references to other data which have an elevation associated with them, are reported in both metres above or below Ordnance Datum (mAOD/mBOD) and metres above Mine Datum (mAMD).

6.1.6 Sources of groundwater inflow to the mine

Groundwater inflows to the Tara workings are derived from the following sources:

- District-scale lateral groundwater flow in the Pale Beds.
- Downward leakage of groundwater from the UDL.
- Recharge derived from precipitation.(Figure 6.5 shows the mean monthly rainfall)
- Leakage from the River Blackwater.

A detailed discussion of these inflow zones is included in Section 6.3. Most of the inflow to the workings occurs via discrete, fracture-controlled inflow zones. Their location is determined by a combination of structure, local jointing and lithology contrasts. The highest groundwater inflow rates occur from the Pale Beds in Nevinstown and the Main Mine. The UDL sequence tends to inhibit the downward movement of groundwater into the Pale Beds over these areas.

Groundwater conditions in the SWEX area are somewhat different to those in the Main Mine and Nevinstown areas. Significant rates of inflow have occurred via old “Navi” drill holes extending into SWEX from the surface. Deeper zones of weathering are present within the upper part of the UDL above SWEX, and it is considered that most of the SWEX inflows are derived from groundwater in the upper weathered UDL flowing downwards through old drill holes. A grouting programme was initiated in late 2005 to plug the old drill holes from ground surface and to pressure-grout fracture systems from the SWEX workings. This programme has resulted in a significant reduction in the rate of inflow to SWEX.

6.1.7 Rates of groundwater inflow to the Tara workings

Inflow rates are measured in litres per second at a weekly frequency from various inflow points in the mine. Table 6.1 presents the mean inflow rate measured during a calendar month. Figure 6.7 presents all groundwater inflows as measured on a weekly basis with time for each mine sector and for the mine as a whole.

Table 6.1 Average groundwater inflow rates to the Tara workings

	A	B	C	D	E	
Year-Month	**Main mine (l/s)**	**Nevinstown (l/s)**	**SWEX (l/s)**	**Subtotal of means A+B)**	**Total of means (A+B+C)**	**Inflow % (B/E)**
2003-02		7.2		7.2	7.2	100%
2003-03		7.6		7.6	7.6	100%
2003-04		8.6		8.6	8.6	100%
2003-05		9.9		9.9	9.9	100%
2003-06		10.3		10.3	10.3	100%
2003-07		10.6		10.6	10.6	100%
2003-08		11.1		11.1	11.1	100%
2003-09		15.4		15.4	15.4	100%
2003-10		18.6		18.6	18.6	100%
2003-11		20.7		20.7	20.7	100%
2003-12		20.1		20.1	20.1	100%
2004-01		19.7		19.7	19.7	100%
2004-02		22.6		22.6	22.6	100%
2004-03	64.6	24.9	4.6	89.5	94.1	28%
2004-04	65.4	24.9	4.0	90.2	94.2	28%
2004-05	62.5	25.4	3.9	87.9	91.8	29%
2004-06	61.2	25.5	3.9	86.7	90.6	29%
2004-07	60.3	25.2	3.8	85.4	89.2	29%
2004-08	60.0	24.9	3.8	85.0	88.8	29%
2004-09	59.3	24.1	3.4	83.4	86.8	29%
2004-10	59.3	23.7	3.4	82.9	86.4	29%
2004-11	59.3	23.6	3.5	82.8	86.4	28%
2004-12	59.3	23.6	3.8	82.9	86.7	28%
2005-01	60.1	24.9	3.7	85.0	88.7	29%
2005-02	61.0	25.6	3.6	86.5	90.1	30%
2005-03	61.2	24.9	20.7	86.1	106.7	29%
2005-04	61.2	26.2	34.1	87.4	121.5	30%
2005-05	61.2	27.3	11.6	88.5	100.1	31%
2005-06	61.2	25.5	6.2	86.7	92.9	29%
2005-07	61.2	24.7	13.5	85.9	99.3	29%
2005-08	61.2	25.0	19.7	86.2	105.9	29%
2005-09	61.2	24.9	29.2	86.1	115.3	29%
2005-10	61.2	24.9	45.4	86.1	131.6	29%
2005-11	61.2	24.9	64.0	86.1	150.1	29%
2005-12	61.2	24.4	61.0	85.6	146.5	29%
2006-01	61.2	24.6	61.4	85.8	147.2	29%
2006-02	61.2	24.4	46.2	85.5	131.7	28%
2006-03	61.2	35.3	40.9	96.5	137.5	37%
2006-04	61.2	24.4	25.3	85.6	110.9	29%
2006-05	60.9	23.6	25.0	84.5	109.4	28%
2006-06	59.4	22.9	22.6	82.2	104.9	28%
2006-07	58.1	22.3	23.3	80.5	103.8	28%
2006-08	58.1	22.0	24.4	80.2	104.6	27%
2006-09	57.3	23.8	25.1	81.1	106.2	29%
2006-10	57.0	24.8	24.9	81.8	106.8	30%
2006-11	57.0	25.5	24.8	82.5	107.3	31%
2006-12	57.0	29.3	26.1	86.3	112.5	34%
2007-01	57.0	29.7	27.2	86.7	113.9	34%
2007-02	57.0	29.1	27.9	86.1	113.9	34%
2007-03	57.0	37.1	30.9	94.1	125.0	39%
2007-04	57.0	42.3	32.0	99.3	131.3	43%
2007-05	57.0	42.0	36.8	99.0	135.8	42%
2007-06	56.8	42.5	40.3	99.3	139.6	43%

	A	B	C	D	E	
Year-Month	Main mine (l/s)	Nevinstown (l/s)	SWEX (l/s)	Subtotal of means A+B)	Total of means (A+B+C)	Inflow % (B/E)
2007-07	55.9	43.8	42.1	99.7	141.8	44%
2007-08	55.9	38.5	30.3	94.4	124.7	41%
2007-09	56.3	35.4	28.1	91.7	119.8	39%
2007-10	56.7	47.0	26.3	103.7	130.0	45%
2007-11	56.3	69.0	28.3	125.3	153.7	55%
2007-12	56.4	59.9	32.0	116.3	148.3	52%
2008-01	56.1	44.8	41.4	100.9	142.3	44%
2008-02	55.6	44.7	48.5	100.3	148.8	45%
2008-03	55.6	45.8	45.5	101.3	146.8	45%
2008-04	55.5	44.6	41.4	100.1	141.5	45%
2008-05	55.5	44.4	41.9	99.8	141.8	44%
2008-06	53.0	45.4	40.7	98.4	139.1	46%
2008-07	52.4	47.3	46.1	99.8	145.9	47%
2008-08	52.8	46.5	56.8	99.3	156.1	47%
2008-09	52.8	47.8	51.4	100.6	152.0	47%
2008-10	53.2	50.6	41.0	103.8	144.8	49%
2008-11	53.7	46.2	41.5	99.9	141.4	46%
2008-12	54.4	40.9	36.7	95.4	132.1	43%
2009-01	54.7	39.4	39.1	94.1	133.3	42%
2009-02	53.0	40.3	43.1	93.3	136.5	43%

Table 6.1 indicates that:

- Mean inflow rate to Nevinstown during the period between February 2007 and February 2009 was 44.6 l/second (equivalent to 3,853 m^3/day).
- Mean inflow rate to Main Mine during the period between February 2007 and February 2009 was 55.2 l/second (equivalent to 4,769 m^3/day).
- Mean inflow rate to SWEX during the period between February 2007 and February 2009 was 38.8 l/second (equivalent to 3,352 m^3/day).
- The mean combined inflow rate to the Main Mine and Nevinstown during the period between February 2007 and February 2009 was 99.8 l/second (equivalent to 8,623 m^3/day).
- The total groundwater inflow to the mine workings during the period between February 2007 and February 2009 was, on average, 139 l/second (equivalent to 12,010 m^3/day). A peak inflow rate to the workings of 156 l/second (equivalent to 13,478 m^3/day) was measured in August 2008.
- Estimated inflows to the Tara workings have increased by around 45% during the period March 2004 to February 2009 from 94.1 l/second (equivalent to 8,130 m^3/day) to 136.5 l/second (equivalent to 11,794 m^3/day).
- The proportion of the estimated inflows to the Tara workings due to inflows into Nevinstown has increased from around 28% in March 2004 to around 43% in February 2009. This is due to the expansion of the Nevinstown mine workings; inflows to the Main Mine have decreased with the expansion of Nevinstown suggesting that the Nevinstown sector is intercepting some of the inflow water which used to flow into the Main Mine.

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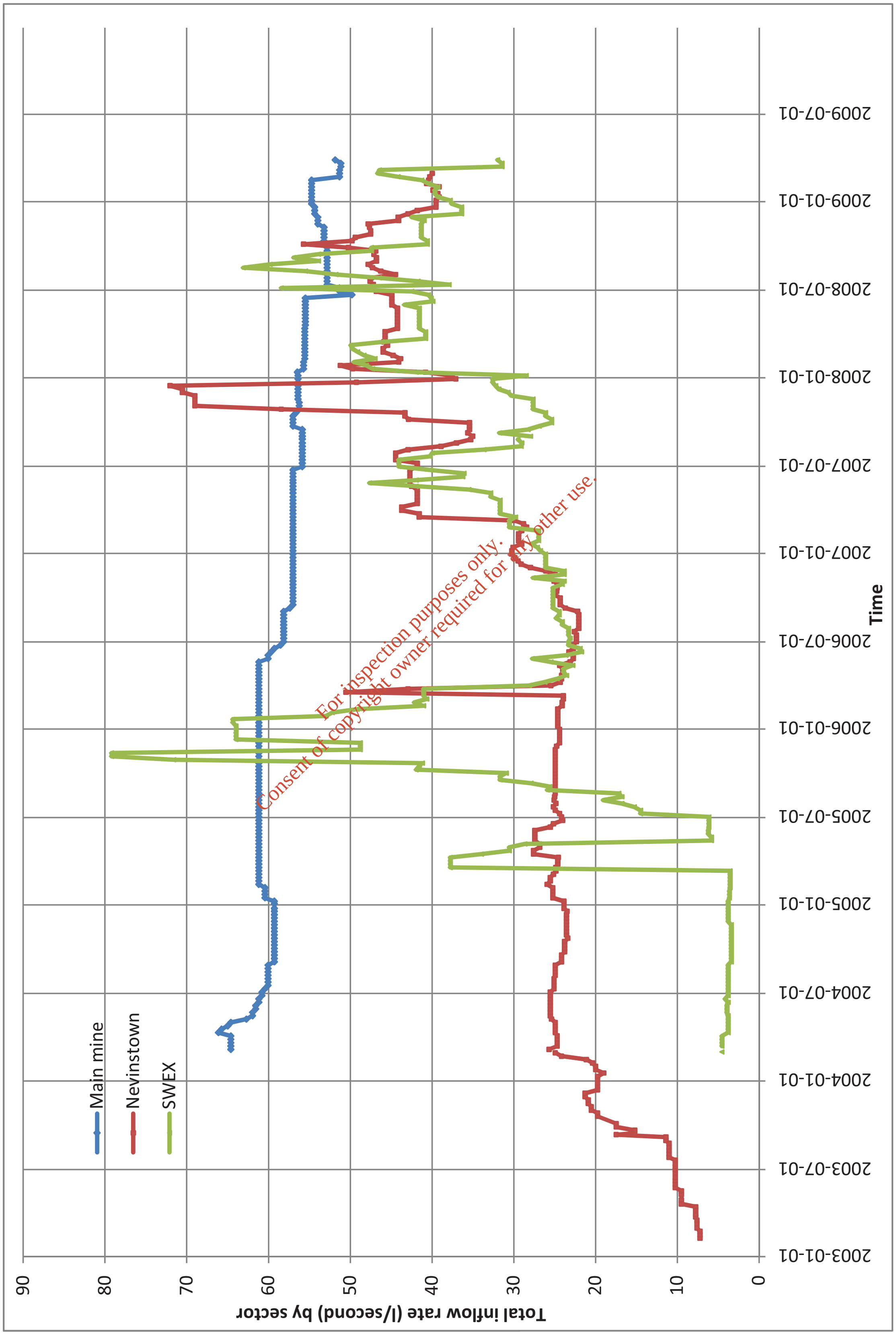
Figure 6.7 Estimated groundwater inflow rates to the Tara workings



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6.2 Geological setting
6.2.1 Introduction

Figure 6.8 presents the regional solid geology of the district while Figure 6.9 is a map of the structural geology of Liscartan and Rathaldron. Figure 6.10 shows the positions of surface drill holes and available groundwater levels. Also shown are the locations of subsurface mine maps and cross sections referred to in text. The cross sections are presented in Figures 6.11 to 6.16.

The solid geology at Liscartan/Rathaldron comprises Lower Carboniferous rocks, cut by NE to ENE trending faults and fault zones. Variable thicknesses of glacial till and alluvial deposits blanket the area. The superficial deposits attain thicknesses in excess of 30 m in the buried Whistlemount Channel to the south of Rathaldron. Recent alluvium occurs along the course of the River Blackwater.

Table 6.2 provides indicative unit thicknesses from geological cross section drawings produced by Tara.

Table 6.2 Indicative unit thicknesses in Liscartan and Rathaldron

a) Section NW761, towards SE limit of section drawing.

Unit	Thickness (m)	Interval (mbgl)		Geological cross section drawing	Intersection with section line
		From	To		
Overburden	12	0	12	NW761	588NE
Upper Dark Limestone	136	12	148	NW761	588NE
Boulder Conglomerate	19	148	167	NW761	588NE
Pale Beds	192	167	359	NW761	588NE
Ore body	22	321	343	NW761	588NE
Muddy Limestone	14	359	373	NW761	588NE

b) Section NW779, towards SE limit of section drawing.

Unit	Thickness (m)	Interval (mbgl)		Geological cross section drawing	Intersection with section line
		From	To		
Overburden	7	0	7	NW779	588NE
Upper Dark Limestone	83	7	90	NW779	588NE
Boulder Conglomerate	10	90	100	NW779	588NE
Pale Beds	225	100	325	NW779	588NE
Muddy Limestone	15	325	340	NW779	588NE

c) Section NW831, towards centre of section drawing.

Unit	Thickness (m)	Interval (mbgl)		Geological cross section drawing	Intersection with section line
		From	To		
Overburden	9	0	9	NW831	562NE
Shaley Pales	11	9	20	NW831	562NE
Pale Beds	180	20	200	NW831	562NE
Ore body	18	172	190	NW831	562NE
Muddy Limestone	12	200	212	NW831	562NE
Laminated Beds	40	212	252	NW831	562NE

d) Section NW584, towards SW limit of section drawing.

Unit	Thickness (m)	Interval (mbgl)		Geological cross section drawing	Intersection with section line
		From	To		
Overburden	22	0	22	NE584	837NW
Shaley Pales	31	22	53	NE584	837NW
Pale Beds	144	53	197	NE584	837NW
Ore body	14	177	191	NE584	837NW
Muddy Limestone	16	197	213	NE584	837NW

6.2.2 Stratigraphic succession at Liscartan and Rathaldron

The following account of the stratigraphy of Liscartan and Rathaldron is based on the account given in Blakeman and Ashton (2006).

6.2.2.1 Lower Palaeozoics

Silurian and Ordovician

The area is underlain by Lower Palaeozoic rocks of Ordovician and Silurian age comprising basic to intermediate volcanics, shales, greywackes, cherts, and cobble conglomerates which are thought to have been deposited in a volcanic arc setting. The youngest rocks in the Lower Palaeozoic are of Wenlockian (Middle Silurian) age. Upper Silurian and Devonian rocks are absent from the succession.

6.2.2.2 Upper Palaeozoics

Red Beds (Navan Group)

Terrestrial/littoral polymictic conglomerates, sandstones and mudstones rest unconformably on the Lower Palaeozoics. The sediments from which they are composed appear to have been derived from the erosion of the Lower Palaeozoics. This unit is known locally as the *Red Beds*. It defines the stratigraphic base of the Lower Carboniferous at Navan.

Laminated Beds (Navan Group)

Above the Red Beds, the Lower Carboniferous is a transgressive marine sequence. The transgression progressed from south to north over the Irish Midlands as a result of the subsidence of several basins in an extensional tectonic regime predominating to the north of the ongoing Hercynian Orogeny. The *Laminated Beds* mark the beginning of the transgression. They comprise thinly bedded, bioclastic calcisiltites and mudstones with subordinate sandstones indicating a littoral/shallow water depositional environment. Several minor sub-aerial erosion surfaces occur along with which indicate minor regressive phases. Occasional horizons of anhydrite and gypsum also occur.

Muddy Limestones (Navan Group)

The Muddy Limestones unit overlies the Laminated Beds. The limestones are predominantly bioturbated, argillaceous, sparsely bio-clastic micrites. The Muddy Limestones and Laminated Beds may be referred to collectively as the *Mixed Beds*, a subgroup defining the lowest part of the Navan Group.

Pale Beds (Navan Group)

The Pale Beds comprise the bulk of the ore horizon at Navan. Most of the district-scale groundwater flow occurs via structures within the Pale Beds unit. The unit is a sequence of oolitic, bioclastic and micritic limestones with occasional argillaceous or arenitic members. The limestones are locally partially dolomitised.

Variably developed, NNW trending, anastomising, carbonate veins and locally open joints occur within the Pale Beds. These are important for local-scale groundwater flow, and many of the observed inflows to the workings are associated with NW/NNW trending joint sets. Bands richer in sand and silt serve as marker horizons to subdivide the Pale Beds sequence. In sequence, moving upwards through the stratigraphic column, the markers are:

- The Lower Dark Marker (LDM).
- The Lower Sandstone Marker (LSM).
- The Nodular Marker (NOD).
- The Upper Dark Marker (UDM).
- The Upper Sandstone Marker (USM).

The LDM occurs only a short distance above the Muddy Limestones in the stratigraphic column. The Shaley Pales unit, which succeeds the Pale Beds in the stratigraphic sequence, begins a short distance above the USM. The full complement of marker horizons is shown on Section NE584.

The Pale Beds unit demonstrates significant lateral variability, although no folding is present. Polished bedding planes occur locally, especially in silty marker horizons. A pale grey micrite, termed the Micrite Unit defines the base of the unit. The Micrite Unit hosts the basal lens (5-Lens) of the Navan Orebody.

Shaley Pales, (Navan Group)

This unit is commonly subdivided into three subunits. The Lower Shaley Pales comprise a series of interbedded bioclastic sandstones, siltstones and shales. The Middle Shaley Pales are a sequence of sandstones and calcarenites. The Upper Shaley Pales are dominantly bioclastic dark shales.

Waulsortian & Argillaceous Bioclastic Limestone (ABL Group)

The ABL Group overlies the Navan Group rocks conformably to the northwest of the Liscartan and Castle Faults. It is absent elsewhere within the mining area, having been eroded away. Its upper boundary is an erosional surface.

The ABL member grades vertically and laterally into the Waulsortian Limestone, becoming an increasingly crinoidal, muddy limestone. The Waulsortian Limestone typically consists of thick to massive beds of pale grey micritic limestone with abundant bioclastic debris.

Erosion Surface and the Boulder Conglomerate

Both the Navan Group and the ABL Group are locally truncated by a submarine erosion surface that downcuts to the southeast. The erosion surface is overlain by a polymictic mega-conglomerate termed the Boulder Conglomerate that contains clasts of both the Navan and ABL Group. The Boulder Conglomerate comprises a sequence of conglomerate layers and mudstone layers. The mudstones may be highly sheared and polished. Pyrite is locally common.

In parts of the Main Mine and SWEX areas of the Navan Orebody, the Boulder Conglomerate contains economic levels of ore mineralisation. These regions of the BC are referred to as the Conglomerate Group Ore (CGO). Significant occurrences of CGO have not been encountered in the Nevinstown or Liscartan/Rathaldron areas.

Upper Dark Limestone (Fingal Group)

The Upper Dark Limestone (UDL) overlies the BC. It is absent from Rathaldron and the north of Liscartan. Over the south of Liscartan it attains thicknesses in excess of 150 m. Further south, over SWEX, the thickness of the UDL exceeds 700 m.

The monitoring data collected during over 30 years of Tara operations indicate the UDL is a low permeability unit that mostly prevents downward movement of water into the dewatered Pale Beds. Generally, the well-bedded nature of the UDL leads to a very low vertical component of permeability within the unit. The Tober Colleen Formation, a mudstone unit that is up to around 30 m thick, forms the basal unit of the UDL, in some areas. The Thinly Bedded Unit (TBU) overlies the Tober Colleen Formation, where the Tober Colleen exists, and directly overlies the BC elsewhere. The TBU is typically 10–15 m thick. It comprises thin interbedded mudstones, calcisiltites and calcarenite beds up to 100 mm thick. The TBU is overlain by a variable sequence of limestone conglomerates, calcilutites, calcarenites, calcirudites, and laminated shales. Two prominent beds, termed the AA and AC markers, occur in this part of the UDL sequence. These beds typically grade upwards from fine cherty calcarenite through medium grey unfossiliferous siltstone and mudstones into black, weak, non-calcareous mudstones. Above the AC marker, graded beds of calcarenite, with thin shaley tops, dominate the UDL succession.

The thicker beds in the UDL are frequently shot through with carbonate-filled extensional veins. Polishing of bedding planes is common. The UDL may also be folded, especially close to major faults where the folding can be very tight. Many of the structures mapped in the Pale Beds do not extend upwards into the UDL. Packer tests in the UDL under the River Blackwater in the neighbouring Nevinstown Sector indicate a moderate to low lateral permeability of 10^{-6} to 10^{-7} m/s.

6.2.3 Overburden

A variable thickness of overburden covers the Liscartan and Rathaldron areas. Figure 6.17 shows the thickness of the coverage. In summary:

- The thickness of the overburden varies from 5 to 15 m over Liscartan, with most areas covered with 7 to 10 m of overburden.
- The thickness of the overburden generally varies from 10 to 30 m over Rathaldron.
- The Whistlemount Channel, a buried channel, can be distinguished to the south of the Liscartan/Rathaldron area as linear region where the thickness of overburden is generally in excess of 20 m and may approach 35 m.

The following overburden units are recognised:

Recent alluvium

Alluvium comprising silts and silty clays occurs along the course of the River Blackwater. The alluvium attains a thickness of up to 5 m over the flood plain of the Blackwater, which is up to 150 m wide in places.

Over most of its coverage area, the recent alluvium rests on clayey glacial till which may reach thicknesses of up to around 10 m. The low permeability of the clayey till tends to limit the rate of any leakage from the recent alluvium around the River Blackwater to the groundwater within the Carboniferous sequence. This is confirmed by the operational experience to date for Nevinstown. Even in areas where the UDL cover is absent above the Pale Beds, there is very little downward leakage of water from the alluvium into the underlying bedrock.

Glacial till

Clayey glacial till accounts for the bulk of the overburden thickness. It mostly comprises boulder clay material and is typically of low permeability. However, it does contain laterally discontinuous permeable sand and gravel lenses. Many of the local domestic wells derive their water from these lenses.

Whistlemount Channel

The Whistlemount Channel is a broad trough in the UDL, which is filled with glacial till. The till comprises stiff, dense to very dense sandy clay with gravel and boulders. The channel is not obvious at ground level but can be delineated from overburden thickness contours. The channel is most fully developed to the south of the River Blackwater. It extends to the north through Rathaldron where it is up to 300 m wide and a maximum of 9 m deep below the surrounding bedrock surface.

Within the Whistlemount Channel, the till is typically underlain by a medium to fine sand unit in the lower part of the channel. The sand unit is considered to be of moderate to low permeability, and it may be locally absent in some areas of the channel.

The sand unit typically rests on a basal sand and gravel unit comprising coarse sandy gravel to gravelly coarse sand, which is generally 1 to 5 m in thickness, the greatest thickness occurring along the long axis of the channel. This basal gravel unit is best developed in areas where the channel is deepest, and may be locally absent where the channel is shallower. The basal gravel unit is known to be permeable. Piezometers installed within the unit indicate it was mostly dewatered prior to mining at Nevinstown, and has since become completely dewatered, with installed piezometers having become dry soon after the commencement of mining in the Nevinstown sector.

The River Blackwater crosses the Whistlemount Channel at around mine coordinates 8,800 mE, 9,900 mN in Rathaldron. The thickness of clayey till in the channel there is around 10 to 15 m. Experience gained from Nevinstown suggests that the low permeability of the clayey till would be expected to limit the rate at which water can infiltrate from the Blackwater to the basal gravel unit of the channel. Above Nevinstown, the upper part of the till is saturated above the dewatered basal gravel unit.

The hydraulic character of the Whistlemount Channel, and its potential as a zone of focused recharge to the deeper groundwater system within the Pale Beds, was an initial concern prior to the of mining at Tara in the 1970s. Pumping tests undertaken in the Rathaldron section of the Channel in 1977 indicated a potentially permeable unit in the UDL beneath the channel. Golder Associates completed a study on the channel for Tara Mines in 1977-1978. Water level monitoring by Tara Mines from the early 1970s onwards demonstrated the progressive dewatering of the basal unit as the mine workings were initially developed. Vertically nested piezometers were installed above Nevinstown in 2002 to investigate the relationship of groundwater heads in the basal gravel unit and the underlying UDL. The shallow piezometer confirmed that the basal gravel unit was largely dewatered prior to mining at Nevinstown. The elevation of the water table in the basal gravels was estimated at about 2 m above the contact with the UDL, which is equivalent to about 20 mbgl. The deeper piezometer showed that heads in the UDL were about 20 m below the top of the UDL defining the base of the channel.

Based on the information available to date, the following conclusions can be drawn regarding the hydrogeological behaviour of the Whistlemount Channel:

- The drawdown in the UDL above the mining area has under-drained the basal gravel layer of the Whistlemount Channel.
- Leakage from the basal gravel unit in the channel is not sufficiently rapid to maintain saturation in the UDL under the channel.
- Leakage through the upper till unit into the basal gravel unit occurs at a lower rate than water leaks downward from the base of the channel into the UDL. Thus, the basal layer of the channel, and the underlying UDL, have both become dewatered.
- Once such a hydraulic disconnection occurs and the hydraulic heads of the UDL and basal gravels have lost contact, becoming separated by an unsaturated zone in the UDL, the rate of leakage from the channel gravels to the water table in the UDL is independent of the difference in hydraulic head between the two units.

In summary, the currently available data show that the Whistlemount Channel has been dewatered and does not constitute a source of significant inflow into the underlying mine workings. It is expected there will be some ongoing seepage from the basal gravel, but this is constrained by the low permeability of the till deposits overlying the channel. The Nevinstown access decline was driven beneath the lowest part of the Whistlemount Channel in 2003. An inflow of about 0.2 l/second occurred directly beneath the channel as the decline was driven. The inflow continued for about a 12 month period, but the zone in the decline is now observed to be dry.

6.2.4 Geological structure

6.2.4.1 Background

Throughout the Liscartan/Rathaldron application area, the Carboniferous sequence dips gently to the southwest. The Pale Beds sequence at Liscartan and Rathaldron is cut by faults that strike NE to ENE.

Figure 6.10 shows fault lineaments proven at the elevation of the footwall of the 1-5 lens of the Navan Orebody at the base of the Pale Beds. The dip of the Pale Beds is apparent on Section NE584. The fault lineaments are projected onto a plan of features at ground surface. The figure also shows the locations of surface drill holes. In addition to the surface drilling, the large number of underground (U series) holes drilled within the Pale Beds has greatly facilitated the general understanding of the structure of the Pale Beds unit.

The Randalstown Fault cuts the base of the Pale Beds a short distance to the west of the Liscartan/Rathaldron application area. It strikes NNE in the vicinity of the Liscartan/Rathaldron application area.

The Castle-Liscartan Fault Complex is the largest fault system within the Liscartan-Rathaldron application area. It forms a northwest dipping system that defines the northwestern boundary to the southwest plunging horst that hosts the Navan Orebody. It strikes NE through the centre of Liscartan. It is thought likely that components of the Castle-Liscartan Fault Complex extend into the stratigraphic sequence above the Pale Beds towards ground surface.

Smaller faults, F25 to F2, to the southeast of the Castle-Liscartan Fault Complex, strike ENE. It is considered unlikely that the smaller F series faults extend into the UDL since the principal extensional phase of movement at Navan occurred before the UDL was deposited.

6.2.4.2 Randalstown Fault

The Randalstown Fault is a major, late, NE to NNE trending sinistral-reverse fault that dips steeply (at around 80º) to the NW. The throw on the fault is 200 m or more. The Randalstown Fault is inferred to have a significant sinistral wrench component. The fault cuts the base of the Pale Beds about 75 m to the west of the boundary of the Liscartan Extension. The Randalstown Fault does not intersect the orebody. It will not be intersected during mining.

It is not known whether or not this fault carries groundwater but holes drilled in the NW part of Zone 1 suggest that it is probably a tight shear zone rather than an open transmissive fault zone.

6.2.4.3 Castle-Liscartan Fault Complex

The Castle-Liscartan Fault Complex appears to splay from the Randalstown Fault to the west. Northeast of the Navan Orebody, it displaces Lower Palaeozoic rocks of the Longford-Down Inlier. The geometry of the fault complex has been interpreted based on its intersection with surface core holes and from underground exposures in the mine workings.

The Castle Fault accounts for the major component of normal displacement while the Liscartan Fault forms a persistent footwall branch, perhaps representing an earlier expression of extensional movement in the area. Complex sliding within the Shaley Pales in association with the Castle-Liscartan Fault Complex indicates that these structures are at least Courceyan in age. A thickening of reef facies of the Waulsortian Limestone across the Castle Fault to the NW suggests reef growth in response to hanging wall subsidence at that time.

Castle Fault Zone

The Castle Fault system may splay laterally over a distance in excess of 100 m at the 1-5 lens ore footwall. At least 6 distinct fault branches have been interpreted in this system. The branches are normal faults dipping to the NW. Throws are typically in the range 80 to 100 m.

The differing strikes of the Castle Fault Zone (NE) and the Randalstown Fault (NNE) in the vicinity of Liscartan result in their increasing separation to the NE. In the south of Liscartan, the Castle Fault Zone is separated from the Randalstown Fault by about 375 m at the base of the Pale Beds. This equivalent figure for the centre of Liscartan is 550 m. In the north of Liscartan the separation is about 660 m.

In the north of Liscartan, the Castle Fault Zone has a width of about 90 m at the base of the Pale Beds. The zone pinches somewhat to a width of around 70 m in the centre of Liscartan and broadens to about 140 m in the south of Liscartan.

Liscartan Fault Zone

The Liscartan Fault Zone strikes NE sub parallel to the Castle Fault Zone. Like the Castle Fault Complex, the Liscartan Fault Zone is a system of normal faults dipping to the NW. The throw is variable, ranging from 30 m on section 729NW to 10 m on section 779NW. The dip of the faults varies over the range 45º to 65º. The Liscartan Fault Zone has been mapped in 1230 B17EX as a 20 m wide zone of at least 10 distinct branches. Overall throw across the zone is greater than 50 m on section 749NW. There appears to be branching between the Liscartan Fault Zone and its much larger neighbour, the Castle Fault Zone. The branching takes the form fault sections dipping sub-vertically to the NW.

When first intersected in 1230 B17EX (1998) the Liscartan Fault Zone yielded approximately 0.4 l/second of groundwater. This water make has since dried up but the zone remains damp.

6.2.4.4 F Series faults

The F series faults strike ENE to the SE of the Castle-Liscartan Fault Complex. The difference in the strike of the F series faults and the Castle-Liscartan Fault Complex results in the distance between the faults increasing to the northeast.

A description of the main F-series faults is given (from west to east). The first of the F series faults encountered, moving SE over the base of the Pale Beds from the Castle-Liscartan Fault Complex, is the F25 Fault. This fault intersects the Liscartan Fault at the base of the Pale Beds about 145 m along the strike of the Liscartan Fault from where the southern boundary of the Liscartan Extension crosses the Liscartan Fault.

Table 6.3 provides a summary of indicative distances of separation of the F Series faults from the Liscartan Fault at the base of the Pale Beds. The separations have been taken along a line running between 8320mE, 10100mN and 8605mE, 9500mN. The line is approximately in the dip direction of the F series faults.

Table 6.3 Indicative separation of the F series faults from the Liscartan Fault

Fault	Indicative separation from the Liscartan Fault (m)
F25 (north branch)	320
F25 (south branch)	370
F24	440
F1	490
F3	580
F2	610

Note: The separation distances are at the base of the Pale Beds along a line running from mine coordinates 8320mE, 10100mN to 8605mE, 9500mN

F25 Fault

Like the Randalstown Fault and the faults of the Castle-Liscartan Fault Complex, the F25 Fault dips towards the NW. This is in contrast to the majority of the F series faults, which dip to the SE. The F25 Fault is a normal fault with a typical throw of about 10 m and typical dip in the range 45º to 65º. It is calcitic and locally vughy along its mapped length. South of the River Blackwater, the F25 Fault appears to exist as two branches, a northwest and a southeast branch. The branches are separated by about 40 m in the vicinity of the southern boundary of the Liscartan Extension, increasing to more than 60 m in the vicinity of drill hole N00829.

The northwest branch is prominent at the base of the Pale Beds in Block 17W, the throw on the branch reaching a maximum of about 18m. The southeast branch there has a throw of less than 5 m.

Moving ENE along the strike of the F25 Fault into the Liscartan/Rathaldron Extension, throws on the northwest branch reduce to around 2 m while throws on the southeast branch increase to around 12 m.

The F25 Fault was always wet when intersected during mine development in Block 4W and Block 15W. In Block 17W, together with its associated structures, F25 made water to the extent of 5.3 to 6 l/second. It has continued to flow at around this rate.

F24 Fault

The F24 Fault dips 45º to 75º to the southeast. It is a normal fault. The F24 Fault branches into at least two distinct components where mapped at the western end of the 1315 190N River Pillar development. The branches are seen on Section NW829 where they were intercepted in surface core holes N01841 and N01842. The throw of the F24 Fault is about 8 m where it crosses 8700 mE falling to the southwest to around 2 m where the fault crosses 8300 mE.

The F24 Fault is often leached and wet. No major or continuous water makes have been recorded from its underground exposures.

F1 Fault

Section NW829 shows that the F1 Fault is a normal fault dipping to the southeast, like the F24 Fault. The dip of the fault increases to the SW from about 50º at 8900 mE to about 70º at 8450 mE. The F1 Fault is calcitic and vughy throughout. Cavities on the fault may have dimensions measuring several metres in diameter. Where not cavernous, F1 is identified with significant leaching, irregular carbonate veining, and very poor ground conditions. As described in Section 6.3, the F1 Fault is thought to be the principal structure influencing district-scale groundwater flow in the Pale Beds towards the Main Mine and Nevinstown. Many of the main sustained inflows have been associated with northwest trending joint sets, which are considered to be fed from the F1 Fault Zone.

F23 Fault

The F23 Fault appears to branch from the F1 Fault around 8625 mE. Section NW829 shows that it is a normal fault dipping to the southeast, similar to the F1 Fault. The interpretation on the section is that the F23 Fault splays into 3 components in the vicinity of surface core hole N00706. The fault dips at around 55º to 60º and the throw on the fault varies from 10 m to less than 3 m.

F3 Fault

The F3 Fault dips to the NW like the F25 Fault, the Castle-Liscartan Fault Complex and the Rathaldron Fault. Section NW829 shows it to be a normal fault. The F3 Fault splits into a northwest and southeast branch to the SW of 8600 mE. The northwest fault is labelled the *F3 Branch Fault* on the structural geology map while the southeast fault is labelled *F3 Fault*. NE of the split, the F3 Fault displays dips of 60º to 70º. The southeast branch demonstrates dips of around 65º and a throw of about 20 m. The northwest branch dips at about 60º with a throw of about 15 m.

The F3 Fault is tight and dry in the vicinity of the River Blackwater but locally open and wet further to the southwest. The same is true of the F2 and F23 Faults.

F2 Fault

The F2 Fault is the most southeasterly of the faults seen on Section NW829. It is a normal fault that dips to the southeast like the majority of the F series faults. The F2 Fault dips at between 45º and 70º with throws of 2 to 15 m. Section NW829 suggests that several northwest dipping normal faults run from the F2 Fault to the F1 Fault.

6.2.5 Basalt Dyke

A north trending dyke of altered basaltic to doleritic composition cuts through the Laminated Beds and Pale Beds. It is seen on Sections NW829 and NW831. The dyke gives rise to problematic ground conditions for mine development including the formation of wedges where close to structures and bedding. For underground mine development, it is usually shotcreted and bolted. Observations to date indicate it is not water bearing.

6.2.6 Cavities

Figure 6.18 shows cavities encountered in the Pale Beds and UDL during drilling at Liscartan and Rathaldron. The thicknesses of the cavities encountered during drilling are indicated. Cavities of thickness 3.3 to 10.5 m were recorded in the UDL in the southwest of Liscartan by surface core holes N01834, N01851 and N01867. The distribution of cavities is better defined in the Pale Beds than the UDL due to the access afforded by the mine workings and underground coreholes.

The largest cavities in the Pale Beds have been encountered in the region of the River Blackwater and the 190N centre line section around 8910 mE and 9840 mN at elevations of -156.7 to -126.7 mBOD (1,370 to 1,400 mAMD). A 24.6 m cavity was recorded in underground drill hole U12323, a 12.3 m cavity was recorded in U12385, and a 5.8 m cavity was recorded in U14363 in this region. In addition to these larger cavities, there are numerous minor cavities of 1 m or less noted on the 190 centre line section and the 1315 Level mapping plan. Minor cavities are also noted in the Pale Beds on Sections NE584, NW829 and NW831.

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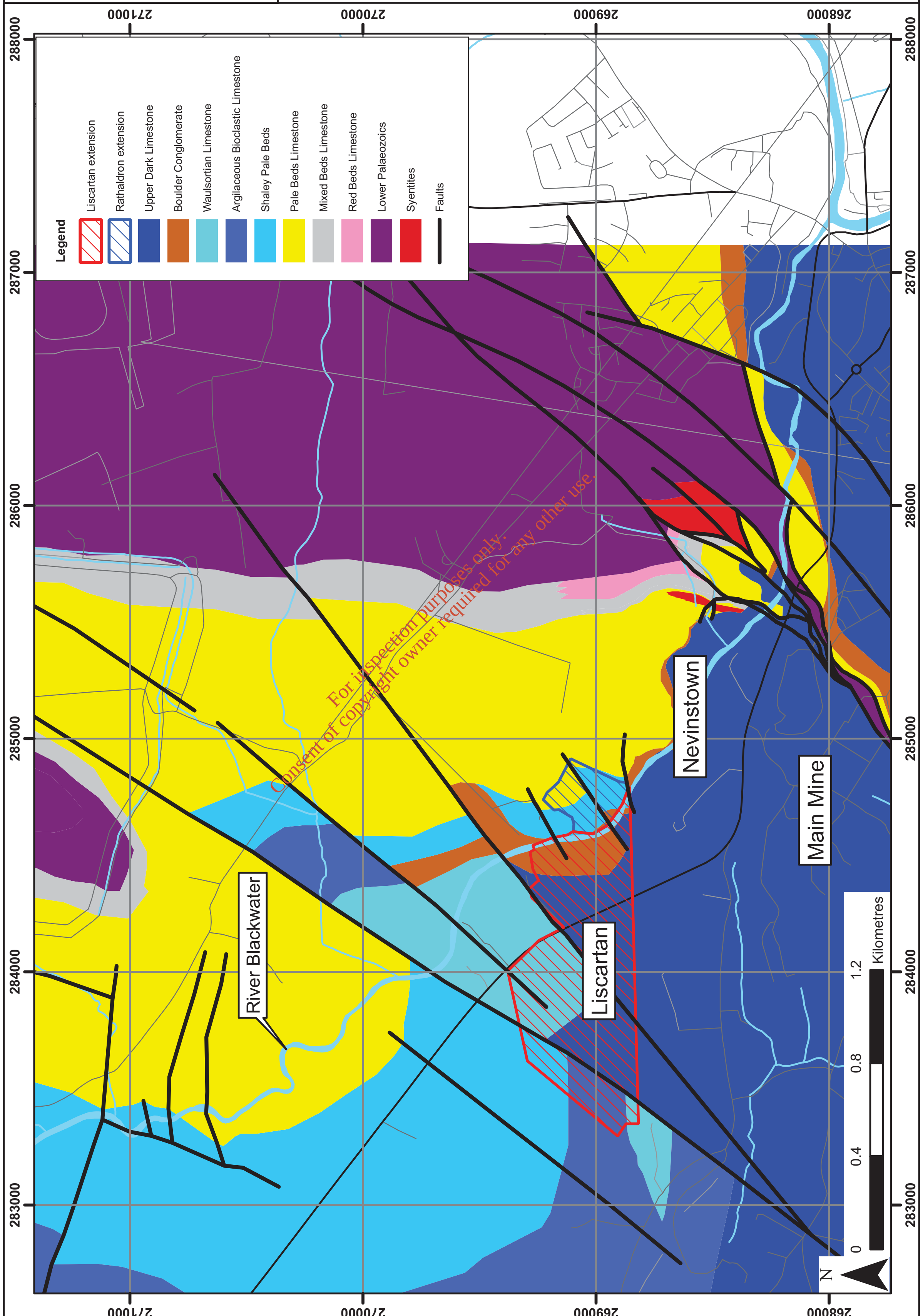
Figure 6.8 District geology map



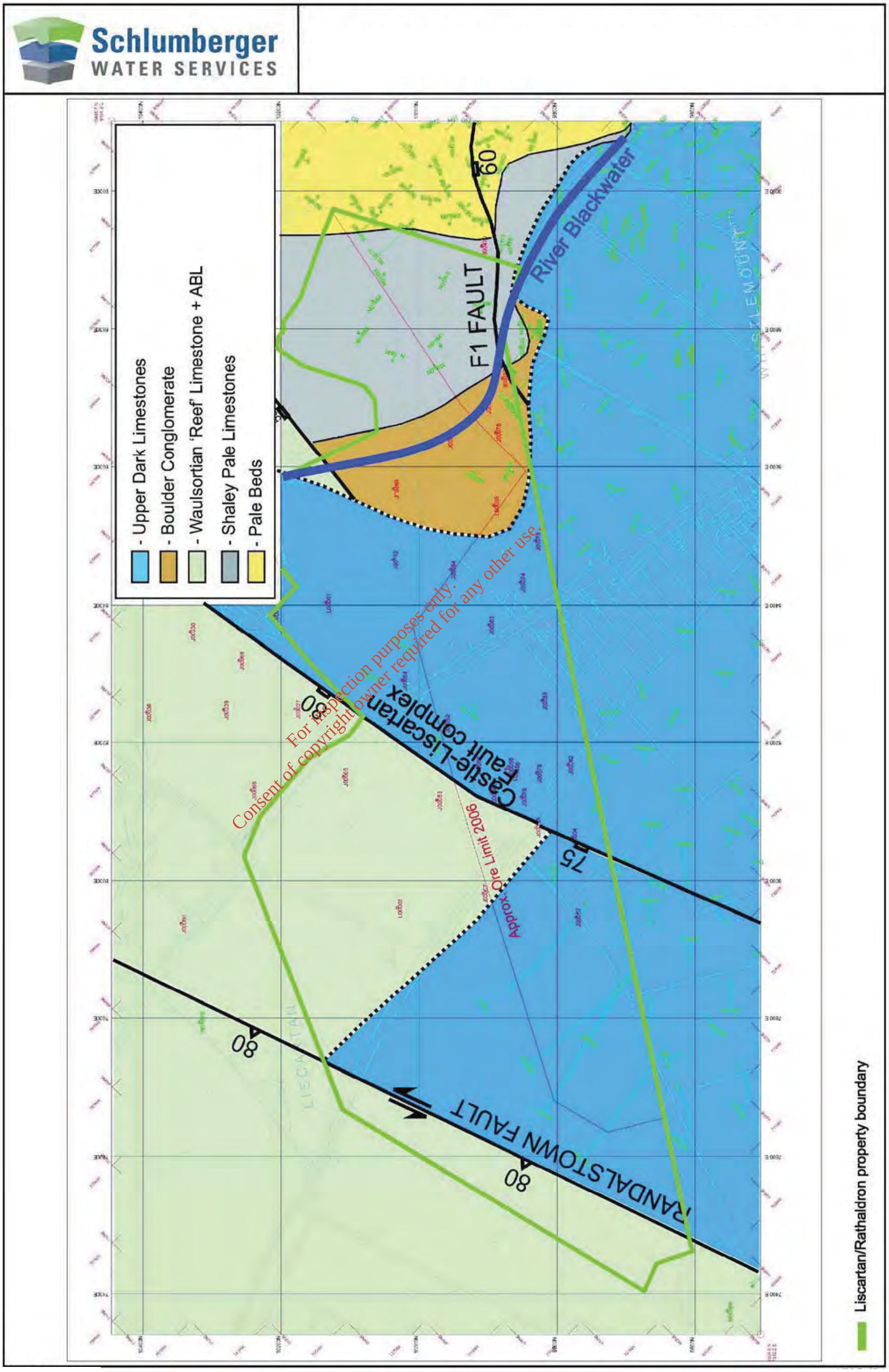


Figure 6.9 Solid geology map of the Liscartan & rathaldron application area

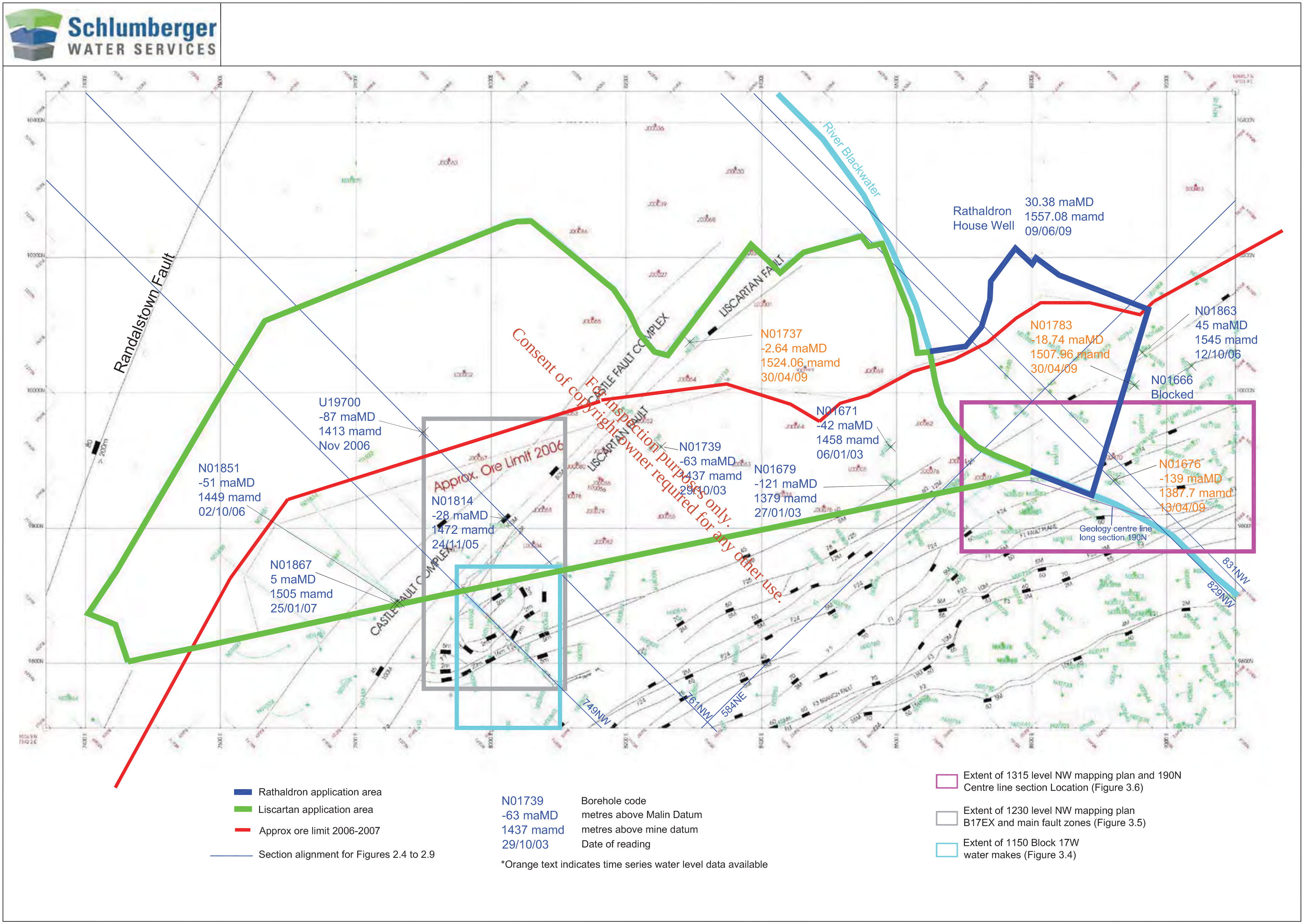


Figure 6.10 Available groundwater level information for the Liscartan & Rathaldron application areas

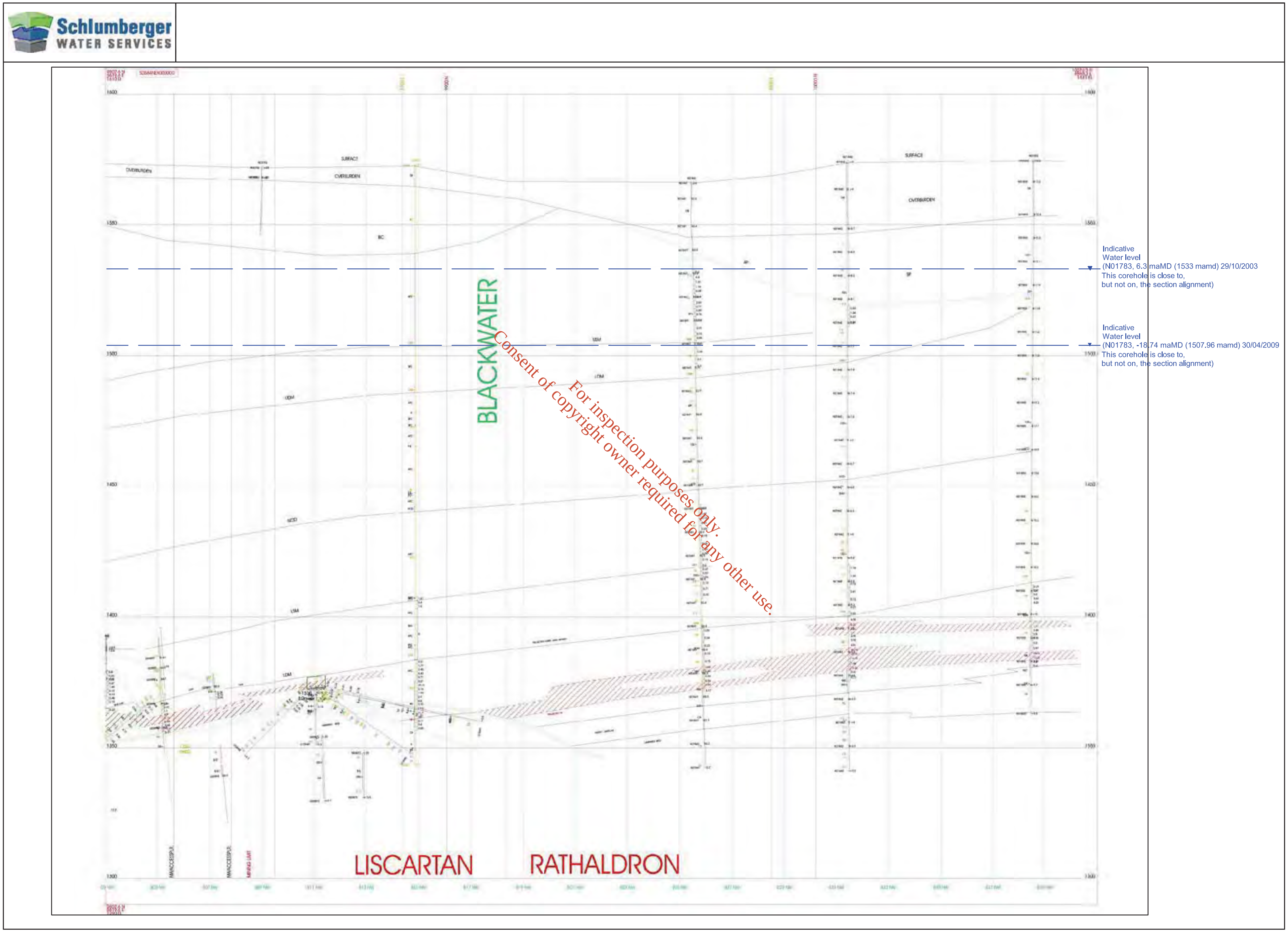


Figure 6.11 Geology cross section NE584

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Figure 6.12 Geology cross section NW749

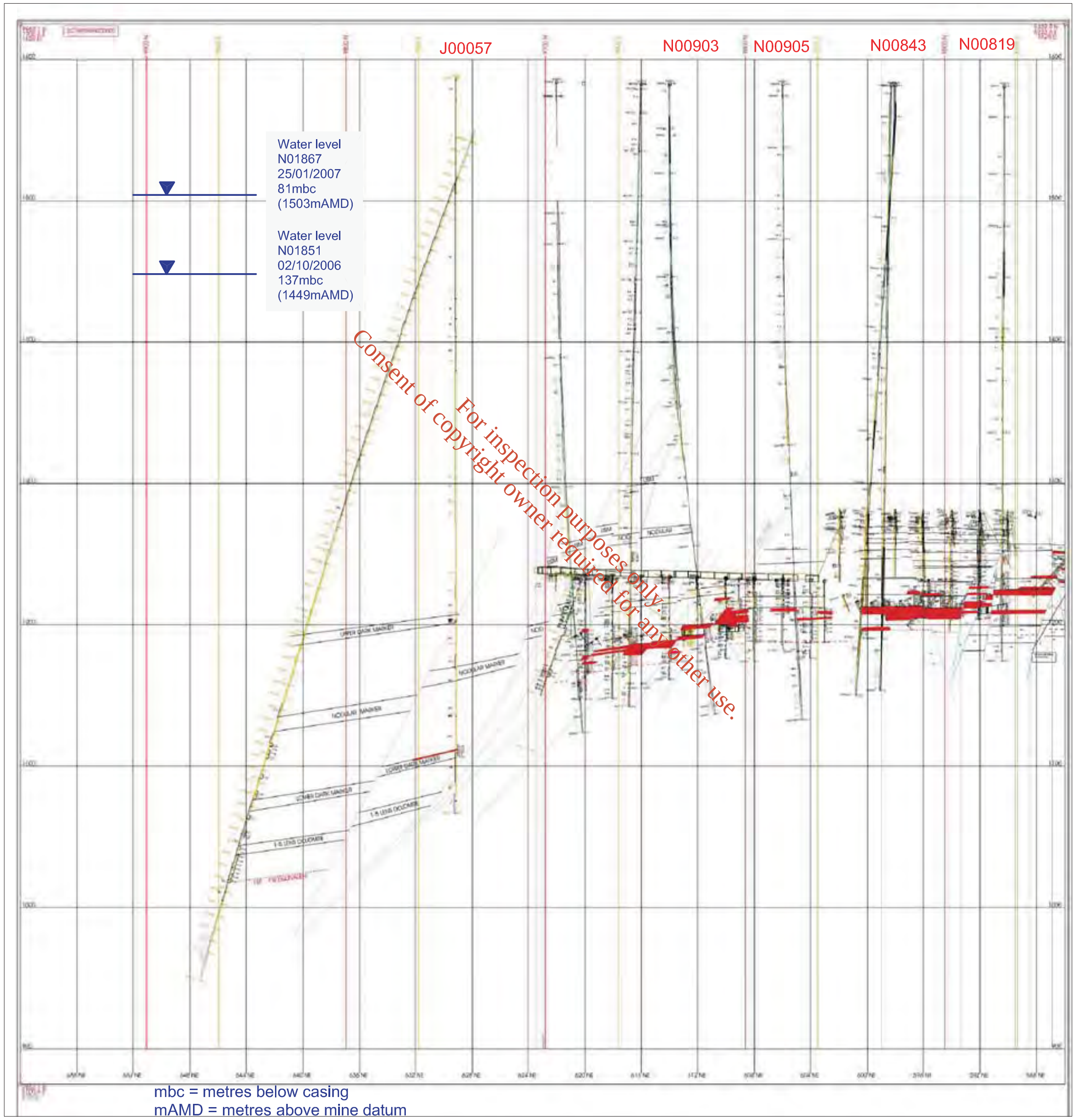

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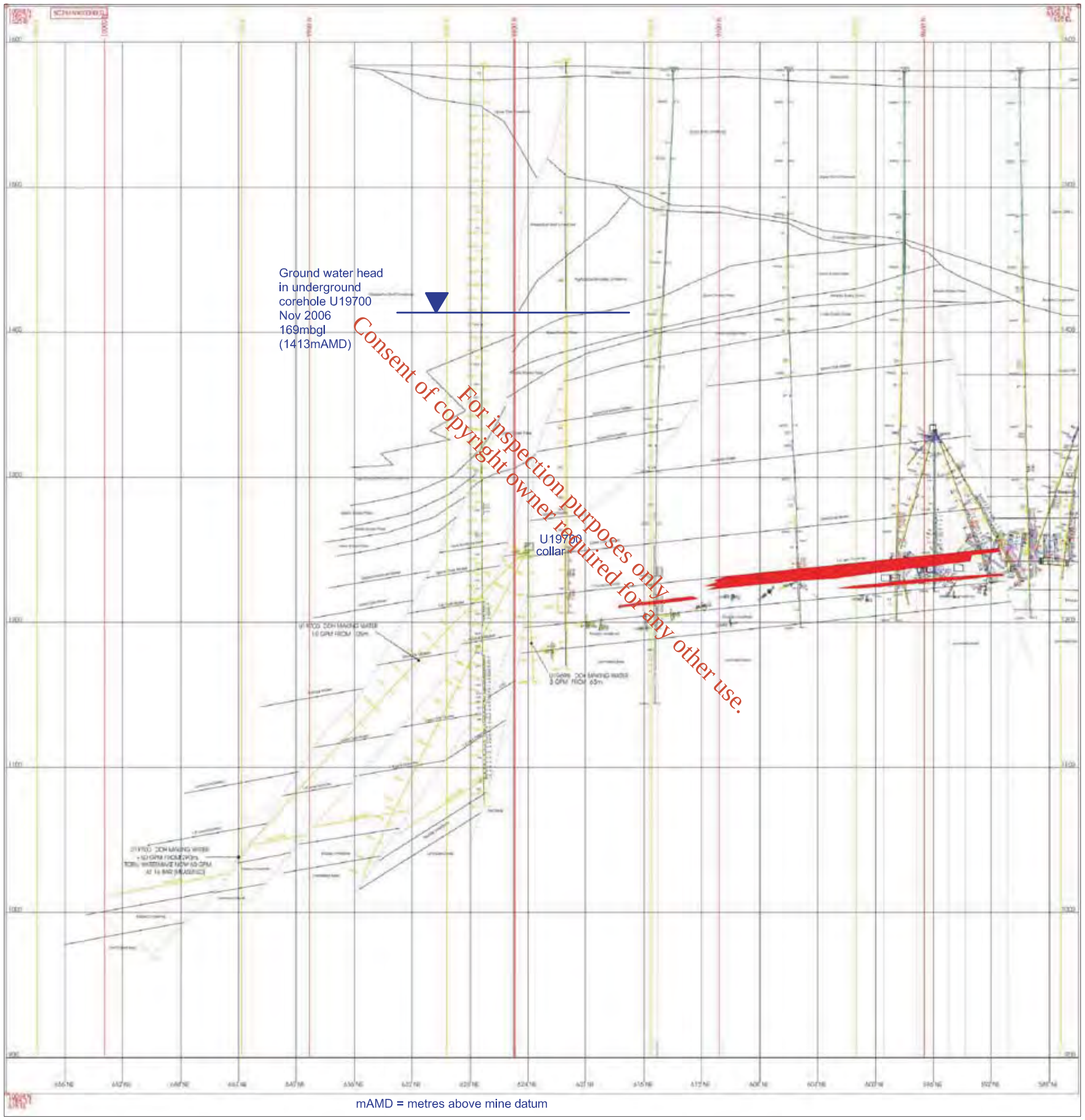
Figure 6.13 Geology cross section NW761



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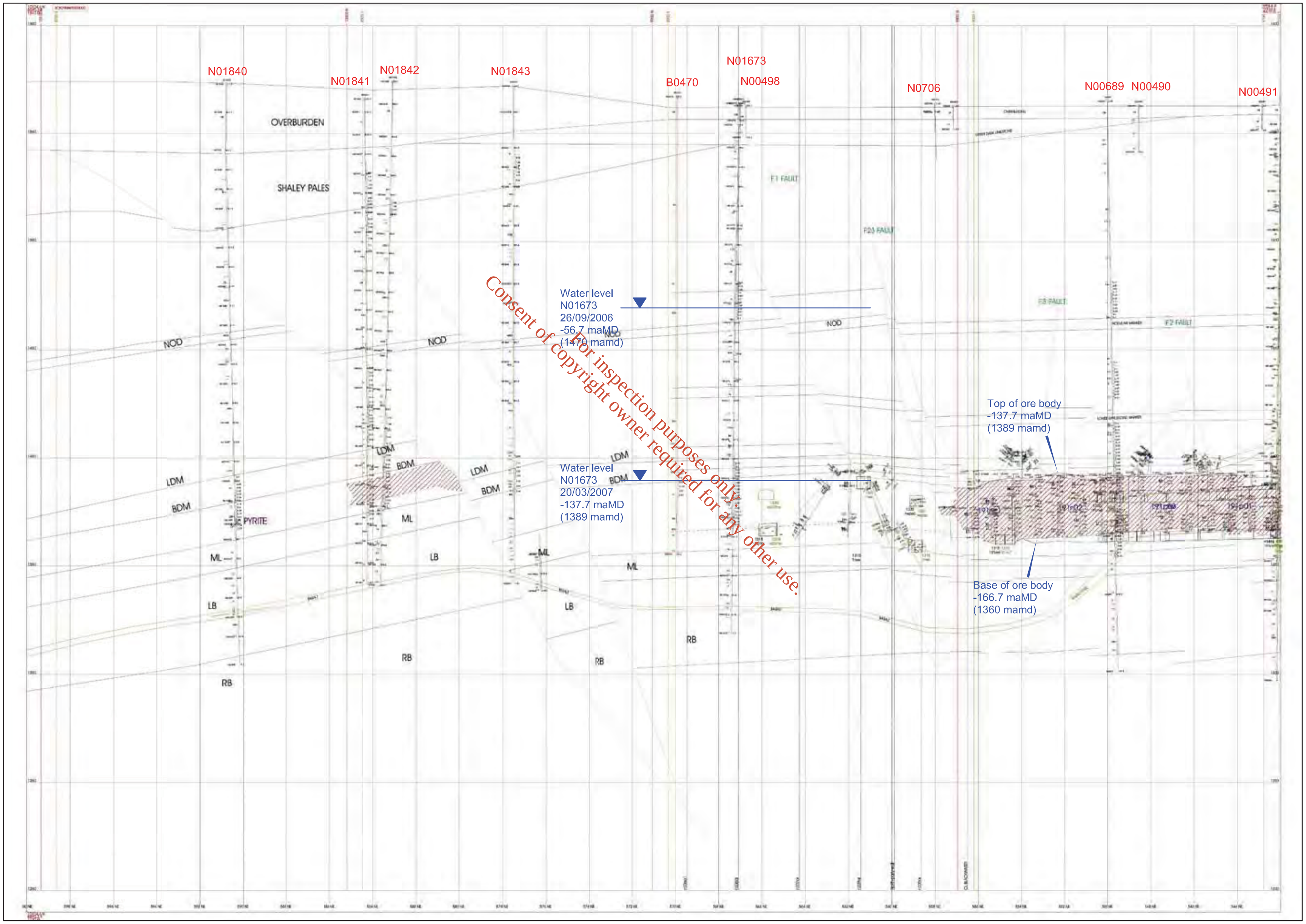
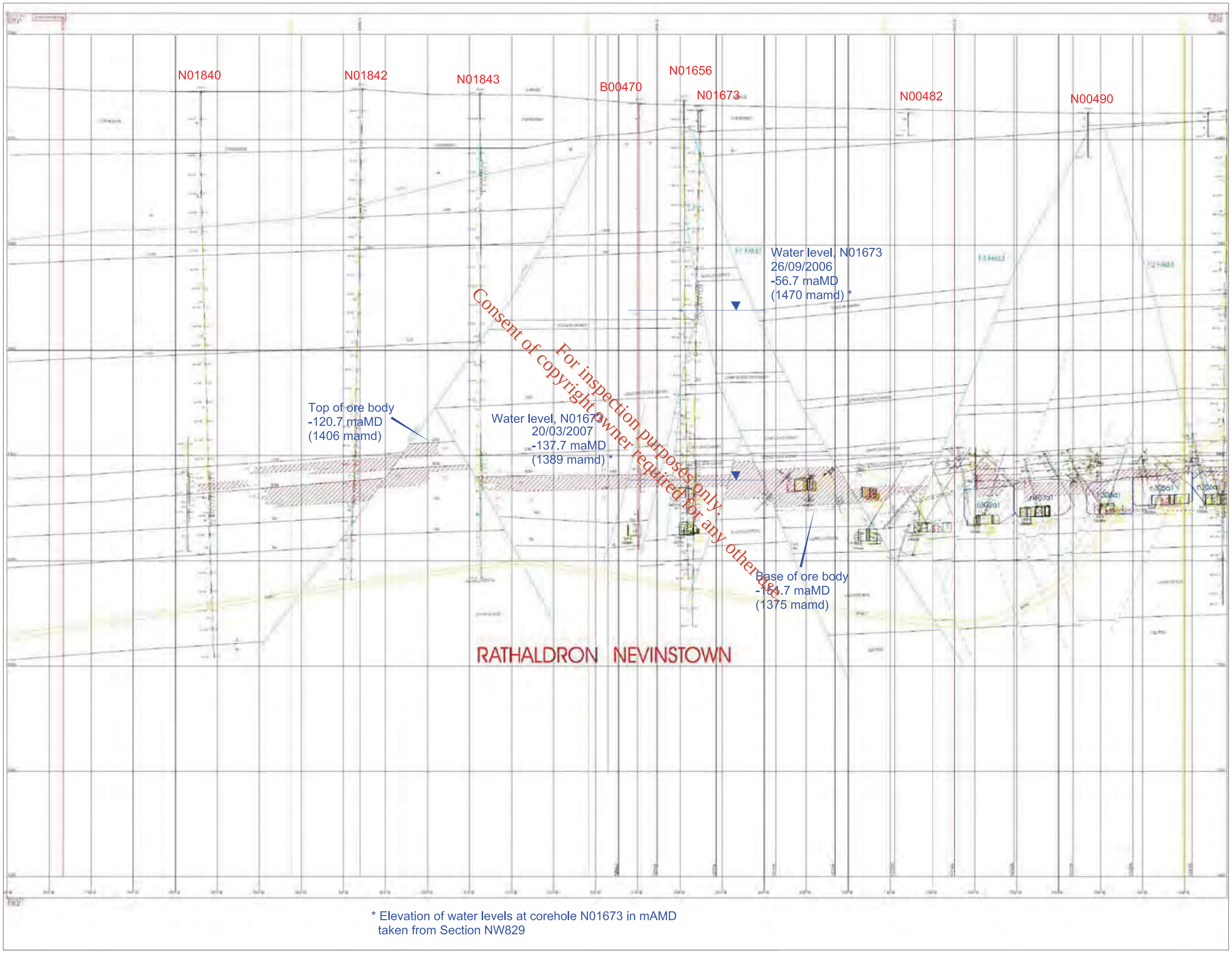


Figure 6.14 Geology cross section NW 829

Figure 6.15 Geology cross section NW831



* Elevation of water levels at corehole N01673 in mAMD taken from Section NW829

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Figure 6.16 Geology centre line long section 190N

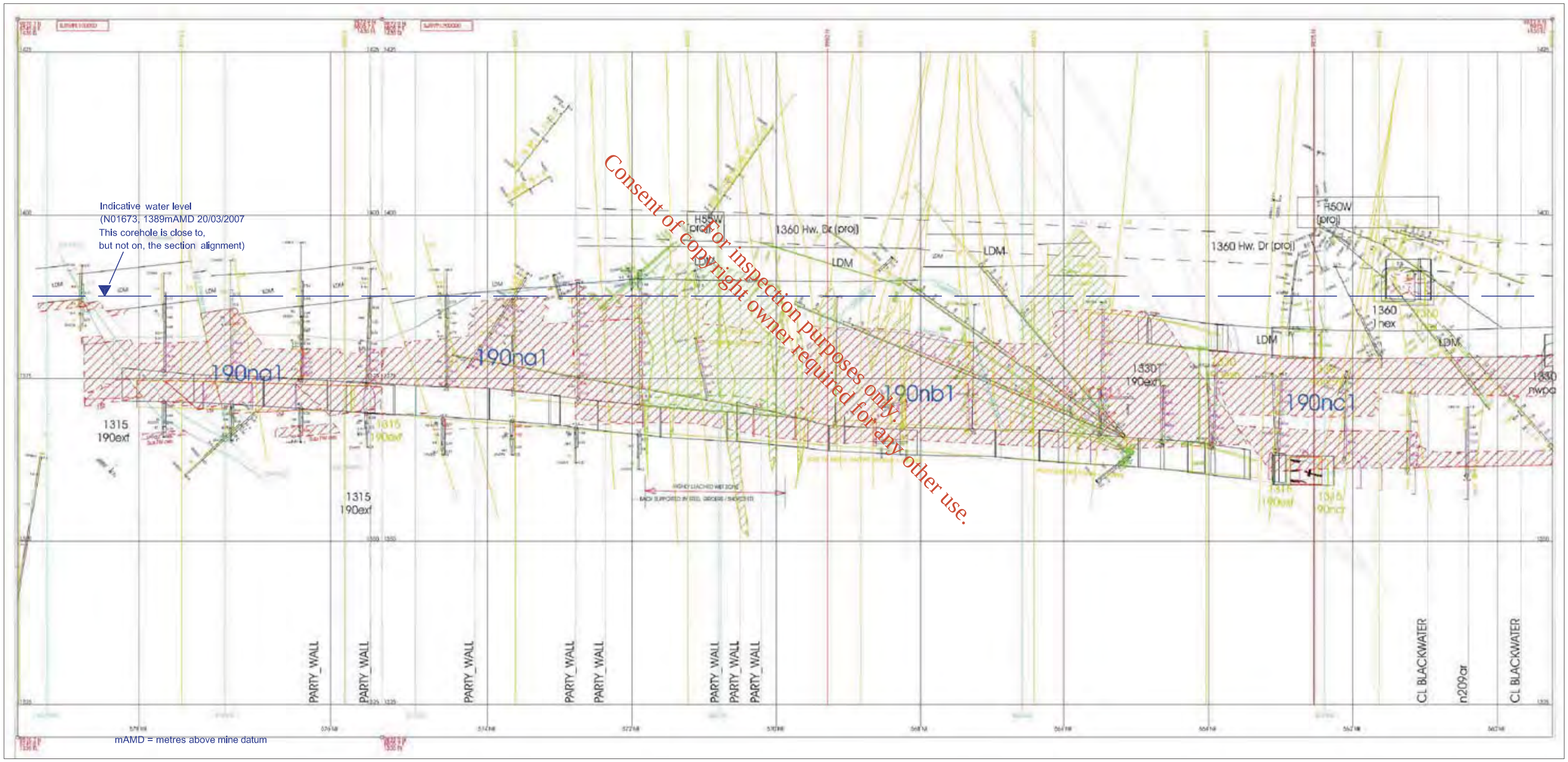

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Figure 6.17 Overburden thickness map

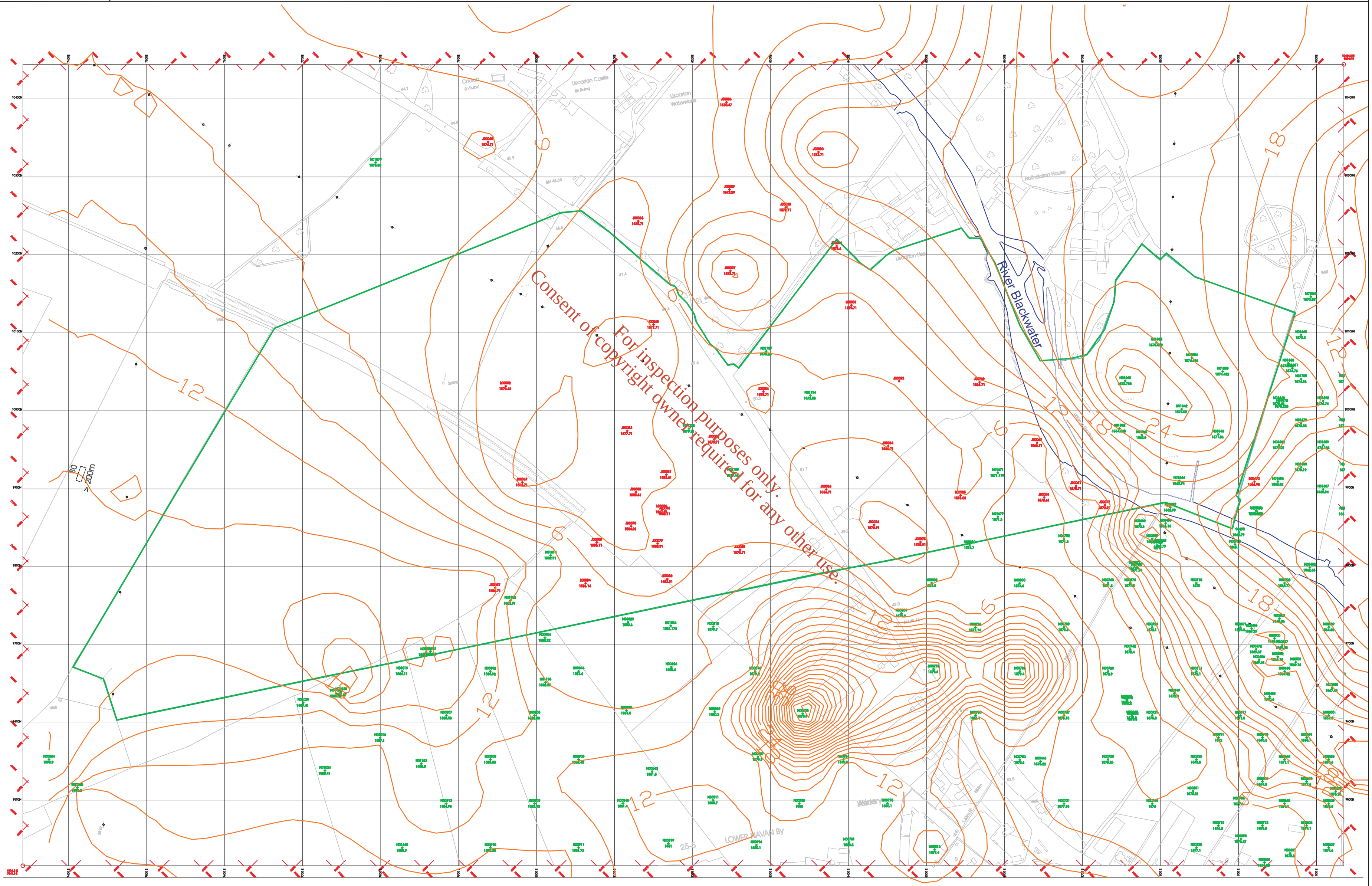

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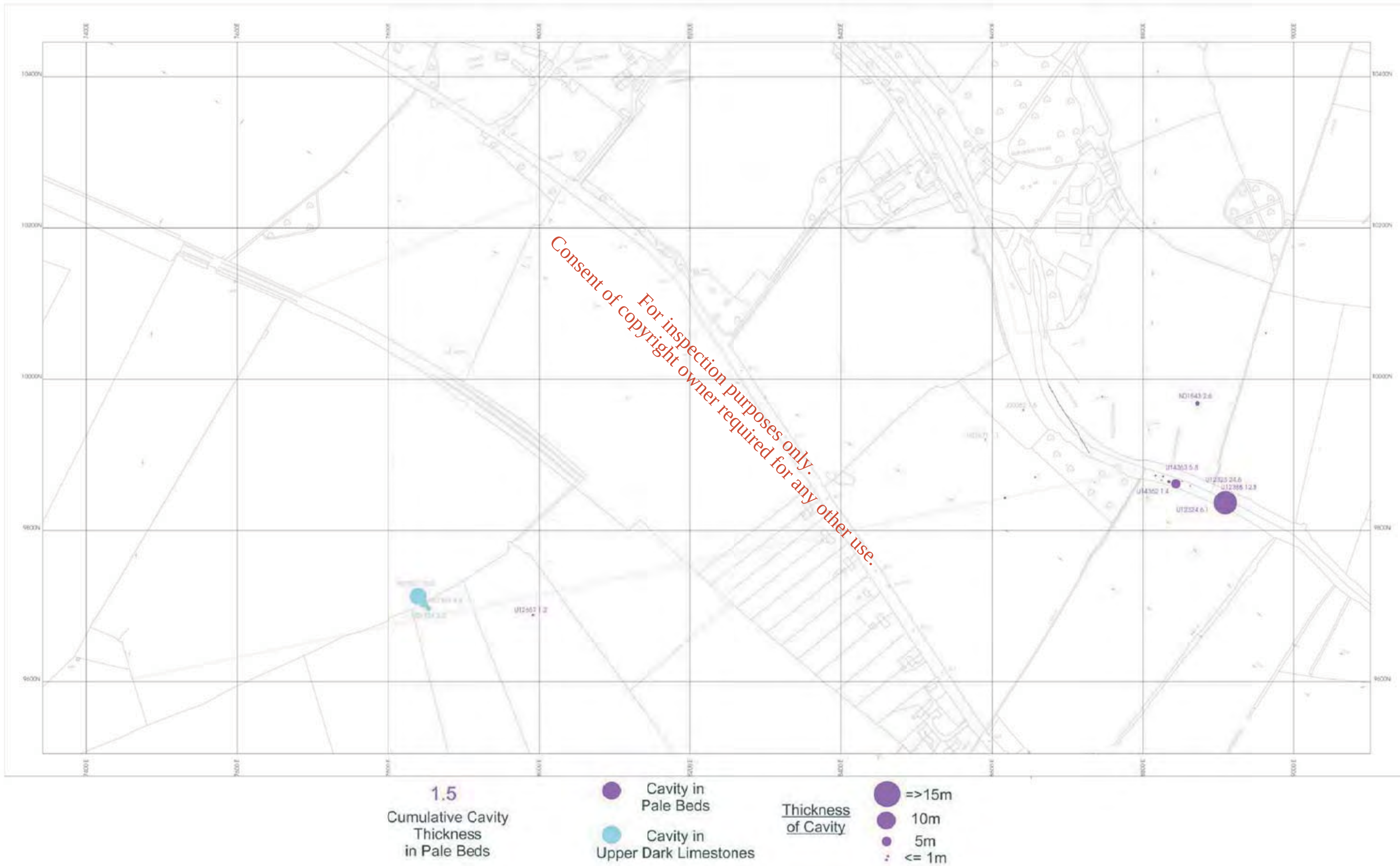
Figure 6.18 Cavity plan



6.3 Hydrogeology

6.3.1 Hydrological dataset

The following hydrological data are available for the Liscartan and Rathaldron application areas:

- Monthly totals of rainfall recorded at the mine for the period January 1971 to December 1986 and daily rainfall totals for the period January 1987 to July 2009.
- Spot water level measurements in 9 surface drill holes distributed throughout the application areas.
- Flow and pressure measurements in two underground holes drilled during underground development (U19700 and U20008).
- Detailed geology logs in over 70 holes drilled to define the area of the application areas.
- Water level measurements for the period April 2004 to May 2009 in 43 monitoring boreholes distributed throughout the area underlain by the adjacent Nevinstown orebody.
- Historical water level measurements and extensive monitoring of inflow records throughout the Main Mine and Nevinstown.

Available hydrogeological data for the Liscartan and Rathaldron application areas are plotted on Figures 6.10 to 6.16.

6.3.2 Rainfall at the mine

Rainfall is recorded daily at the Tara Mines weather station (Irish OS coordinates 284,820 mE, 268,450 mN). The rain gauge is a Casella *Simple Rain Gauge* with inner can and flat measuring jar.

Monthly rainfall totals for the period January 1971 to July 2009 are included in Appendix A. Figure 6.19 shows the mean monthly rainfalls. The figure also shows the accumulation of the mean monthly totals through the year as a surrogate cumulative rainfall plot for an average year. The end of year total thus derived is 852.7 mm. This is very similar to the mean of all annual total rainfall values: 851.1 mm.

The boreal temperate maritime climate of Ireland is seasonal. Depressional weather systems and associated fronts tracking west from the Atlantic provide much of Ireland's rain. During the summer, continental high pressure systems may extend over part of Ireland, reducing the rainfall total. Convective systems may produce showers and thunderstorms, particularly during the warmer summer months.

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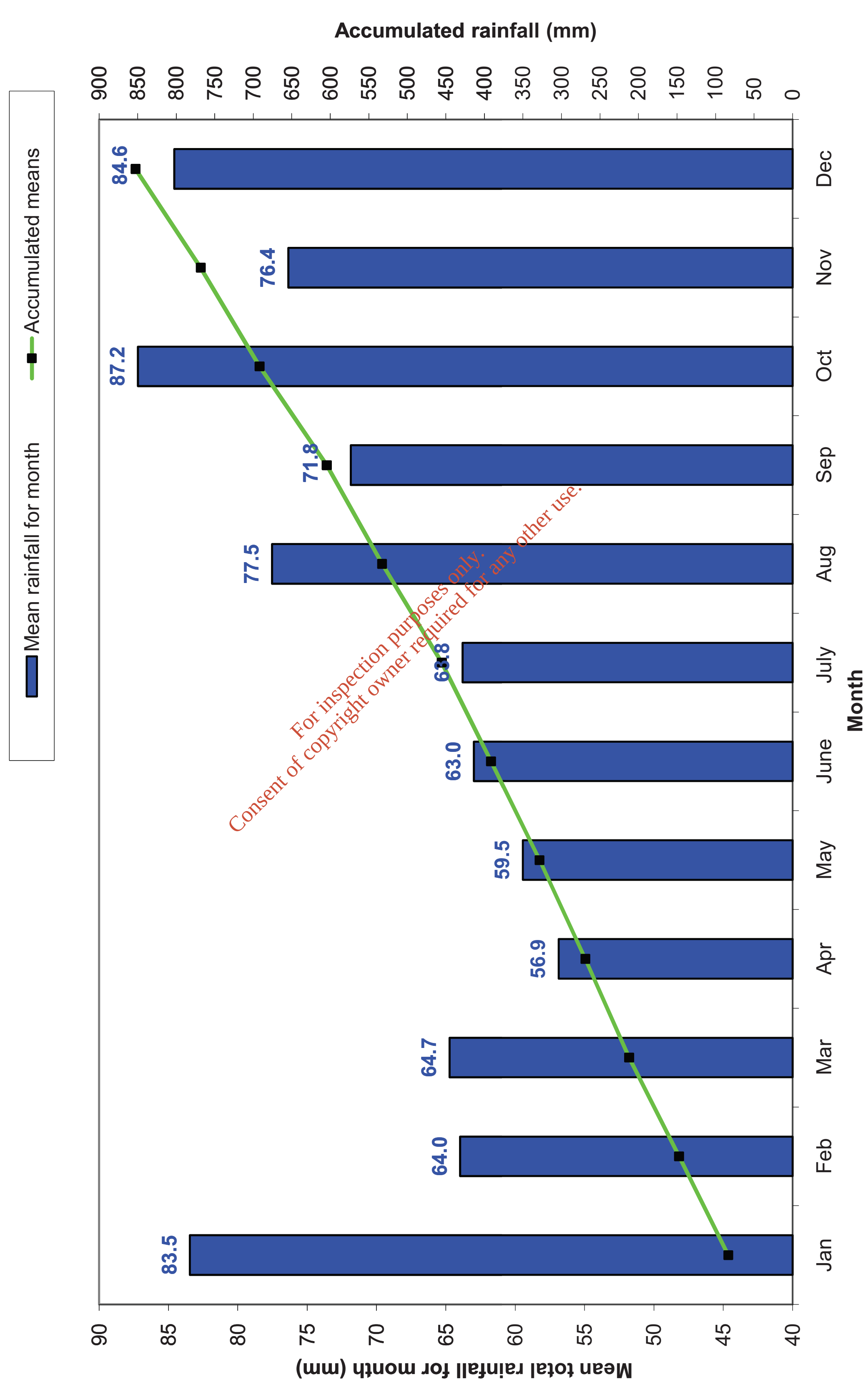
Figure 6.19 Monthly rainfall for the period 1971 - July 2009



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The rainfall record at Tara demonstrates this seasonality. An autumn-winter wet season (October to January) and a summer dry season (April to July) are seen. The month with the highest mean is October with 87.2 mm. April has the lowest total at 56.9 mm.

The wettest year on record was 2006; the driest was 1971. Table 6.4 shows the mean monthly rainfall for the period of available data.

Table 6.4 Mean monthly rainfall at the Tara mine

Month	**Number of monthly totals available (n)**	**Mean rainfall (mm)**
January	39	83.5
February	39	64.0
March	39	64.7
April	39	56.9
May	39	59.5
June	39	63.0
July	39	63.3
August	38	77.5
September	38	71.8
October	38	87.2
November	38	76.4
December	38	84.6
	Sum of means:	852.2

6.3.3 Groundwater head measurements

Table 6.5 summarises the groundwater level information available for Liscartan and Rathaldron core holes. Table 6.6 summarises all available groundwater level data for the surrounding mine monitoring boreholes which form part of the monitoring network. These latter data are plotted on Figure 6.20, 6.21 and 6.22.

Regular groundwater level measurements are taken in three core holes located close to the Liscartan & Rathaldron application area; their hydrographs are presented in Figure 6.23. The following points are noted:

- The groundwater level in N01673 (on Section Line NW829 in Rathaldron) was fairly stable at around 58 to 55 mBOD, (1468.7 to 1471.7 mAMD) until October 2006 when groundwater levels began to drop. By April 2007, the groundwater elevation was about 139 mBOD (1387.7 mAMD). This drop of around 80 m in 6 months demonstrates localised dewatering of the Pale Beds in the vicinity of the hole.

Table 6.5 Available groundwater level information for the Liscartan/Rathaldron area

Drill hole	Easting	Northing	Collar elevation[a]		Measurements available	Representative water level measurement date	Representative groundwater level[a]			
	m	m	maMD	maOD			mbc	mbgl	maMD	maOD
N01671	8591.35	9920.71	1571.12	71.12	Single measurement	06 Jan 2003	113	-	1458	-42
N01679	8591.35	9864.14	1571.30	71.30	Single measurement	27 Jan 2003	193	-	1379	-121
N01739	8251.94	9920.71	1579.46	79.46	Single measurement	29 Oct 2003	142	-	1437	-63
N01814	8018.19	9814.79	1582.91	82.91	Single measurement	24 Nov 2005	111	-	1472	-28
N01851	7863.90	9691.63	1585.64	85.64	Single measurement	02 Oct 2006	137[c]	-	1449	-51
N01863	8963.74	10060.99	1574.45	74.45	Single measurement	12 Oct 2006	29	-	1545	45
N01867	7863.90	9691.63	1585.64	85.64	Single measurement	25 Jan 2007	81[d]	-	1505	5
U19700	-	-	1250[e]	-250	Single measurement	Nov 2006	-	169	1413	-87
U20008	-	-	1250[e]	-250	Single measurement	Nov 2006	-	220	1362	-138

Notes:

a) *maMD = m above mine datum; mbc = m below collar of corehole; mbgl = m below ground level; maOD = m above Ordnance Datum*

b) *N01851 recorded water level for 02 Oct 2006, 145.71 mbc, has been corrected based on an assumed corehole inclination of 70°*

c) *N01867 recorded water level for 25 Jan 2007, 85.8 mbc, has been corrected based on an assumed corehole inclination of 70°*

d) *Holes U19700 & U20008 are underground core holes with an inclination of -45° on an azimuth of 315°, extending through the Castle Fault Complex to the downthrown 1-5 lens footwall, northwest of the fault. U19700 is on Section Line NW761. U20008 is on the closely adjacent Section Line NW759. The 1230 B17EX drift in this region is at about the 1,250 m elevation. Pressure heads at hole collars were 16 bar (168.8 m H20 at 4ºC) at U19700 and 11 bar (112.2 m H20 at 4ºC) at U20800*

Table 6.6 Available groundwater level information for monitoring network boreholes

Name	X	Y	Datum elevation (maMD)	Datum elevation (maOD)	No. of readings	Groundwater depth		Groundwater elevation (maMD)				Groundwater elevation (maOD)		
						Min.	Mean	Max.	Min.	Mean	Max.	Min.	Mean	Max.
N01640	285527	268378	1566.2	39.5	62	31.5	82.05	100.1	1534.7	1484.2	1466.1	8.0	-42.5	-60.6
N01644	285384	268473	1563.7	37.0	10	49.5	49.59	49.7	1514.2	1514.1	1514.0	-12.5	-12.6	-12.7
N01647	285639	268422	1571.1	44.4	11	80	83.05	86.2	1491.1	1488.1	1484.9	-35.6	-38.7	-41.8
N01648	285345	268938	1574.5	47.8	62	39.7	54.55	65.2	1534.8	1519.9	1509.3	8.1	-6.8	-17.4
N01650	285458	268433	1563.9	37.2	62	24.05	28.41	30.9	1539.9	1535.5	1533.0	13.2	8.8	6.3
N01651	285356	268711	1571.9	45.2	8	57	60.51	65.2	1514.9	1511.4	1506.7	-11.8	-15.3	-20.0
N01661	285615	268310	1567.1	40.4	62	89.1	94.97	99.7	1478.0	1472.1	1467.4	-48.7	-54.6	-59.3
N01662	285019	268800	1572.9	46.2	9	56.1	57.89	60.6	1516.8	1515.0	1512.3	-9.9	-11.7	-14.4
N01663	285521	268411	1567.7	41.0	9	85.5	91.56	100.9	1482.2	1476.1	1466.8	-44.5	-50.6	-59.9
N01666	284965	269009	1573.7	47.0	8	27	31.52	33.2	1546.7	1542.2	1540.5	20.0	15.5	13.8
N01673	284827	268859	1564.0	37.3	61	90.7	103.32	176.3	1473.3	1460.7	1387.7	-53.4	-66.0	-139.0
N01674	285173	268344	1572.2	45.5	8	37.15	37.71	38.4	1535.1	1534.5	1533.8	8.4	7.8	7.1
N01675	285172	268345	1572.3	45.6	6	21.2	21.27	21.4	1551.1	1551.0	1550.9	24.4	24.3	24.2
N01711	285111	269114	1574.8	48.1	62	22.7	36.33	57.8	1552.1	1538.5	1517.0	25.4	11.8	-9.7
N01726	285396	269069	1574.4	47.7	12	21.6	24.93	28.15	1552.8	1549.5	1546.3	26.1	22.8	19.6
N01737	284238	269159	1573.3	46.6	62	15.6	37.59	62.6	1557.7	1535.7	1510.7	31.0	9.0	-16.0
N01742	285379	269358	1572.5	45.8	62	9.1	18.67	39	1563.4	1553.8	1533.5	36.7	27.1	6.8
N01743	285244	269408	1572.9	46.2	62	12.1	21.72	38.1	1560.8	1551.1	1534.8	34.1	24.4	8.1
N01744	285150	269538	1571.6	44.9	62	9.3	15.04	19.3	1562.3	1556.6	1552.3	35.6	29.9	25.6
N01745	285067	269379	1574.4	47.7	62	15.9	25.58	44.5	1558.5	1548.8	1529.9	31.8	22.1	3.2
N01749	285322	268800	1572.7	46.0	62	45.1	57.54	77.7	1527.6	1515.2	1495.0	0.9	-11.5	-31.7
N01750	285561	269057	1574.1	47.4	62	10.2	14.16	21.7	1563.9	1560.0	1552.4	37.2	33.3	25.7
N01751	285662	268654	1573.1	46.4	62	8.3	9.75	11.3	1564.8	1563.4	1561.8	38.1	36.7	35.1
N01752	285899	268953	1573.4	46.7	62	0.6	1.37	3.2	1572.8	1572.0	1570.2	46.1	45.3	43.5
N01753	285170	268959	1575.8	49.1	62	54.3	72.38	96.6	1521.5	1503.4	1479.2	-5.2	-23.3	-47.5
N01754	285712	268303	1566.9	40.2	62	7.9	10.56	14.8	1559.0	1556.4	1552.1	32.3	29.7	25.4
N01755	285281	268553	1563.2	36.5	62	7	14.90	26.4	1556.2	1548.3	1536.8	29.5	21.6	10.1
N01756	285282	268552	1563.3	36.6	62	0	0.65	1.5	1563.3	1562.6	1561.8	36.6	35.9	35.1
N01757	285166	268592	1563.4	36.7	62	0.9	2.52	4.04	1562.5	1560.9	1559.3	35.8	34.2	32.6

Name	X	Y	Datum elevation (maMD)	Datum elevation (maOD)	No. of readings	Groundwater depth		Groundwater elevation (maMD)				Groundwater elevation (maOD)		
						Min.	Mean	Max.	Min.	Mean	Max.	Min.	Mean	Max.
N01758	285167	268592	1563.4	36.7	62	0.1	0.62	3.2	1563.3	1562.7	1560.2	36.6	36.0	33.5
N01759	285710	268303	1567.0	40.3	62	0.3	1.53	2.8	1566.7	1565.5	1564.2	40.0	38.8	37.5
N01761	284826	268860	1563.9	37.2	62	0.2	2.71	4.7	1563.7	1561.2	1559.2	37.0	34.5	32.5
N01765	285661	268109	1571.2	44.5	60	1.4	2.27	3.7	1569.8	1569.0	1567.5	43.1	42.3	40.8
N01766	285556	268103	1571.7	45.0	60	13.02	16.23	16.99	1558.6	1555.4	1554.7	31.9	28.7	28.0
N01767	285411	268075	1575.5	48.8	60	2.7	5.36	12.4	1572.8	1570.2	1563.1	46.1	43.5	36.4
N01778	284978	267756	1578.0	51.3	56	1.1	3.81	5.05	1576.9	1574.2	1573.0	50.2	47.5	46.3
N01779	284735	267789	1575.0	48.3	53	3.55	4.72	6.4	1571.5	1570.3	1568.6	44.8	43.6	41.9
N01783	284910	269017	1575.0	48.3	55	34.95	53.49	90.2	1540.0	1521.5	1484.8	13.3	-5.2	-41.9
N01786	285277	268852	1573.2	46.5	54	14.05	63.84	86.3	1559.1	1509.3	1486.9	32.4	-17.4	-39.8
N01787	285443	268725	1571.1	44.4	53	42.9	70.55	86.9	1528.2	1500.6	1484.2	1.5	-26.1	-42.5
OB 1765	285661	268109	1571.2	44.5	60	1.3	2.15	3.3	1569.9	1569.1	1567.9	43.2	42.4	41.2
OB 1766	285556	268103	1571.7	45.0	60	0.7	1.52	3.3	1571.0	1570.1	1568.4	44.3	43.4	41.7
OB 1767	285411	268075	1575.5	48.8	60	2.6	3.53	4.7	1572.9	1572.0	1570.8	46.2	45.3	44.1
RCH	284655	269282	1567.7	41 (estimated)	20	7.72	9.09	11.5	1560.0	1558.6	1556.2	33.3	31.9	29.5

Notes:

a) *maMD = m above mine datum; mbc = m below collar of corehole; mbgl = m below ground level; maOD = m above Ordnance Datum*

b) RCH = Rathaldron House Well (Irish NGR coordinates 284655 E 269282 N). This is a private production well, which supplies water for agricultural and domestic use at Rathaldron House. The well is understood to have a drilled diameter of 6" (152 mm) and a drilled depth in excess of 50 m. The geological map indicates that the solid geology at the well is the Waulsortian Limestone. Datum elevation is estimated based on recent topographical maps of area.

- The water level in N01783 (on Section Line NW846 in the north of Rathaldron) is fairly steady, varying from 6 to 10 mBOD (1532.7 to 1536.7 mAMD) until around February 2007 when groundwater levels then drop to their lowest elevation of 45 mBOD (1481.7) in December 2007 and then fluctuate between 30 to 20 mBOD (1496.7 to 1506.7 mAMD) until April 2009.

- Groundwater levels in N01737 (on Section Line NW802 in the north of Liscartan) has fluctuated between 20 and 35 mBOD (1506.7 to 1491.7 mAMD) during the monitoring period. The hydrograph shows that frequent fluctuations in groundwater levels of up to 25 m are a common occurrence in this well. Groundwater levels fell to their lowest elevation of around 20 mBOD (1506.7 mAMD) in December 2007.

- Groundwater levels in RCH have remained relatively stable throughout the monitoring period and has fluctuated between 30 and 31 mBOD (1496.7 and 1495.7 mAMD). The hydrograph for this well shows no fluctuations which are of a similar trend or magnitude to the fluctuations observed in (N01673, N01783 and N01737).

Figure 6.20 Groundwater hydrographs for all monitoring wells

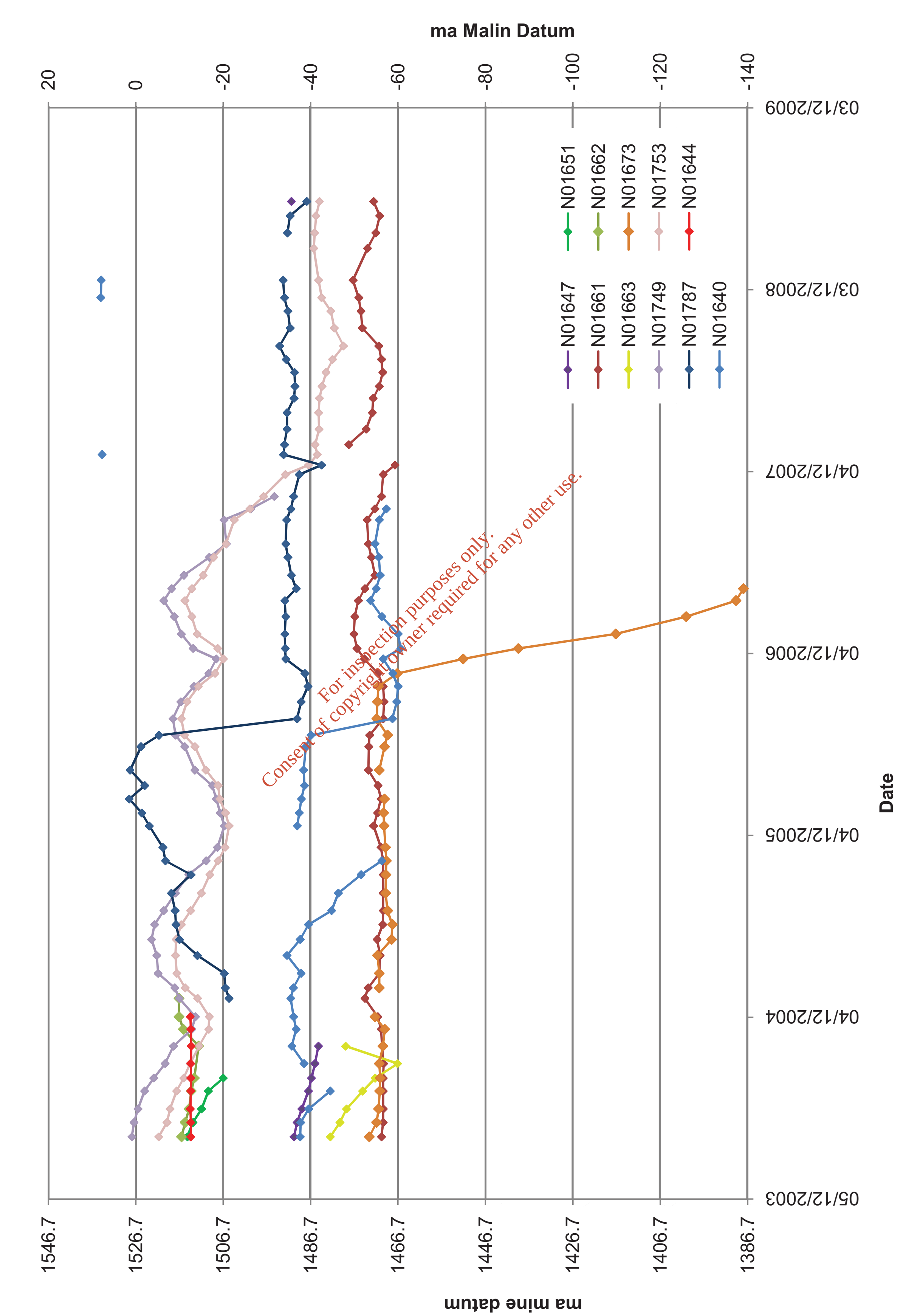

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Figure 6.21 Groundwater level hydrographs for all monitoring wells

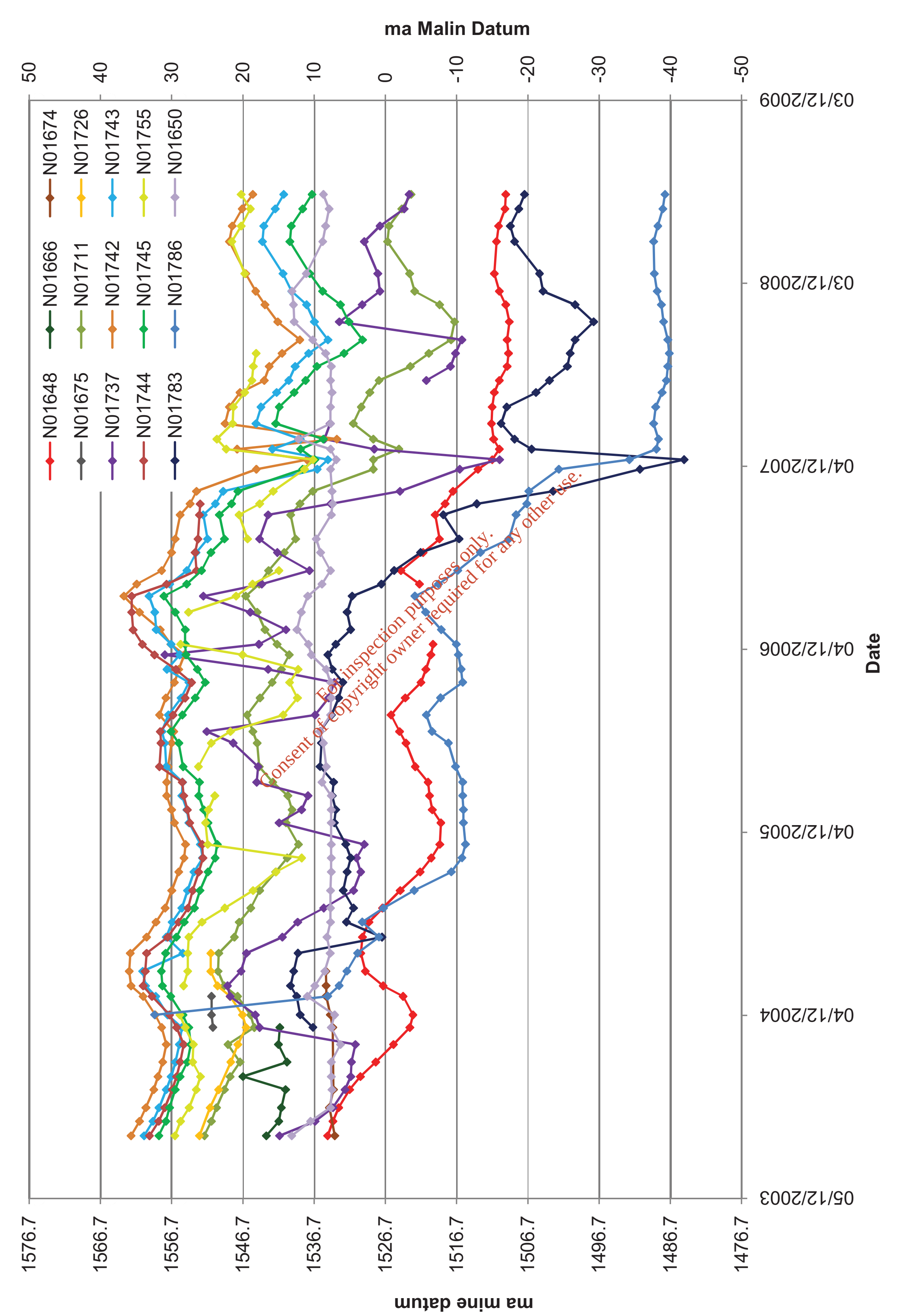

Figure 6.22 Groundwater level hydrographs for all monitoring wells

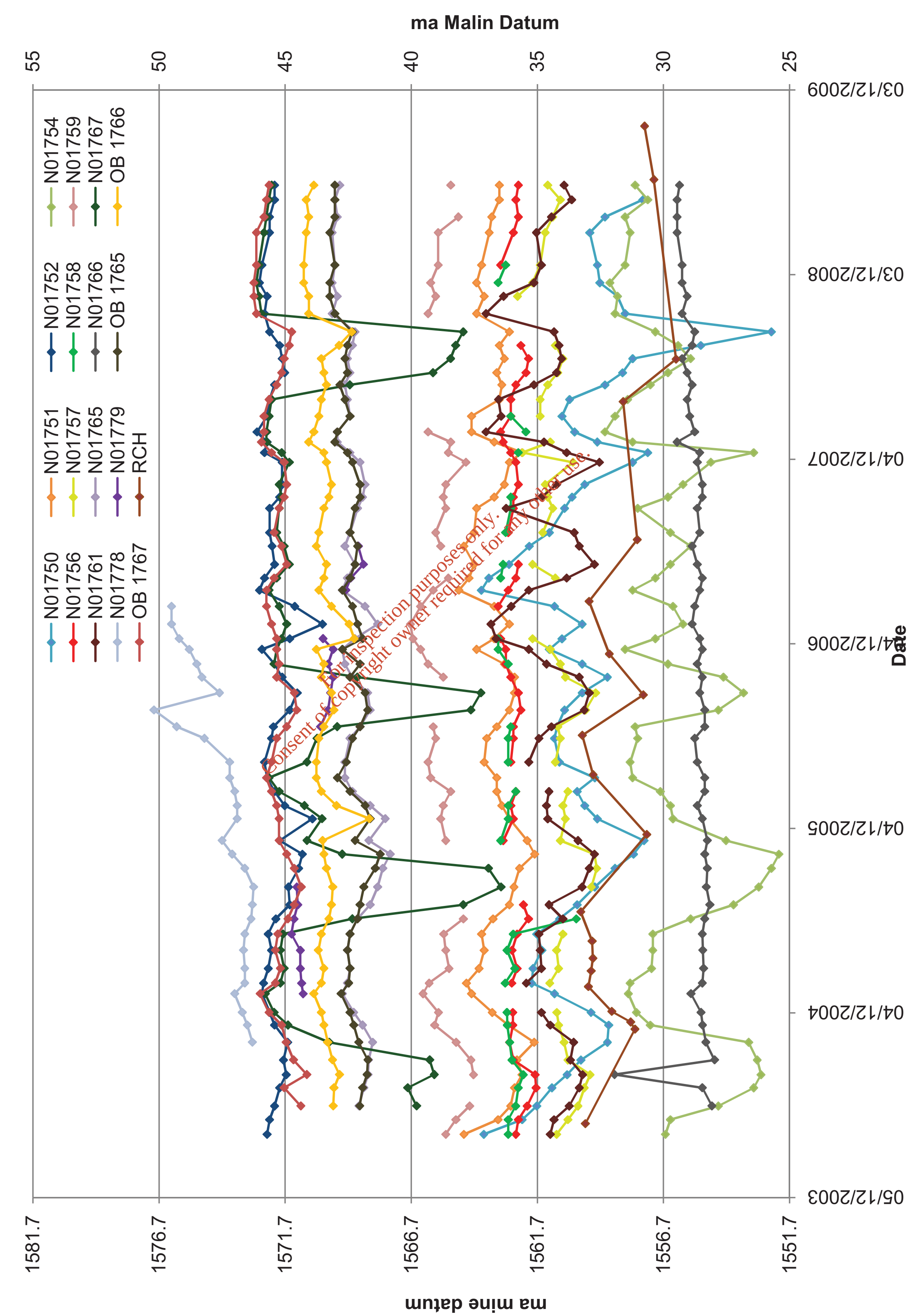

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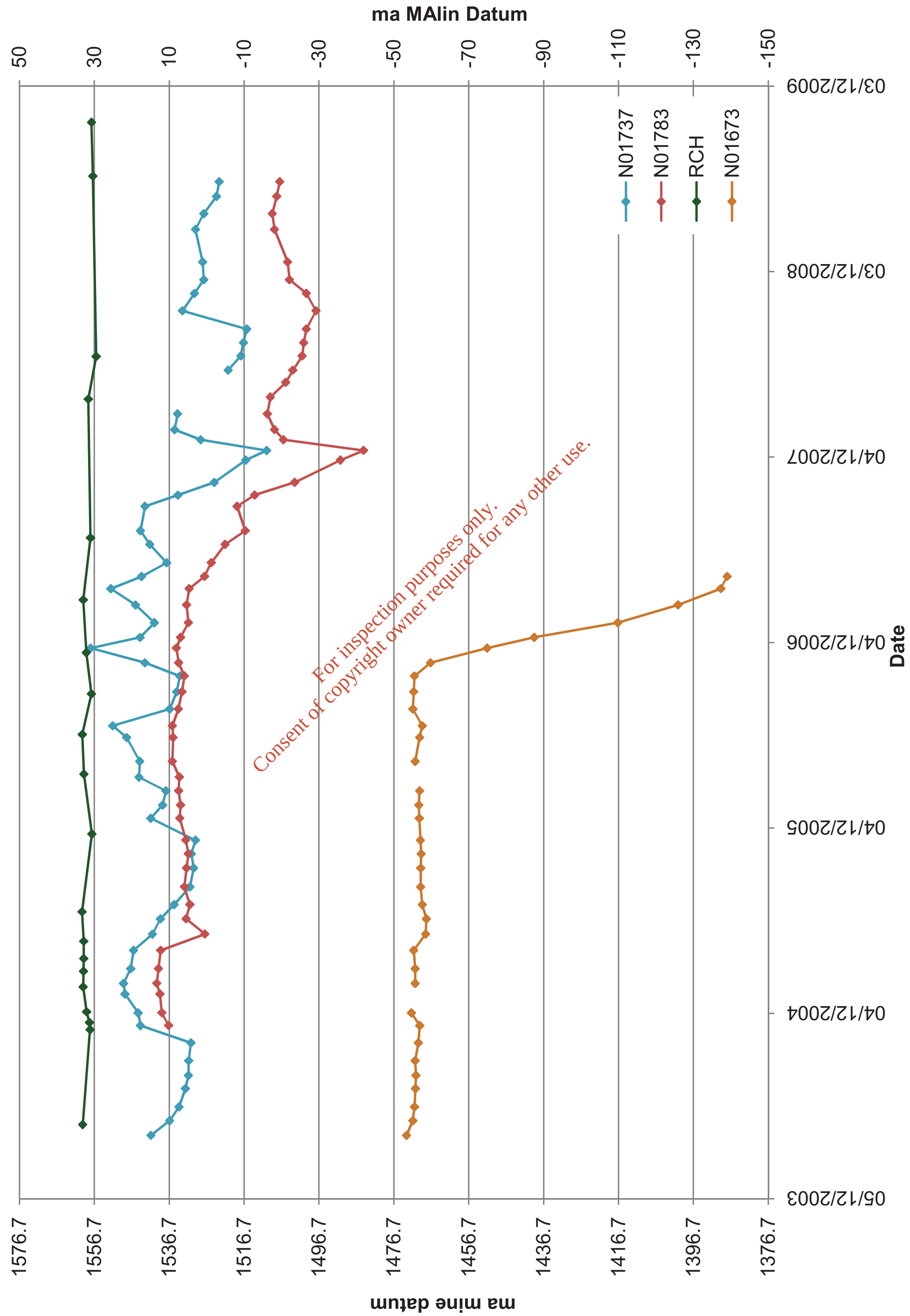
Figure 6.23 Groundwater level hydrographs for monitoring wells close to the Liscartan/Rathaldron application area



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6.3.4 Observed groundwater inflow rates

6.3.4.1 Overall groundwater inflows

Figure 6.7 presents the weekly estimates of total water make to: (i) Nevinstown; (ii) the main mine; and (iii) SWEX. The combined water make to the Main Mine and Nevinstown is currently in the region of 100 l/second (equivalent to 8,640m^3/day) (based on the data period February 2007 to February 2009).

When "new" groundwater has been encountered as the Nevinstown workings have been opened up, so there has generally been a reduction in the inflow rate to the Main Mine, down-dip from Nevinstown. The groundwater inflow rate to the Nevinstown workings is currently about 44.6 l/second (equivalent to 3853 m^3/day). A gradual augmentation has been observed in the measured inflows to Nevinstown since January 2004, as new stoping areas have been opened up throughout Nevinstown. The estimates of groundwater inflow to Nevinstown in previous years were: 20 l/second in January 2004, 25 l/second in January 2005 and 2006, 30 l/second in January 2007, 45 l/second in January 2008 and 40 l/second (equivalent to 3888 m^3/day) in January 2009.

Figures 6.24, 6.25 and 6.26 show water makes on the:

- 1150-level Block 17W;
- 1230-level NW; and
- 1315-level;

respectively. The centre line long section 190N of Figure 6.16 also provides some groundwater inflow information. The regions covered by these drawings are shown on Figure 6.10.

Most of the inflow to the Tara workings occurs in discrete inflow zones that are controlled by a combination of lithology, structure and local jointing. All of the major inflow zones occur with the Pale Beds unit. In general, the overlying UDL sequence acts to inhibit the downward movement of groundwater into the Pale Beds, except in certain discrete areas.

Discrete inflows to the Tara workings of 7.6 litres/second (equivalent to 100 gpm) or greater, in the last 2 years of monitoring data are presented in Table 6.7.

Table 6.7 Inflows to Tara mine ≥7.6 litres/second recorded in the last 2 years

Name	Min. Flow (l/s)	Mean Flow (l/s)	Max. Flow (l/s)	% of Total sector inflow	Date min. recorded	Date max. recorded
1150 B.17 F-8000-9600-1195	2	7	9	17	03-Feb-07	28-Feb-09
Zone 1+2 +NW	38	38	38	71	03-Feb-07	28-Feb-09
Zone 3	8	8	8	14	03-Feb-07	28-Feb-09
1330 N208EX-8960-9891-1385	3	4	11	26	03-Feb-07	28-Feb-09
1390 N303CA-9050-9920-1392	0	15	49	99	03-Feb-07	28-Feb-09
1390 N305D1-9092-9956-1410	0	1	8	19	12-Jan-08	28-Feb-09
1390 N3CHLG-8997-9933-1380	1	4	8	19	03-Feb-07	28-Feb-09
0650 MANWAY-6850-6865-663	0	8	23	49	30-Jun-07	05-Jul-08
0675 3UEX1-6900-6920-670	0	3	8	19	03-Feb-07	28-Feb-09
0725 B.120-7080-7110-730	5	8	11	26	03-Feb-07	28-Feb-09
0725 H90W-6925-6788-745	0	9	21	49	16-Feb-08	28-Feb-09
0750 H81W-6900-7000-805	2	11	28	65	03-Feb-07	28-Feb-09
0750 H81WR3	0	6	11	28	20-May-07	09-Jun-07

Notes:
% of Total sector inflow = Maximum recorded inflow expressed as % of total sector inflow on that date.

In the third week of March 2006, a transient inflow occurred to the Nevinstown sector of the workings as a result of flood water from the River Blackwater entering an old drill hole located on the flood plain and flowing down the hole into the workings (1500 N508H). This inflow peaked at about 26.5 l/second and lasted for about 2 weeks until the hole was sealed with grout.

Higher than anticipated groundwater inflows have occurred to the SWEX portion of the workings. Peak inflows to SWEX were above 61 l/second in early 2006, but subsequently declined to less than 23 l/second. It is currently interpreted that most of the SWEX inflows result from shallower water from the weathered portion of the UDL (less than about 300 m depth) moving down old Navi drill holes into the current active workings. A grouting programme has been underway since late 2005 to plug the old Navi holes from the surface and to inject grout under pressure from the workings into facture systems connecting into the old drill holes. To date, both the surface and underground grouting programmes have been successful, resulting in a significant reduction in the inflow rate to the SWEX sector of the mine.

Figure 6.24 Map showing water makes in 1150 level Block 17 W

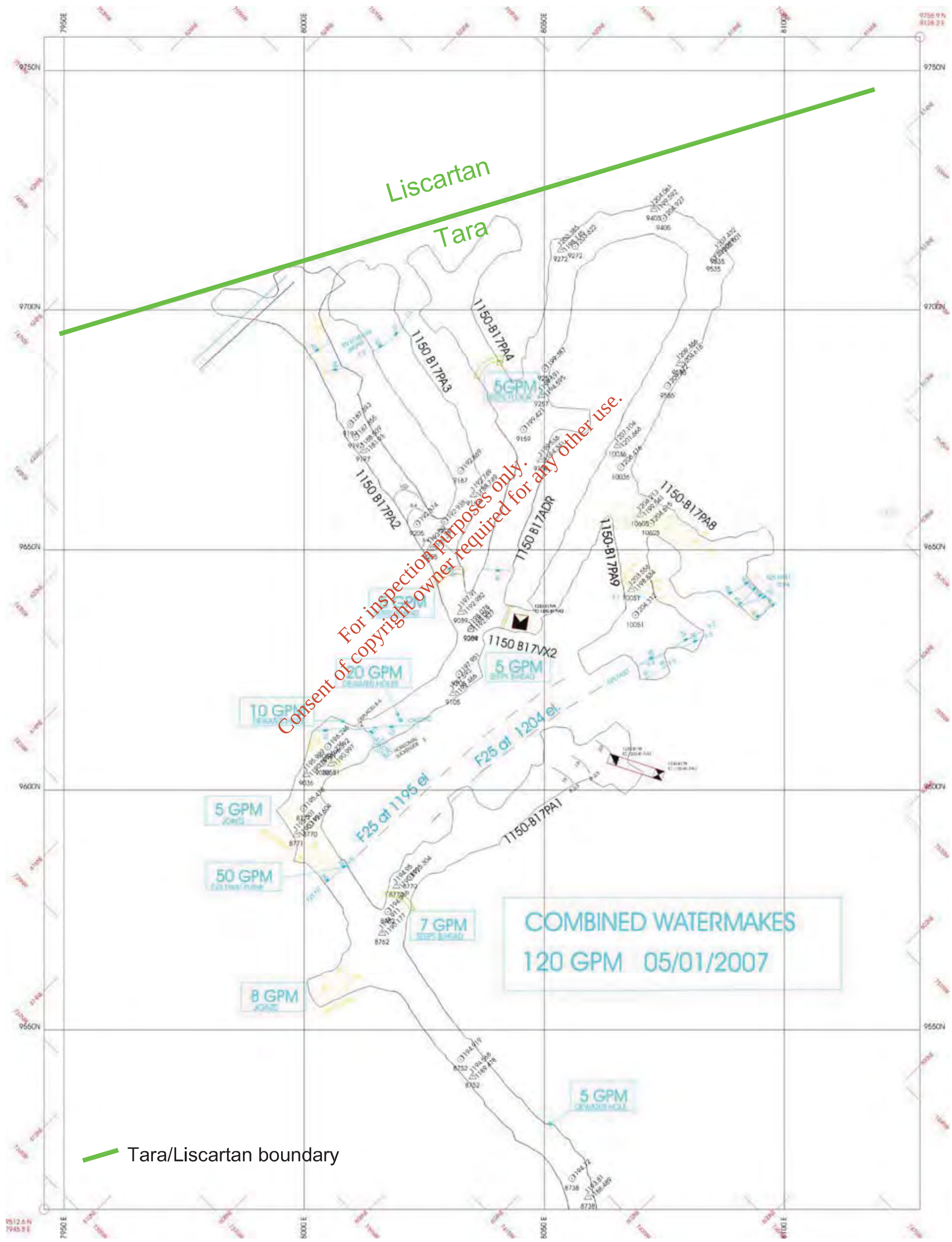

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Figure 6.25 Mappingon the 1230 level NW

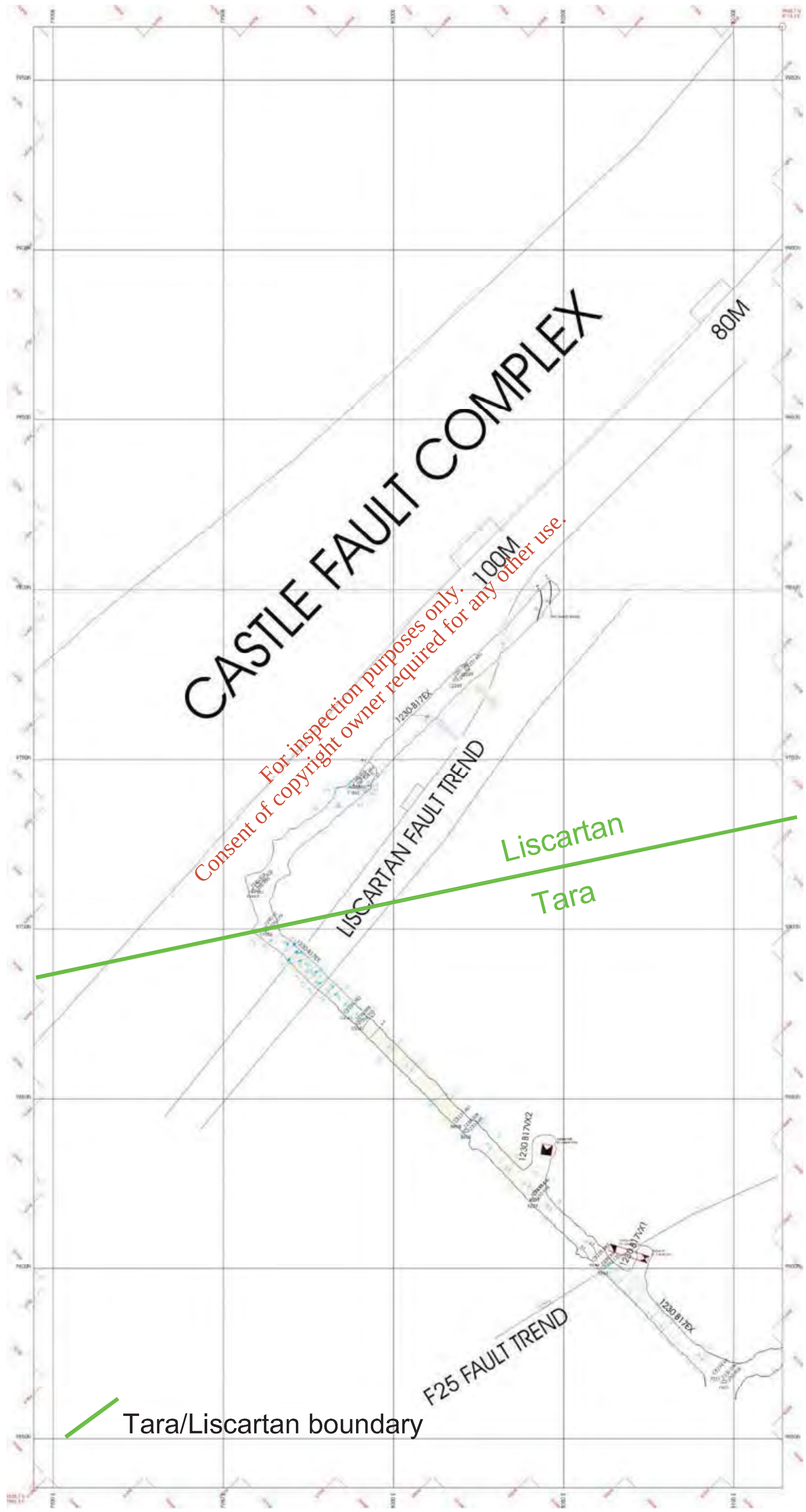

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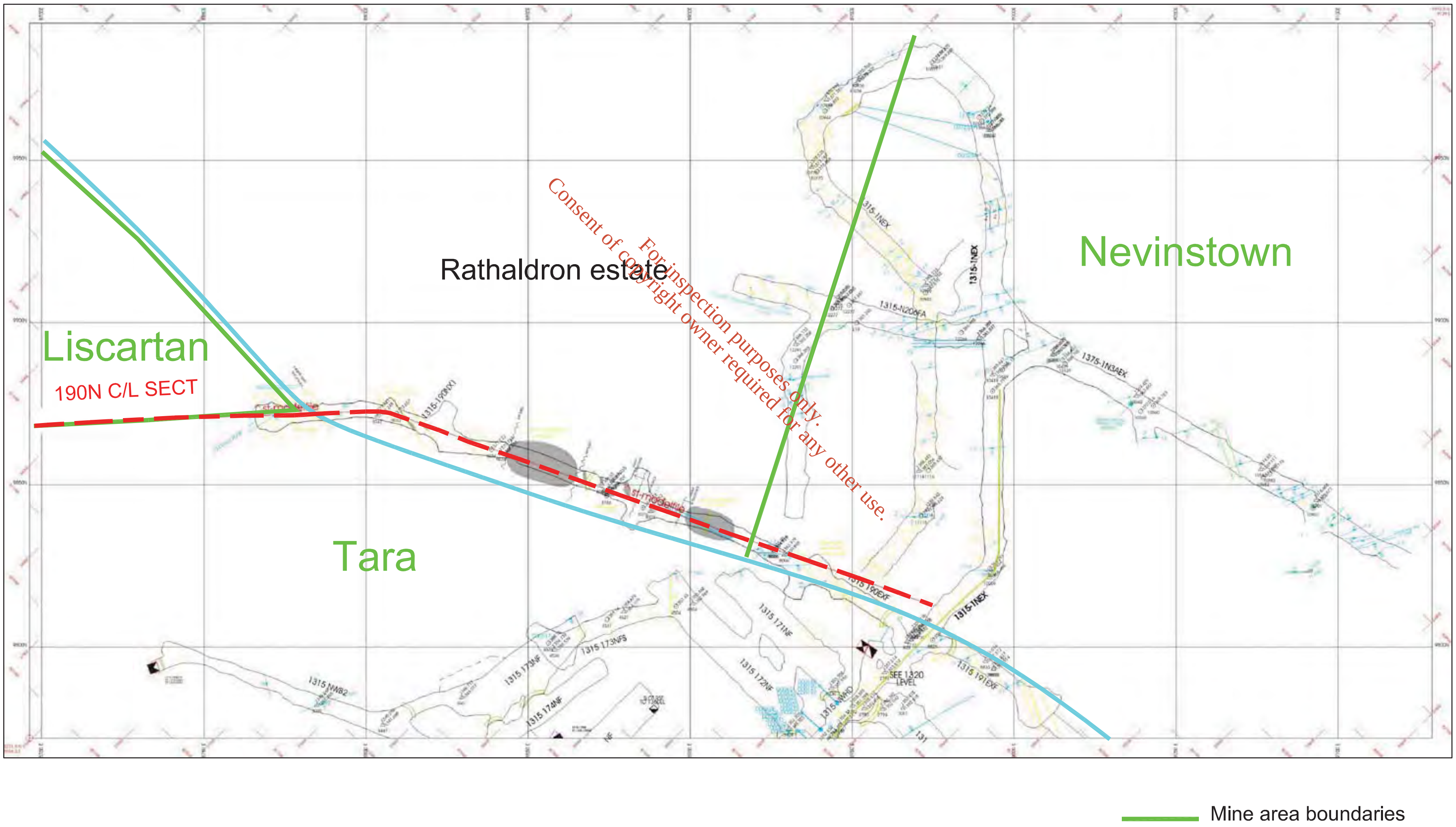
Figure 6.26 Map showing 1315 level



6.3.4.2 Observed inflows in drifts extending towards the Liscartan application area

Groundwater inflow rates to the workings are monitored on a weekly basis. Groundwater inflows for 1150 Block 17F and the 1315 level, located closest to the Liscartan/Rathaldron application area are summarised as follows:

- 1150 Block 17F, located in the Main Mine sector, was estimated to have water makes totalling 2.6 l/second in February 2009 compared with 9.1 l/second in January 2007. The intersection of the mine workings with the F25 Fault at the 1,195 mAMD (-331.7 mBOD) elevation accounted for 3.8 l/second, which is 42% of the total inflow.
- Inflows to the 1315 level are estimated at 0.1 l/second in February 2009, compared to 0.5 l/second in January 2007, from vughy joints intersected by the mine workings at mine coordinates 8925 mE, 9910 mN, at an elevation of around 1,365 mAMD (-161.7 mBOD).

Three of the six AQ diameter core holes (U19698, U19700 and U20008) drilled from the 1230 B17EX drift have shown significant water makes. Holes U19698 and U19700 are on Section Line NW761. U20008 is on the closely adjacent Section Line NW759. The 1230 B17EX drift in this region is at around 1,250 mAMD - (276.7 mBOD), which equates to about 330 m below ground level. U19698 is a vertical hole extending to about 95 m below the floor of the 1230 B17EX drift. U19700 and U20008 have an inclination of -45º on an azimuth of 315º, extending through the Castle Fault Complex to the downthrown 1-5 lens footwall, northwest of the fault. U19698 and U19700 were drilled around November 2006. U20008 was drilled in early March 2007. The observed inflows are summarised as follows:

- U19698 made 0.2 l/second at 63 m below the floor of the 1230 B17EX drift. The pressure head was reported to be minimal.
- U19700 made 0.8 l/second at 105 m of hole length (74 m below the floor of the drift, just below the Nodular Marker in the Pale Beds). The inflow rate increased as the hole was continued within the Pale Beds. At 290 m hole length the reported inflow rate was 4.5 l/second at 16 bar.
- U20008 made 4.5 l/second at 99 m of hole length and 6 l/second at 150 m of hole length.

Water make 1230 B.17 EX1 demonstrated increased discharge rates from spring through summer 2007 as the volume of the mine void at Nevinstown increased and additional probe and ore delineation DDHs were drilled. The impact of the increased discharge from the water makes is apparent in the falling water levels in Pale Beds monitoring wells such as N01737 and N01783 at this time (See Figure 6.27). Water makes in this part of the mine workings (1230 B17EX1.8040-9780-1250 and 1230 B17EX2.8000-9700-1240) have decreased since the start of 2007 to inflow rates which are no greater than 3 l/second. There was an increase in inflow rate from 1230 B.17 EX1 during November 2009; it is considered that this was due to higher rates of recharge to the aquifer system in the area due to an increase in rainfall during winter.

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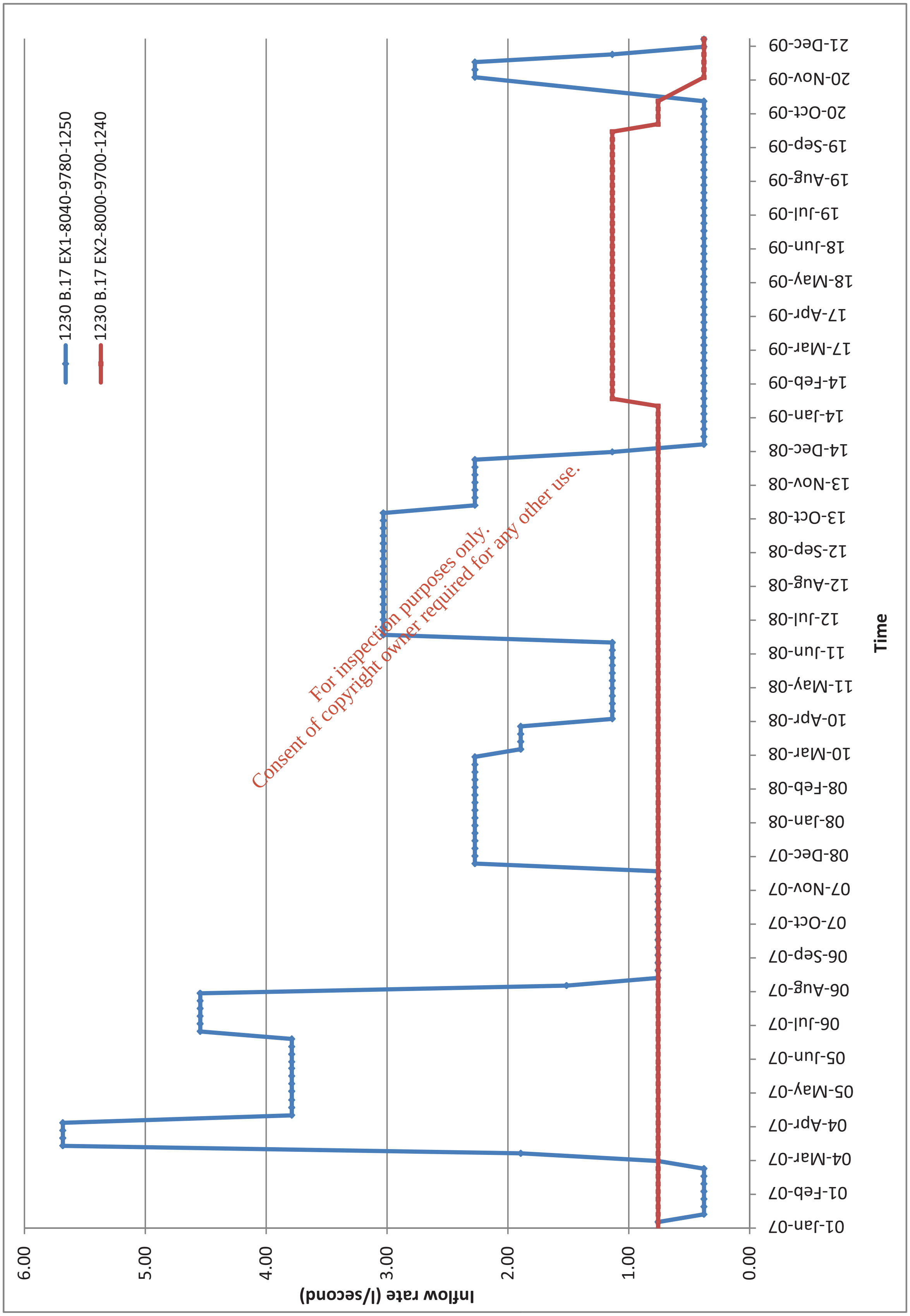
Figure 6.27 Hydrograph showing water inflow rates at B17 EX1 and B17EX2 water makes since 2007



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6.3.5 Sources of water flowing to the mine

Groundwater inflows to the Tara workings are currently derived from four principal sources:

- District-scale groundwater flow in the Pale Beds.
- Downward leakage from the UDL into the Pale Beds.
- Recharge derived from precipitation.
- Leakage from the River Blackwater.

The groundwater balance for the Main Mine and Nevinstown is currently interpreted as follows:

- Total groundwater inflows to Nevinstown and the Main Mine: 99.8 l/second (equivalent to 8,623 m^3/day).
- Groundwater inflows to Nevinstown: 44.6 l/second (equivalent to 3853 m^3/day).
- Groundwater inflows to the Main Mine: 55.2 l/second (equivalent to 4,769 m^3/day).
- Total inflows derived from district-scale flow in the Pale Beds (including downward leakage of storage in the UDL): 76 l/second (equivalent to 6,566 m^3/day).
- Inflows derived from infiltration of precipitation over the area of the workings: 9.5 l/second (equivalent to 821 m^3/day).
- Inflows derived from the river: 1.5 l/second (equivalent to 130 m^3/day).

In addition to the above water balance, groundwater inflows to SWEX are currently about 38.8 l/second. The source of groundwater to SWEX is different to the source of groundwater to the Main Mine and Nevinstown. For SWEX, the main source feeding the inflows is groundwater in the upper weathered zone of the UDL moving downwards towards the workings. For Nevinstown and the Main Mine, the main source feeding the inflows is district-scale flow within the Pale Beds. The difference in sources is reflected by differences in the chemistry between the Main Mine and Nevinstown, and SWEX.

The Pale Beds unit occurs throughout the district, with an outcrop area of about 13 km^2. The Pale Beds is the main permeable groundwater unit in the region of Tara Mines. Groundwater flow within the Pale Beds is fracture controlled, with discrete flow paths associated with the faulting, joint sets and bedding.

Extensive monitoring of the Nevinstown and Main Mine inflows and water chemistry over the past 3-4 years has confirmed that most of the water entering the Main Mine and Nevinstown workings is the result of district-scale groundwater flow within the Pale Beds. As inflows have been encountered due to opening up of the Nevinstown workings, so there has been a general decrease in the magnitude of inflows down-dip in the Main Mine. Current inflows are virtually all derived from district-scale flow rather than from storage removal.

Observed groundwater levels in the Liscartan, Rathaldron and west Nevinstown areas are shown in Figure 6.23. Although the data are collected from open drill holes, the information is considered to reflect groundwater levels in the Pale Beds. A large amount of drawdown is observed in all holes monitored. This indicates the area of the Liscartan/Rathaldron application area has become dewatered as a result of inflows to the Main Mine and Nevinstown. The current water levels are somewhat variable, ranging from -39 to 5 mBOD. In the eastern part of the study area (the west side of Nevinstown), Pale Beds water levels are -139 mBOD. In the western part of the project area, west of the Castle-Liscartan Fault Complex, the available data indicate water levels to be 0 to 5 mBOD (1526.7 to 1531.7 mAMD). This is consistent with the propagation across the fault complex of the depressurisation of the Pale Beds groundwater system owing to groundwater discharge to the mine workings.

Further down-dip, the Pale Beds in the SWEX area occur at an increasing depth below the UDL. As mining advanced down-dip into SWEX, most of the initial inflows were minor (less than 2 l/second) and were derived from local storage of connate groundwater. Mining in SWEX started to encounter high groundwater inflows in early 2002 as a result of mining into surface drill holes. Initial inflow rates from the drill holes to underground were about 15-23 l/second, but dropped to 2-4 l/second after 2-3 days Five water-bearing holes were intercepted during the period 2002 to 2004. Higher inflows from surface holes to SWEX occurred in February 2005, when surface drill hole N1569 was reached by the mine workings. As additional holes were encountered by the underground workings, so inflow rates progressively increased, and the total SWEX inflow peaked at over 64 l/second in November 2005. Underground and surface grouting programs have now successfully reduced the connection to the surface, and current inflow rates to SWEX are now in the range 40 l/second. Much of the current water entering SWEX is derived from downward flow though the overlying UDL. The magnitude of the inflows to SWEX is largely independent of the rate of groundwater inflow to the Main Mine and Nevinstown.

6.3.6 Pale Beds groundwater

The available monitoring data indicate that the Pale Beds is the main groundwater bearing unit in the Main Mine, Nevinstown, and the Liscartan and Rathaldron application areas. The overlying UDL contributes a minor amount of water, but mostly as a result of vertical downward leakage as the underlying Pale Beds become dewatered.

Under pre-mining conditions, groundwater discharged from the Pale Beds by upward leakage through the alluvial deposits to the lower part of the Blackwater flood plain area. It is expected that most of the active groundwater circulation would have occurred in the upper 50-100 m of the outcrop area of the Pale Beds, with the groundwater becoming increasingly static down-dip. Under the current conditions of active mining all bedrock groundwater in the district discharges into the underground workings.

The Nevinstown monitoring data show that, since early 2005, Pale Beds groundwater levels have been fairly steady, responding mostly to seasonal variations in rainfall and groundwater recharge. Below the central part of the Nevinstown orebody, current groundwater levels beneath the river are inferred to be about -136 to -117 mBOD (1,390-1,410 mAMD), representing over 150 m drawdown. To the north of the river, the groundwater levels rise fairly rapidly in the un-mined area. At about 900 m northeast of the river in Nevinstown, water level elevations are currently about 23 to 33 mBOD (1,550-1,560 mAMD). Groundwater levels in the Pale Beds between Nevinstown and the Liscartan appear to be similar in elevation to those in the central part of Nevinstown.

The overall behaviour of the groundwater system indicates a low overall drainable porosity for the Pale Beds. The short-term flow increases that have occurred as a result of mining the stopes have been low and would indicate overall values of drainable porosity of less than 0.01 (although values are likely to be locally higher in areas of greater cavity development). This is typical of a groundwater system dominated by fracture flow with low matrix porosity.

Within the immediate area of the Main Mine and Nevinstown, groundwater is observed to flow along prominent northwest trending joint sets. The density of open jointing may be higher closer to the main structural lineaments, such as the F1 Fault. The most recent monitoring data continue to support the concept that the F1 Fault Zone is the main conduit feeding water into the Nevinstown workings and the Main Mine. The main inflows to Nevinstown are associated with NW trending joint sets in the Pale Beds that are connected to the F1 Fault Zone. Groundwater conditions associated with the F1 Fault Zone have been stable for the past 2 years.

The available water chemistry data also indicate that virtually all of the water makes in the Main Mine and Nevinstown are representative of young, calcium-bicarbonate type water flowing within the Pale Beds (Australian Mining Consultants, 2003). There is virtually no chemical signature of river water in the underground water makes apart from two instances. The first was the former groundwater inflow zone where the North Exploration Decline passes below the Whistlemount Channel (1500 NDEX2). The initial flow from this zone was about 5 gpm, but the zone has been dry since early 2006. The second was N00022 on the flood plain of the river, where seasonal flood waters directly entered the drill hole, as discussed in Section 6.3.4.1.

Down-dip mining of the Main Mine and SWEX has removed Pale Beds groundwater storage at progressively deeper levels below ground.

6.3.7 UDL groundwater

The UDL sequence is strongly layered and generally forms a low permeability vertical barrier to groundwater between the overlying superficial deposits (alluvium) and the underlying dewatered Pale Beds. Carbonate jointing tends to be restricted to the thicker beds. Such jointing typically remains within the individual beds. The joints are usually carbonate infilled. Occasional beds within the sequence exhibit more open jointing and/or fracturing giving them some groundwater flow potential. Bedding planes are frequently polished. Apart from faults, cross-cutting structures are rare. Close to faults, the UDL is often folded. The folding can be tight. Significant regional groundwater flow is not thought to occur within the UDL.

In the Nevinstown and Rathaldron areas, the Pale Beds beneath much of the alignment of the river are overlain by low permeability and strongly layered UDL rocks. The UDL cover occurs within the central part of Nevinstown and to the south. The UDL cover is absent in the area where the F1 and the A Fault Zones cross the river in Nevinstown. It is also absent in most of the up-dip area to the north of the river.

Vertical leakage occurs from the UDL into the underlying Pale Beds. As a result, all monitoring points within the UDL above Nevinstown have shown a significant amount of drawdown (typically 20-50 m). However, UDL groundwater levels above Nevinstown are stable, and have shown little change since mid-2004. As a result of leakage from the UDL downward into the Pale Beds, a vadose zone (unsaturated zone) has opened up within the upper part of the UDL, often beneath saturated superficial deposits. The vadose zone opened up shortly after the commencement of the dewatering of the Main Mine. The incremental local bedrock drawdown due to Nevinstown has not significantly modified the character of the vadose zone.

In the Rathaldron area, and in the area to the north and northeast of Nevinstown, the UDL cover is mostly absent. To the southwest, drawdown has occurred in the UDL as a result of inflows into SWEX. Above SWEX, much of the downward leakage within the UDL is thought to occur down old mineral exploration drill holes. Apart from the SWEX area, there are no UDL groundwater monitoring holes away from the immediate area of Nevinstown. However, it is considered unlikely that any significant drawdown has occurred within the UDL outside the immediate area of dewatered Pale Beds.

6.3.8 Groundwater in the Palaeozoic rocks

Observations to date for the groundwater system around Tara indicate the Palaeozoic rocks are generally of low permeability and are expected to form a barrier to the spread of drawdown away from and beneath the mine workings. Currently, the only available groundwater monitoring data for the Palaeozoics is for the area immediately to the northeast of Nevinstown (N01765). The Palaeozoics in this area are in fault contact with the Pale Beds.

Close to the area where significant drawdown has occurred within the Pale Beds, it would be expected that some drawdown would propagate into the margins of the Palaeozoic rocks. However, because of their low overall permeability, it is not expected that significant district-scale drawdown would occur any distance into the Palaeozoic rocks.

6.3.9 Groundwater in the superficial deposits

A groundwater table occurs within the alluvial deposits of Liscartan and Rathaldron. This water table is typically encountered within 1 to 4 m of ground surface. The water table is closest to the surface in lower lying areas along the River Blackwater.

The formation of multiple (unsaturated) vadose zones within the hydrostratigraphic sequence overlying the Nevinstown workings limits the rate of leakage of groundwater from the superficial deposits into the UDL (where present), and from the UDL into the Pale Beds, in response to the depressurisation of the Pale Beds. The following sequence is seen:

- Water table in the alluvium.
- Intermediate water table in the UDL, at typically 20–50 m depth.
- Deep water table in the Pale Beds, at typically 30–170 m depth.

In up-dip areas, where the UDL is absent, two water tables occur, one in the superficial deposits and one the Pale Beds. Field inspections made by WMC in the UDL free area of Nevinstown throughout 2005, and during May 2006, confirmed that shallow groundwater conditions in the superficial deposits are largely unchanged as a result of the mining of Nevinstown. Although there are no superficial monitoring wells overlying the Nevinstown area, there are a number of surface depressions and pits in which surface expressions of near-surface groundwater can be observed.

Because of the presence of the vadose zones, when incremental drawdown occurs within the Pale Beds as a result of mining the Liscartan and Rathaldron application areas, the downward leakage from the alluvium is not expected to increase. To date, superficial groundwater levels and moisture contents in the alluvial deposits have not been significantly altered on a site-wide scale. None of the alluvial monitoring wells above the Main Mine show any trends of declining water levels. Future mining of the Liscartan and Rathaldron application areas is not expected to have an effect on the current soil moisture balance of the alluvial deposits.

An observed cavity in the 1530 HWEX2 heading, north of the river at Nevinstown was transmitting near-surface groundwater, from superficial deposits directly above the cavity, downwards into the underground workings. The initial observed flow rate to the cavity was about 0.4 l/second, but the flow rate through the fracture zone above the cavity varied with rainfall. Although such local features may transmit water from superficial deposits downward into shallow workings, the associated vertical flow zones are discrete, occurring only in areas of extensive jointing and cavity development, and contribute relatively minor amounts to the total groundwater inflow to the mine workings.

The basal sands and gravels of the Whistlemount Channel have dewatered as they have lost groundwater by leakage into the UDL faster than water from the River

Blackwater has leaked through the clayey till to recharge them. The till itself has remained saturated.

6.4 Implications for the Licartan/Rathaldron application area

6.4.1 Current groundwater levels above the workings

Figures 6.10 to 6.16 show groundwater levels as follows:

- **West of Castle-Liscartan Fault Complex:** Groundwater elevation of 21.7 mBOD and 113.7 mBOD (1505 and 1413 mAMD) at N01867 (measurement taken on 25 January 2007) & U19700 (measurement taken in November 2006). Groundwater heads at this time were above the lowest planned mining horizon (around 316.7 mBOD or 1210 mAMD). It is likely that groundwater levels have declined by a further 20 to 30 m (based on the additional drawdown observed in N01737 over this time period) owing to continued dewatering in the area.

- **Along Castle-Liscartan Fault Complex:** Groundwater elevation of 54.7 mBODMD (1472 mAMD) in the central part of the zone at N01814 (based on the spot measurement on 24 November 2005), with recent (April 2009) groundwater levels of 2.64 mBOD (1524.06 mAMD) towards the NE at N01737. Groundwater heads measured at N01814 in November 2005 were above the lowest planned mining horizon (around 316.7 mBOD or 1210 mAMD in central zone and 166.7 mBOD (1360 mAMD) in the northeast. It is likely that groundwater levels have declined by a further 20 to 30 m (based on the additional drawdown observed in N01737 over this time period) owing to continued dewatering in the area.

- **East side of the Castle-Liscartan Fault Complex:** Groundwater elevation of 89.7 mBOD (1437 mAMD) at N01739 on 29 October 2003. This spot measurement indicates that groundwater was above the lowest planned mining horizon (around 226.7 mBOD or 1300 mAMD) at this time. It is likely that groundwater levels have declined by a further 20 to 30 m (based on the additional drawdown observed in N01737 over this time period) owing to continued dewatering in the area.

- **East Liscartan area:** Groundwater elevation of 68.7 mBOD and 147.7 mBOD (1458 and 1379 mAMD) at N01671 and N01679 (both spot measurements taken in January 2003), respectively. The groundwater levels measured at this time were above the the lowest planned mining horizon of around 176.7 mBOD (1350 mAMD). It is likely that groundwater levels have declined by a further 30 to 50 m (based on the additional drawdown observed in N01673 over this time period) owing to continued dewatering in the area.

- **SE Rathaldron/SW Nevinstown:** Groundwater elevation of 139 mBOD (1387.7 mAMD) at N01673 as of April 2007. It is likely that current groundwater levels are at or below the lowest planned mining horizon in this area of around 151.7 mBOD (1375 mAMD).

- **North Rathaldron area:** Groundwater elevation of 18.74 mBOD (1507.96 mAMD) at N01783 in April 2009. These groundwater levels are above the lowest planned mining horizon in this area of around 141.7 mBOD (1385 mAMD).

6.4.2 Predicted inflow rates during mining

The available data show that deep groundwater heads have reduced significantly over the Liscartan/Rathaldron application area. The drawdown has occurred as a result of previous inflows to the Main Mine and Nevinstown workings. Based on the spot groundwater level measurements from various boreholes, the data suggest significant drawdown has occurred to the west of the Castle-Liscartan Fault Complex, indicating that this zone does not act as a major barrier to groundwater flow across its strike.

However, water levels throughout the area of the application area are generally still 30-300 m above the planned mining horizon, and so additional dewatering of the area would be required. Based on previous experience mining the Main Mine and Nevinstown, it is anticipated that the required additional drawdown can be achieved by intercepting and managing new inflows as development headings are driven to the west and northwest.

Assuming that the Randalstown Fault acts as a reasonably tight barrier to groundwater flow, and using an overall drainable porosity for the Pale Beds of 0.01, it can be estimated that about 2-3 million m^3 of groundwater may need to be removed to allow mining of the planned extension. If this water were to be removed over a period of 3-4 years, the incremental flow rate to the mine would be within the range 15-30 l/second, which represents about a 15-30% increase on the current inflow rate to the entire mine. The actual rate of inflow will depend on the rate of mining advancement and the degree of internal compartmentalisation within the area of the extension. A significant amount of compartmentalisation is evidenced by the variations in water level in drill holes separated by relatively short distances.

A rate of 15-30 l/second is considered reasonable for current planning purposes. However, based on operating experience to date in the up-dip area of the orebody, it is possible that the actual inflow rate could be somewhat less than 15-30 l/second; for Nevinstown, the actual inflow rate was less than originally predicted. The actual dewatering predictions will be refined as the workings are opened up and the falling water levels are monitored.

The predicted incremental inflow rate (15-30 l/second) may be considered as a monthly average. The "new" inflows will occur as a result of drilling or mining into fracture zones. It is possible that zones of more intense fracturing may be associated with some of the main NE to ENE trending structures. If extensive fracture zones are intercepted by the advancing mine workings, there is potential for short-term inflows to be somewhat greater than 30 l/second. The normal way to deal with this during operations is to drill cover holes ahead of development headings in new areas. The cover holes would be drilled 50 m, or more, ahead of the advancing heading to identify permeable fracture zones. When such zones are encountered, the water would be allowed to drain through the cover holes into the workings, so that much of the groundwater storage will have already been removed by the time the actual heading reaches the zone.

The risk of encountering high short-term high inflows would be reduced by cover hole drilling, monitoring of the falling water levels in advance of development drifts, and by drilling shorter probe holes into the face of the heading if water levels ahead of the development are not falling.

As "new" groundwater inflow zones are encountered, it is expected that the initial high flow rates would gradually reduce with time as groundwater is removed from the particular fracture system. However, it is likely that some of the "new" zones will produce sustained flows that do not reduce below a certain rate. As has been observed at Nevinstown, as "new" sustained water is encountered in development headings, there is likely to be a reduction in inflow to existing workings. However, the scale of reduction may not be as great as for Nevinstown because the Liscartan application area is generally across the strike of the NE to ENE trending structural zones.

As is normal for any new mining situation, there are a number of uncertainties that will need to be addressed by interactive monitoring as the application area is opened up. A proposed monitoring program to cover the uncertainties is discussed in Section 6.4.5. Currently the main uncertainties relate to:

- **The high groundwater levels along Castle-Liscartan Fault Complex to the NE.** Groundwater levels in drill hole N01737 have fallen as mining has progressed northward. To ensure that sustained inflows along the strike of the fault zone from the north will not occur, an additional bedrock monitoring point would be beneficial in this area as part of the future mining operation. It should be noted that N01737 is more than 300 m to the southwest of the River Blackwater.

- **The extent to which downward leakage will occur from the alluvium along the line of the river.** The northeast part of Liscartan and southwest part of Rathaldron lie in close proximity to the River Blackwater. Conditions during the expansion of the workings beneath the Liscartan and Rathaldron application area are not expected to be any different to conditions experienced at Nevinstown, where virtually no leakage from the river has been observed to date. However, it will be necessary to obtain some additional monitoring data to confirm conditions as part of the planned mining of the extension. In addition, operational monitoring data will also be required to confirm any potential interaction between the Waulsortian and the Pale Beds prior to mining in that area.

- **The high water levels in the north part of the Rathaldron area.** Groundwater levels in the north part of Rathaldron are currently consistent with those in the north part of Nevinstown (30-40 m depth below ground). However, the mining horizon for Rathaldron is somewhat deeper than at Nevinstown, so some additional dewatering will be required in the up-dip area. To confirm conditions, groundwater monitoring data will need to be collected from the current holes as workings to the south become opened up.

- **The extent to which drawdown will occur on the west side of Castle-Liscartan Fault Complex.** The current dataset indicates groundwater levels have become reduced on the west side of Castle-Liscartan Fault Complex and that heads across the fault will become further reduced as mining progresses. This will be confirmed by continued operational monitoring to ensure there is no potential for headings that cross the fault to encounter groundwater under an elevated head.

- **The extent to which the Randalstown Fault acts as a barrier.** The Randalstown Fault is currently considered to be a groundwater flow barrier. Because proposed mining of the Liscartan/Rathaldron application area does not cross the fault zone, the current situation is not expected to change as additional workings are opened up. Again, monitoring will be carried out to confirm this.

All of the above uncertainties are best addressed by monthly groundwater monitoring as mining advances to the west in Liscartan and to the north in Rathaldron. The groundwater monitoring plan is described in Section 6.4.5.

6.4.3 Operational dewatering

6.4.3.1 Operational dewatering

Dewatering of the Liscartan/Rathaldron application area will be carried out in a similar manner to the current dewatering system. It is expected that all new inflows will be collected and managed in development and haulage headings, similar to present operations. Given the current dataset, there is no benefit in trying to carry out any dewatering using surface wells.

Groundwater levels in available surface holes will be monitored throughout mining. If new developments occur into a zone where in excess of 50 m head is known to be present, cover holes in advance of the new heading will need to be considered. If the cover holes fail to intersect fractures and reduce groundwater levels in advance of the heading, additional probe holes, ahead of the advancing face, should also be considered.

Similar to the current Nevinstown operations, the Liscartan/Rathaldron application area will mine through zones with enhanced cavity development. Mining into cavities is a hazard of underground mining in limestone areas. A number of cavities have already been intersected by the Nevinstown workings. The cavities are often infilled with sandy clay material, and have the potential to create minor mud rushes if they are encountered by mining operations. Procedures have been developed to drill additional cover and probe holes in areas where cavity development is known to be more pronounced. Where they are encountered, the cavity zones may flow for several days before the flow rate reduces. Using experience at Nevinstown as an illustration, in April 2006, minor sustained inflows were noted in a cavity zone encountered in a heading close to the surface (and above the water table) in 1530 HWEX2. The void occurred within a previously known and mapped zone of increased cavity development. It was about 1 m across and was filled with “soft mud”, which flowed into the drift. The location of the cavity was about 150 m to the north of the river and about 50 m depth below ground surface. A fracture zone was observed extending for about 6-8 m from the cavity towards the surface. The fracture zone flowed at about 0.4 l/second. The cavity had been intersected following a period of heavy rainfall. The outflow rate from the cavity decreased significantly during drier weather.

The predicted groundwater inflow chemistry for the Liscartan/Rathaldron application area is similar to the current Main Mine and Nevinstown inflow chemistry. In the Main Mine and Nevinstown, virtually all of the underground water makes are representative of very young calcium-bicarbonate type water flowing within the Pale Beds. There is virtually no chemical signature of river water in the underground water makes. The only mine inflow with a water chemistry signature close to river water was in 1500NDEX2 (the Nevinstown exploration decline). This inflow zone is directly below the Whistlemount Channel and flowed at about 0.2 l/second. Inflow into 1500NDEX2 subsequently ceased as the basal sands and gravels of the Whistlemount Channel became dewatered.

Under the current water management system, water from underground is pumped to the tailings management facility where it is reclaimed for use in the mine and mill. Surplus water is discharged to the River Boyne through a storage pond under the Tara IPPC (Integrated Pollution Prevention and Control) licence. The quality of the water is monitored to ensure IPPC compliance. No significant changes to water quality are anticipated following expansion of the workings into the Rathaldron/Liscartan application area.

6.4.4 Assessment of potential impacts

Based on the currently available dataset, the potential impacts that may result from mining the application area are expected to be very similar to current conditions. No significant incremental impacts are currently anticipated. However, the following areas will have to be addressed by the operational monitoring programme:

- The potential for increased drawdown to influence the district-wide groundwater system.
- The potential for impacts to the River Blackwater floodplain area.
- Potential changes to the moisture balance of the alluvial soils lying above the planned area of the extension.
- Possible development of sink holes at the surface.

6.4.4.1 District-scale drawdown

The Pale Beds unit in the immediate vicinity of the Tara Mine is classified as a poor to locally productive aquifer according to the criteria developed by the Geological Survey of Ireland (Knight Piésold, 1996). Areas of sands and gravels within the superficial deposits are also water-bearing and may constitute superficial aquifers of local importance. A survey of groundwater users was carried out in 2002 and identified only one potential user of bedrock groundwater in the Tara district (the deep borehole at Rathaldron Castle).

The Liscartan/Rathaldron application area is in an area that has already become dewatered. A considerable amount of drawdown is already observed on west side of Castle-Liscartan Fault Complex. It is considered unlikely that the extent of district-scale drawdown will change greatly from current conditions. Currently, it is not anticipated that mining of the application area will cross any bounding structures that are not already dewatered on their footwall side.

Additional drawdown will occur locally to the west of Castle-Liscartan Fault Complex (to the east of the Randalstown Fault Zone). The potential for additional drawdown to the west of the Randalstown Fault Zone is considered to be low, but this should be confirmed by operational monitoring. If additional drawdown on west side of Randalstown Fault were to occur, it is currently expected that the incremental increase from current conditions would be marginal.

6.4.4.2 Local streamflow

The current monitoring data indicate that drawdown in the Pale Beds unit in the vicinity of the River Blackwater at Rathaldron is of the order of 30 m. It is therefore expected that losses from the river and the flood plain alluvial deposits will be controlled by the permeability of the superficial deposits, rather than by ongoing drawdown in the Pale Beds.

Observations at Nevinstown indicate that the fine-grained nature of the overburden and river-bed materials have minimised downward leakage of river water. Virtually no leakage from the shallow alluvium, the flood plain deposits or the river itself has been observed to date in response to mining beneath the river at Nevinstown. Current losses from flood plain and river are negligible (1.5 l/second or less). Except for hole N00022 (on the floodplain), and the Nevinstown exploration decline (1500NDEX2), both of which are now dry, there has been no chemical indication of river water inflow to the Main Mine or the Nevinstown workings.

Mining at Tara has been carried out close to, or beneath, the River Blackwater for over 30 years. Virtually all stope blocks located in the vicinity of the river are mined with no significant leakage of water from the river or the shallow alluvial water table of the floodplain. The main potential for increased future inflows is likely to be associated with differential movement across structural zones underlying the flood plain. At Nevinstown, this is being monitored by extensiometers placed across the main identified structures.

Given the current dataset, there is no indication that conditions beneath the river will be any different for the Liscartan/Rathaldron extension. However, it should be appreciated that mining below or adjacent to any surface water body needs to be carried out with great care. Additional monitoring holes close to the river are recommended, as discussed in Section 6.4.5. Also, as mining is extended beneath the River Blackwater, the inflow chemistry should be monitored to detect any chemical signatures similar to river water or shallow alluvial groundwater.

6.4.4.3 Soil moisture balance

The moisture content of a soil through the year is a function of the balance between soil water inputs and outputs.
Rainfall which does not:

(i) runoff to surface water courses; or
(ii) evaporate from surface water bodies, the land surface or intercepting vegetation; is available to infiltrate to the soil. Water may leave the soil via evapotranspiration, or as recharge to the groundwater system. The seasonal bias of precipitation (more rainfall in winter) and plant growth (plants grow slowly, die back or are dormant in winter) results in soil moisture contents peaking in winter. According to the classic model of soil moisture budgeting, once a soil reaches a moisture content referred to as its field capacity, further inputs of water will drain under gravity towards the zone of underlying saturation (the shallow water table of the superficial deposits). This vertical drainage of water represents recharge to the shallow groundwater system.

Surface observations above the area of the Main Mine and Nevinstown have indicated that soil moisture conditions have not altered significantly as a result of dewatering the underlying Carboniferous strata. Although there are no purpose-installed monitoring points to observe groundwater heads in the alluvium, a number of test pits and other shallow excavations have been observed, which indicate the presence of shallow groundwater within 1-3 m of the surface. The observations to date support the study on soil moisture carried out in 2002 by Dr J Mulqueen of the Teagasc Land & Water Management Unit, Department of Civil Engineering, National University of Ireland. The study indicated that additional water level reductions in the Carboniferous strata would be unlikely to affect soil moisture conditions.

The soil moisture store is unlikely to be adversely impacted by drawdown in the Carboniferous strata for the following reasons:

- The soil at Tara is a clay loam with 60% silt and clay. It is a heavy soil with good moisture retention capacity.
- Soil moisture is hydraulically semi-isolated from groundwater heads in the Carboniferous strata by the layer of clayey glacial till that underlies the soil.
- The water tables in the UDL and Pale Beds are hydraulically disconnected from shallow water tables in the alluvium by the presence of intervening vadose zones.

The agricultural productivity of the land in the vicinity of the mine should therefore not be adversely impacted by the planned expansion of the workings.

6.4.4.4 Development of sink holes at the surface

Sink hole development in the area around Tara is mostly confined to the Pale Beds unit. Most of the known near-surface sink holes occur in the subcrop area of the Pale Beds in the Nevinstown area. Other localised zones of sink hole development are associated with near-surface expressions of prominent structural zones where the UDL is thinner. From the mining perspective, sink hole development is of most concern: 1) along the line of the river, 2) close to any other surface water features, and 3) within built-up areas.

Because groundwater levels have already fallen, and a large proportion of the required future Pale Beds drawdown has occurred already, the concern with respect to future sink hole development is reduced. Sink hole development is most likely to occur during prolonged periods of dry weather when the elevation of the near-surface water table in the superficial deposits falls. Once such sink hole occurred to the north of Nevinstown in April 2003 following a period of dry weather. The zone was noted to be within a natural topographic depression that constituted a small internal drainage system.

In the planned area of the extension, groundwater levels have already been substantially lowered beneath the river. This will be confirmed by installation of additional observation holes in the Rathaldron area, as described in Section 6.4.5. Locally, there are no other significant tributary streams or other surface water features that could be affected by sink hole development in the Pale Beds subcrop area. As discussed above, the development of additional regional drawdown is not expected. This minimises concerns with respect to sink hole development within built-up areas.

Previous calculations of carbonate saturation indices have shown that further rapid carbonate dissolution is not expected. As a result, leakage of water from the superficial deposits, into the underlying limestones, is unlikely to open up significant flow paths as a result of dissolution of $CaCO_3$.

6.4.4.5 Implications for mine closure

When the underground dewatering pumps are finally shut down, all of the mine workings (SWEX, the Main Mine, Nevinstown and the Liscartan and Rathaldron application areas) will progressively fill with water. An inward hydraulic gradient to the workings will be maintained throughout the active filling period, so there will be minimal risk of any potential contaminants entering the surrounding groundwater system.

Following full recovery of the groundwater system, it is anticipated that there will be an inward hydraulic gradient towards the river. It is expected that the shallow groundwater flow system in the alluvium and shallow bedrock will be very similar to pre-mining conditions. This will comprise recharge from infiltration of precipitation and subsequent upward discharge to the flood plan deposits along the line of the river. Groundwater discharge rates via the river flood plain deposits following closure are expected to be similar to pre-mining rates.

Following post-closure stabilisation of conditions, deeper groundwater levels within the Pale Beds at Liscartan will recover to a depth of approximately 2-8 m below ground level. Because the Pale Beds will be hydraulically interconnected throughout the area of the current and planned future workings, the groundwater table within the Pale Beds at the mining horizon is expected to be virtually flat. Pale Beds groundwater levels will only recover to the level of the River Blackwater. As a result, the stabilised post-mining Pale Beds groundwater levels will be a few meters below pre-mining levels over most of the planned area of the extension.

The post-closure shallow groundwater table in the alluvium and shallow bedrock will roughly follow topography. The groundwater gradient will be towards the river, and the water table is expected to be similar to the pre-mining water table. It is anticipated that the groundwater system in the Whistlemount Channel will fully recover following recovery of heads in the UDL.

Because the deeper groundwater levels in the Pale Beds will be virtually flat, there will be a downward hydraulic gradient around the southern part of Liscartan, decreasing in magnitude moving closer to the river. As is currently the case, the near surface soil moisture balance within the alluvium is not expected to change, post-closure.

Because both the groundwater recharge and discharge will occur at shallow levels, once the water levels in the workings have fully recovered and stabilised, there is unlikely to be any significant flow from the deep workings towards flood plain deposits or the river. There will be no mining or disturbance of the shallow bedrock in the crown pillars, so there will be no potential for the post-closure shallow groundwater to flow through old mine workings. It is therefore unlikely that any potential contaminants will be flushed from the mine workings towards the river. At shallow levels, the rock mass will not be exposed to oxidation. As a result, there is no significant potential for the generation of acid mine drainage and subsequent transport to the river.

The potential for discharge of water from the deeper mine workings must also be considered as part of the closure assessment. The same hydraulic boundaries that currently occur, and limit the lateral spread of drawdown away from the mine, will also influence conditions post closure. Furthermore, because the Pale Beds groundwater levels at the mining horizon will not fully recover, a permanent slight inward hydraulic gradient is expected across these boundaries. Therefore, based on current understanding, no movement of deep groundwater away from the mine would be anticipated.

6.4.5 Operational monitoring plan

The current data set and working knowledge has provided adequate information to characterise the overall groundwater conditions in the area of the Liscartan and Rathaldron extensions. However, a number of risk areas have been identified for operations, as described in Section 6.4.2. An operational monitoring programme has been specified to allow areas of uncertainty to be monitored and to allow future mining and environmental risks to be minimised.

The objectives of operational monitoring plan for the Liscartan/Rathaldron application area are as follows:

- To reduce the risk of high short term groundwater inflows and pressures in development headings and at the mining horizon.
- To confirm that leakage from the river will be minimal, similar to the last 20 years of mining. To minimise the risk of high short term inflows of alluvial groundwater, close to the river.
- To confirm the district drawdown will be similar to currently observed conditions.
- To confirm there will be minimal overall change to the groundwater balance of the alluvium.
- To monitor for the presence of fracture zones and cavity areas and minimise the risk of these to influence mining or surface conditions.

To achieve these objectives, the following operational monitoring programme is recommended:

6.4.5.1 Underground inflows

There is currently a thorough monitoring and reporting plan for characterising inflows to the underground workings. This has provided excellent data with which to assess groundwater conditions at Tara. The current programme should be continued. The actual monitoring plan should be adapted to suit changing operating conditions, but the following guidelines should be followed:

- Weekly measurement (or estimation as appropriate) of all individual inflows greater than 0.4 l/second.
- Weekly summary totals of the mine inflows from each sector.
- Mapping of the joints and fractures in headings to help understand the mechanism of individual inflow zones.
- “One-time” sampling of the chemistry of all new inflows and measurement of field parameters (temperature, electrical conductivity, pH).
- Weekly monitoring of the field parameters at each inflow zone with inflows greater than 0.8 l/second.

Quarterly sampling and laboratory analysis of the largest 5 inflows in each sector, including all individual inflows greater than 3.8 l/second.
Investigative sampling of other inflows as considered appropriate during on-going operations.

6.4.5.2 Underground drill holes

Flows and pressures should be monitoring opportunistically in geology holes drilled from underground. In addition, routine monitoring should be carried out in all holes that remain open and flowing. Again, the actual monitoring plan should be adapted to suit changing operational conditions, but the following guidelines should be followed:

- "One-time" measurement and reporting of the flow rate in all holes drilled.
- Measurement of shut-in pressure in all holes that are completed with valved collars.
- "One-time" sampling of the chemistry of any hole making more than 1.5 l/second and analysis for field parameters (temperature, electrical conductivity, pH).
- Weekly measurement (or estimation as appropriate) of all holes with sustained inflows greater than 0.4 l/second.
- "One-time" sampling and laboratory analysis of the chemistry of any hole with a reported inflow of greater than 7.6 l/second.
- Investigative sampling of other inflows as considered appropriate during on-going operations.

6.4.5.3 Monitoring of surface holes and piezometers

The following on-going water level monitoring of surface holes should be considered as part of the mining operations for the Liscartan/Rathaldron extensions:

- Water level measurement in the 9 existing surface observation points. The holes should be monitored monthly.
- Installation of a new dual completion bedrock observation well close to the River Blackwater. The shallow completion would be installed into the Waulsortian. The deep completion would be installed into the Pale Beds. The completions should be monitored monthly.
- Installation of a new dual completion alluvial observation well drilled from the same platform as the dual bedrock observation well. The shallow alluvial completion would be installed at about 4 m below river level. The deep alluvial completion would be installed at the base of alluvium (monthly monitoring).
- A second dual-level alluvial piezometer set located close to river. Again, the shallow alluvial completion would be installed at about 4 m below river level, with the deep alluvial completion installed at the base of alluvium. The completions should be monitored monthly.

- Two new Pale Beds observation holes drilled into Castle-Liscartan Fault Complex, one in northwest sector of the Liscartan extension, and one in the southwest sector. The completions should be monitored monthly.
- One new Pale Beds hole drilled immediately to the east of the Randalstown Fault (immediately to the west of the planned western extent of the planned Liscartan mining area). This hole should also be monitored monthly.

Ongoing monitoring of all available Nevinstown surface holes should also be carried out monthly.

6.4.5.4 Additional underground monitoring

Based on the knowledge of the groundwater system gained to date, specialised monitoring to better characterise the identified key areas is currently not anticipated. However, it is essential that operating conditions are reviewed on an on-going basis and that additional investigation work is carried out if deemed appropriate. If it were to be required, any detailed investigative work would probably be limited to the area of the river, or the area of the Castle-Liscartan Fault Complex. However, other key zones may be identified as mining progresses. If specialised monitoring were to be considered, the following would be most likely:

- Pressure monitoring in any hole considered appropriate to help reduce uncertainty in a new heading or mining area. Currently, for the Liscartan and Rathaldron extensions, it is anticipated than any required pressure monitoring would be carried out by shutting in holes at the collar. No specially constructed underground piezometers are currently anticipated, but this should be reviewed on an on-going basis depending on the hydrogeological response in surface monitoring holes close to the alignment of the River Blackwater and the Castle-Liscartan Fault Complex.
- Placement of extensiometers across key geological structures close to the river, where possible differential movement could influence local hydrogeological conditions. The AMC geotechnical report produced concurrently with this report notes that hanging wall drive of a stope offers good options for the installation of hanging wall instrumentation. Any future recommendation to place extensiometers would be provided in consultation with AMC. Currently, the geotechnical evaluation work indicates that settlement would only have the potential to significantly influence groundwater if differential movement (opening) of structures were to occur. This could lead to an increase in the permeability along the plane of the structure. The F24 and F25 Fault Zones occur beneath the river in the Rathaldron area. However, the mining horizon at this location is relatively deep and it is unlikely that differential settlement would be a concern for groundwater flow towards the workings in this region. This will need to be evaluated however by operational monitoring. No significant movement, or permeability enhancement, associated with the F1 Fault Zone is known beneath the western part of Nevinstown at the time of writing.

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SECTION 7 BLASTING VIBRATION AND AIR-OVERPRESSURE NOISE

7.1 Introduction

Tara Mines Limited, the largest operating lead-zinc mine in Europe, is located at Knockumber, 2 km west of Navan in County Meath. Originally sited in a rural area, expansion of Navan has resulted in the development of residential areas nearer to the mine although much of its surroundings remain flat agricultural land drained by prolific fishing rivers.

The proposed development involves the mining of proven ore reserves in the townlands or part thereof Liscartan and Rathaldron. The surface characteristics and features of the 'mining area' will not be altered by mining activity and there will be no surface infrastructure in this area.

The Liscartan / Rathaldron section of the 'Navan orebody' is an uninterrupted northwest extension of existing mine workings that are currently being mined by Boliden Tara Mines Limited (Tara Mines). The Liscartan / Rathaldron section of the orebody dips to the southwest and strikes to the northwest in common with the general characteristics of the orebody, giving a depth below surface ranging from 150m to 575m with ore thickness ranging from 4m to 12m.

Mining follows a cyclic pattern resulting in the removal of ore underground followed by the filling of the voids using cement and waste sand material that remains after the ore treatment process. The surface characteristics and features of the Liscartan / Rathaldron townlands will not be altered by mining activity and there will be no surface infrastructure in the area.

7.2 The Liscartan / Rathaldron Proposal

The proposed development involves establishing access to the orebody by underground mining methods via the existing underground mine with no surface development in the area required.

The necessary infrastructure 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

7.3 The Existing Blasting Vibration (Air-overpressure Noise) Environment

7.3.1 Ground Vibration

Cause of Blast Vibration

Ground vibration is caused by the imperfect utilisation of the explosive energy released during blasting operations. The energy that is unused in the fragmentation of rock propagates as an elastic disturbance away from the shot area as seismic waves. These waves, which radiate in a complex manner, diminish in strength with distance from the source. The theory relative to this motion is based on an idealised (sinusoidal) vibratory motion. When these waves come into contact with a free face, physical motion results as the energy induces oscillation in the ground surface. Blasting vibration is a surface wave type, which incorporates components of both body and surface motion.

Ground vibration itself is inaudible, however air vibrations both audible and sub-audible usually accompany it. The resulting impacts of blasting vibration are often characterised as being impulsive and of short duration, usually less than 6 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.

7.3.1.1 Ground Vibration Control

Ground vibration from blasting at any receptor point is influenced in the main by:

- maximum instantaneous charge of explosives
- medium between blast source and receptor point and,
- 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.

7.3.1.2 Blasting and Vibration Control at Tara

In modern day mining the blast designed to be more efficient in terms of cost and production also minimises the generation of vibration. Tara Mines applies the most up to date technology in their mine blasting operation. Ground vibration is currently being recorded continuously and simultaneously for each blast at four permanent locations and five temporary locations see Figure 7.1. The temporary monitoring locations use portable vibration monitors and is ulilised whenever the need arises. The ground vibration limit at the nearest relevant monitoring Station 1 (V1) and Station 4 (V4) has not been exceeded since 1985.

The environmental department liaises on a routine basis with the blast engineer in the mine planning department to ensure maximum vibration control. Comparing the planned blast layout with the actual recorded ground vibration waveform and modifying blast designs if deemed necessary achieve this.

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 40 and 900 meters from the surface and as close as 75m to a Tara residential property (almost directly under a Tara occupied house in the most easterly area of mining close to the Blackwater River). Historically the eastern most area of the mine which 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 A, C, D and T series fault structure (Figure 7.2).

7.3.2 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.

In surface blasting (which Tara does not propose to carry out) the significant pulse of energy that gives rise to an air blast, travels from the source on surface directly through the air. The much smaller pulse of energy that is derived from ground transmission/movement at the receiver is generally insignificant. In underground blasting the air blast that is generated from the movement of the ground at the receiver is insignificant and generally at such a low level that it becomes difficult to measure accurately. Air overpressure (air blasts) is difficult to record accurately below 110 dB and this is due to existing similar levels derived from typical low wind velocities.

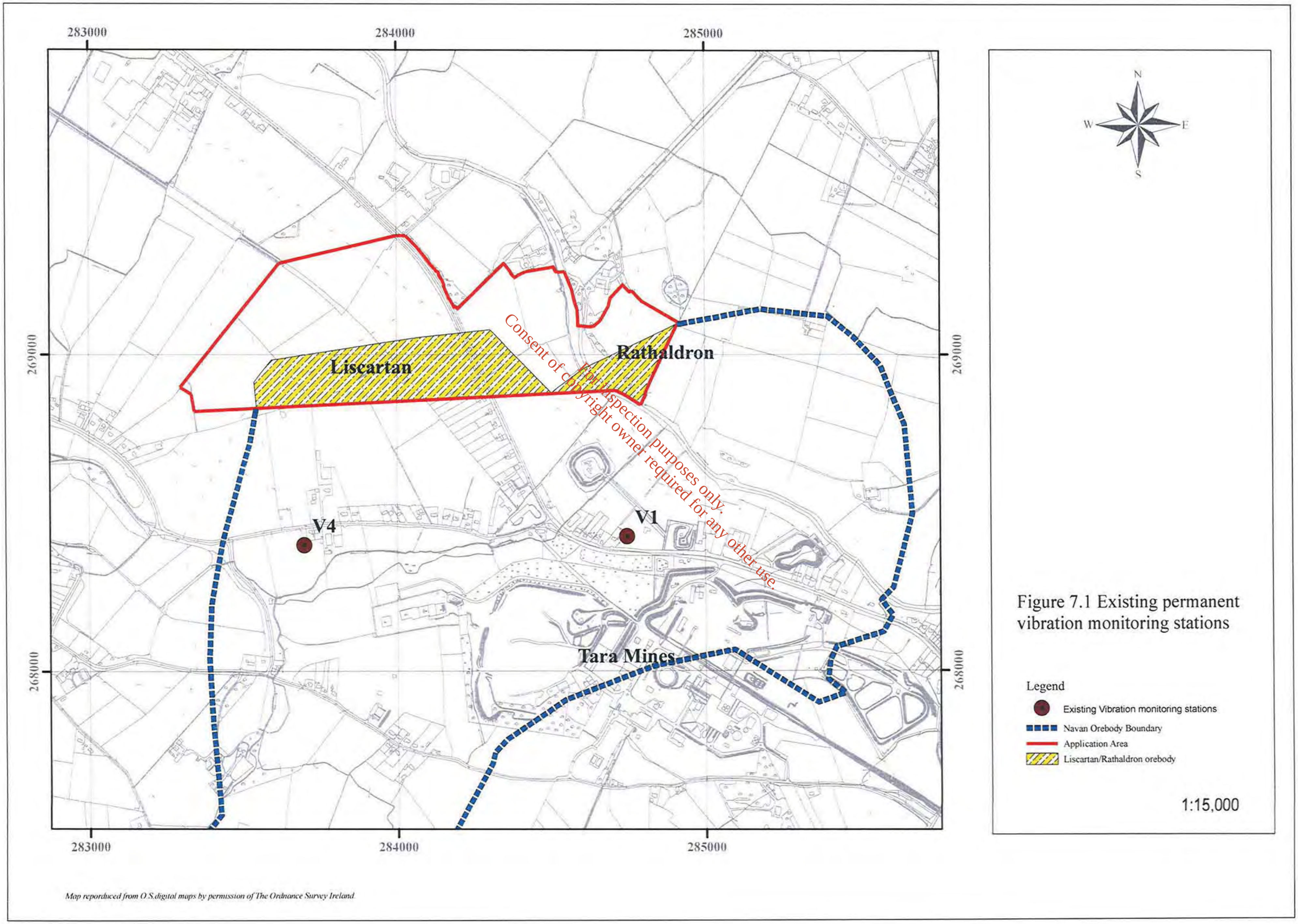


Figure 7.1 Existing permanent vibration monitoring stations

Map reporduced from O.S.digital maps by permission of The Ordnance Survey Ireland

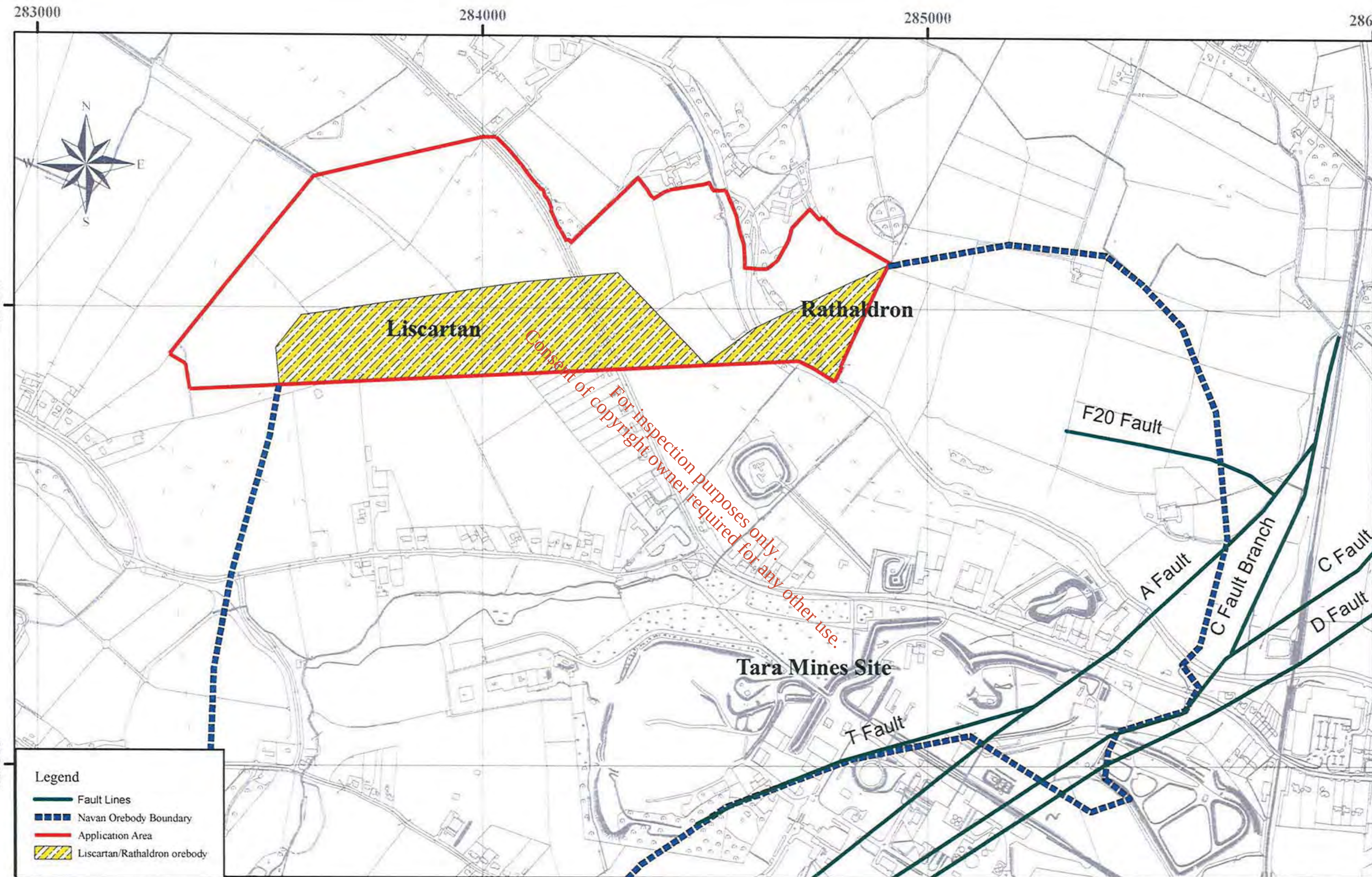


Figure 7.2 Faulting projections to the south and east of the application area

1:12,000

Map reporduced from O.S.digital maps by permission of The Ordnance Survey Ireland.

7.4 Blasting Vibration Impacts

The Liscartan / Rathaldron orebody forms the uninterrupted northwest extension of the existing main orebody. A 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 Liscartan / Rathaldron are essentially identical to those that occur in the 'Nevinstown orebody' which forms part of the same structure.

The proposal for underground mining methods is similar to the existing methods being used. Blasting will be carried out at greater distances from residential property than that already experienced on the periphery of the existing mine. The mining development progression northwest will increase the distances from blasting vibration sources for the more populated residential areas on the east and south-east of the mine.

The level of ground vibration predicted should be no more intense than that experienced over the last 30 years. Blasting ground vibration will be controlled by adhering to a control regime currently in place - sequential detonation, control of maximum instantaneous charge of explosives used and continuous measurement of ground vibration to ensure compliance.

For 'future Tara development / production blasting', the vibration / noise limits will be similar to those existing and given in the EPA IPPC Licence No 01- 516 *Condition 8. Noise*: '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

'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

Note: Daytime is defined as 08.00 hrs to 22.00 hrs and night-time is 22.00 hrs to 08.00 hrs

It is anticipated that the 'Liscartan and Rathaldron orebody' will be mined out over a period of approximately 5 years.

7.5 Ameliorative Measures for Blasting Vibration Control

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 that the maximum amount of explosive on any one delay, the maximum instantaneous charge is controlled so that the ground vibration levels are maintained below that specified in the IPPC Licence

- 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 continuous monitoring stations and by additional portable ground vibration monitoring as the need arises.

NB The measures which control ground vibration generated from underground blasting will also control air overpressure noise**.**

7.6 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 study review and analysis of over 30 years of vibration monitoring data has shown that Tara's ground vibration limit compliance has exceeded 99.9%.

7.7 References

O'Reilly, B., (2000), *Noise and Vibration Around an Active Base Metal Mine*, M.Phil. thesis, University of Liverpool.

Struthers. M.A., Lee. M. F., Australian Mining Consultants (UK) Ltd (2003), *Nevinstown Geotechnical Study – Executive Summary*

Siskind, D. E., Stagg, M. S., Kopp, J.W., and Dowding, C.H. (1980B*), Structural Response and Damage Produced by Ground Vibrations* from Surface Blasting, Report of Investigations 8507, U. S Bureau of Mines, Washington, DC.

7.8 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

SECTION 8 SURFACE WATER

8.1 Introduction

The proposed development involves the mining of proven ore reserves in the townlands of Liscartan and Rathaldron. The surface characteristics and features of the 'mining area' will not be altered by mining activity and there will be no surface infrastructure facilities in this area. The Liscartan/Rathaldron section of the 'Navan orebody' is an uninterrupted extension of existing mine workings that are currently being mined by Boliden Tara Mines Limited (Tara Mines).

8.2 Existing Environment

The area around the Tara Mine comprises flat to gently undulating farmland, with some relatively recent residential development. Ground surface elevation along the River Blackwater is around 62 metres above Ordnance Survey Malin Datum (mAOD) as it flows through the area of the Liscartan/Rathaldron application area. The elevation of the land surface rises away from the River Blackwater, attaining around 75 mAOD in the centre of Rathaldron, and around 93 mAOD in the southwest of Liscartan. Figure 8.2 shows the topography of Liscartan and Rathaldron.

The River Blackwater defines the boundary between the Liscartan and Rathaldron land holdings, and also separates Nevinstown from the Main Mine area. The River Blackwater is a major tributary of the River Boyne. The source of the Blackwater is Lough Ramor, County Cavan, from where the Blackwater flows about 30 km SE to join the Boyne at Navan.

8.3 Water Management System

Sources of water inflow to the mine workings

i. Drawdown
   a. District-scale lateral groundwater flow in the Pale Beds.
   b. Downward leakage of groundwater from the UDL.
   c. Recharge derived from precipitation.(Figure 6.5 shows the mean monthly rainfall)
   d. Leakage from the *River Blackwater*.

ii. Backfill water

iii. Water used by mining equipment e.g drills

The groundwater inflows to the Liscartan/Rathaldron extension (including all groundwater inflow / backfill water / service water) will be collected at a central underground pumping station. All dewatering flows will continue to pass through a large settling sump at this pumping station, where suspended solids settle out, prior to being pumped via the production shaft to the second stage of settlement/clarification in the Minewater/Reclaim Water Ponds. There are no plans for additional water management facilities on surface.

The total pumping capacity of the mine is 21,600 m^3/d while the current total inflow to the mine is 11,979 m^3 / day.

It is anticipated that the proposed development could lead to an increase of between 15-30% of the current inflow to the entire mine. There is sufficient flexibility and storage in the current water management system to accommodate all anticipated additional water collected and pumped from underground (ref Section 6).

8.3.1 Water treatment

All minewater (groundwater inflow / backfill water / service water) is collected at a central underground pumping station. It passes through a large settling sump at this pumping station, where suspended solids settle out, prior to being pumped via the production shaft to the second stage of settlement/clarification in the Minewater/Reclaim Water Pond.

Surface runoff is collected by a system of drainage ditches which feed into the Main Site Drainage Water Pond, where suspended solids settle out prior to the water being pumped to the Reclaim Water Pond.

The waste water from the process plant is pumped to the Tailings storage facility (TSF). The TSF is designed to operate as a large sedimentation/aeration pond where solids settle to the bottom and clear water at the surface is drawn off for recirculation to the Reclaim Water Pond. The limestone in the tailings maintains the water at an alkaline pH, which precipitates all but traces of the metals remaining in solution from the milling process. The large surface area of the facility provides adequate aeration for aerobic degradation of the organic reagents, so as to assure a low B.O.D. level in the water.

The tailings area is also used for water storage and designed such that there is always an excess storage volume of approximately 1,000 acre feet available, over and above that required for the storage of plant tailings, which can be used for the retention of water during low flow periods in the River Boyne. The excess water accumulates in the tailings area during summer months when the flows in the River Boyne are low and released to discharge into the River Boyne by way of the Reclaim Water and Clear Water Ponds in the winter months when the river flow is high.

The second and third stages of water processing (the Reclaim Water Pond and the Clear Water Pond, respectively) are common to all three water sources. The Reclaim Water Pond is divided into two sections to facilitate cleanout as required. Water from the reclaim pond is either pumped to the processing plant for reuse or is discharged to the River Boyne. The water to be discharged to the River Boyne overflows from the Reclaim Water Pond into a Clear Water Pond.

A weir structure at the pond outlet measures the discharge volume to the River. The discharge is recorded and controlled from the Mill Central Control room which is manned 24 hours per day, 7 days per week. The discharge point to the River Boyne is displayed in Figure 8.1.

An automatic gauging station installed on the river provides a continuous record of the water level and therefore the flow in the River Boyne. Excess water is discharged under strict quality conditions prescribed in the Company's Integrated Pollution Prevention Control Licence (IPPCL) P0 516-01. Water is discharged at a dilution ratio of 100: 1, so for every cubic meter of water discharged there must be a flow of 100 cubic meters in the river. Emission Limit Values for the discharge are presented in Table 8.1.

Table 8.1 Emission Limits for Tara Mines Surface Water Discharge

Parameter	Emission Limit Value
Temperature	25°C (max.)
pH	6-9
Toxicity	5 TU
	mg/l
BOD	20
COD	1500
Suspended Solids	30
Zinc	2
Lead	0.5
Copper	0.5
Filtered Iron	1
Cadmium	0.2
Arsenic	0.5
Antimony	1
Cyanide	0.2
Chromium	1
Mercury	0.05
Mineral Oils	1
Total Nitrogen (as N)	15
Total Phosphorus (as P)	2

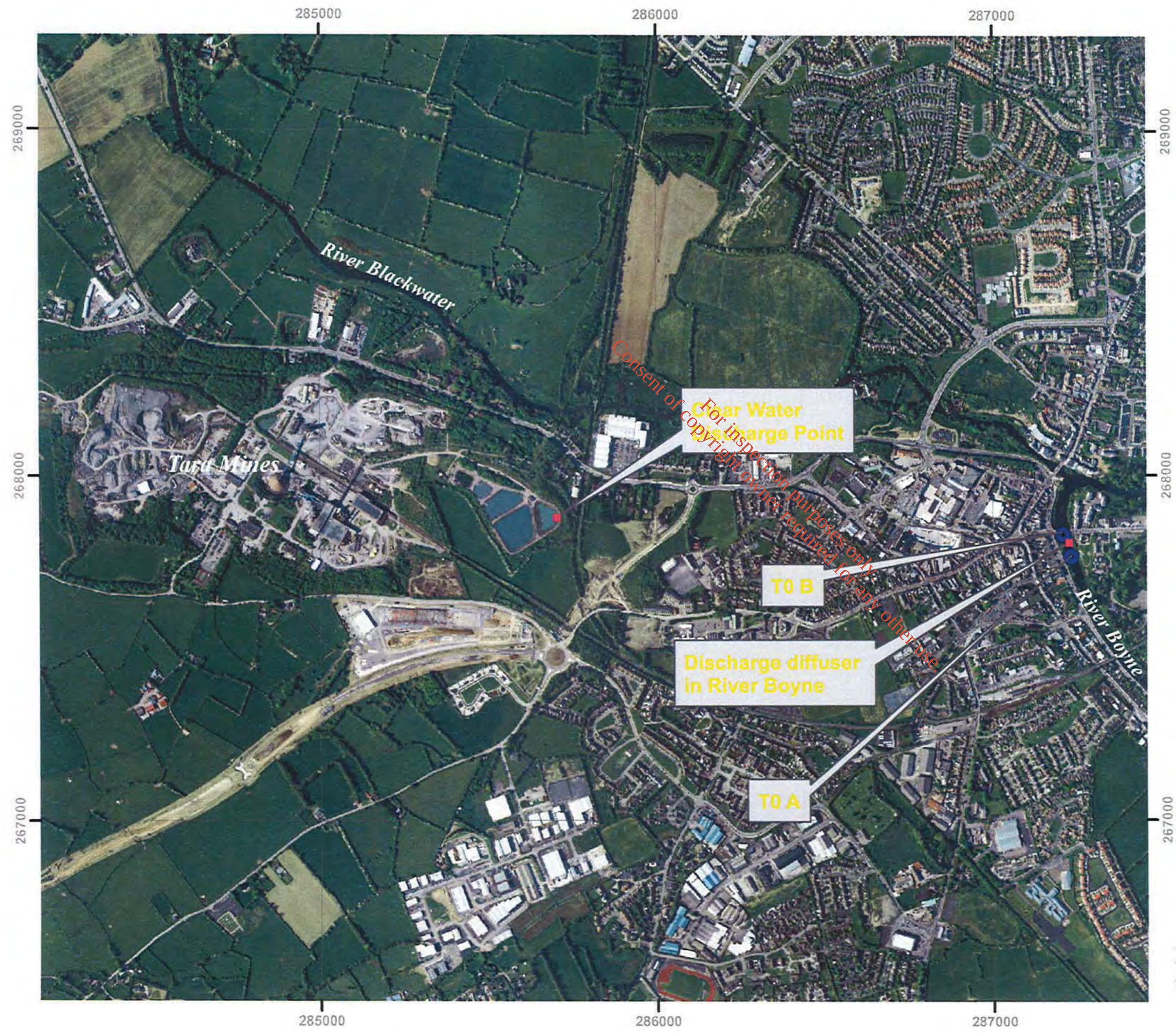


Figure 8.1 Water discharge system & water quality sampling points

8.4 Water Quality Monitoring

Effluent is sampled and tested daily at the discharge from the Clear Water Pond. The receiving water, the River Boyne, is sampled monthly at two sampling stations one upstream of the discharge point and one downstream of the discharge point.

Figure 8-1 displays the sampling locations.

Summary water quality data are presented in Tables 8.2 and 8.3 these comprise:

- Discharge water quality. C.W.D (Clear water discharge)
- Receiving water quality – summary of monthly samples between 2001 and 2009 for the following stations:
  - TOA - (Located immediately upstream of the discharge diffuser)
  - TOB - (Located immediately down-stream of the discharge diffuser)

Table 8.2 Water quality of effluent discharged to the Boyne

	Temp °C	pH	BOD	COD	S. Solids (mg/l)	Zinc (mg/l)	Lead (mg/l)	Copper (mg/l)	Filtered Iron
2001	5.9	7.7	2.28	<14.29	5.25	0.72	<0.0407	<0.031	<0.022
2002	12.0	7.7	1.43	<12.69	7.38	0.67	<0.0317	<0.014	<0.087
2003	12.4	7	3.67	<18.59	9.44	1.06	<0.0303	<0.024	<0.053
2004	12.0	7.1	2.89	<16.05	8.58	1.21	<0.0304	<0.005	<0.003
2005	12.3	7	2.67	<16.72	9.14	1.16	<0.0302	<0.006	<0.002
2006	13.0	6.9	2.66	<17.28	11.92	1.07	<0.0323	<0.006	<0.009
2007	13.0	6.9	2.76	<15.06	9.22	0.64	<0.0268	<0.004	<0.003
2008	12.8	6.9	1.80	<15.98	11.46	0.71	<0.0154	<0.003	<0.002
2009	11.9	6.9	1.94	<22.74	12.46	0.79	<0.0115	<0.003	<0.002

	Cadmium (mg/l)	Arsenic (mg/l)	Antimony (mg/l)	Cyanide (mg/l)	Chromium (mg/l)	Mercury (mg/l)	Mineral Oils	Total Nitrogen (N)	Total Phosphorus (P)
2001	<0.015	<0.026	0.26	<0.05	<0.018	<0.014	<0.04	42.17	0.073
2002	<0.002	<0.008	0.14	<0.05	<0.004	<0.0007	<0.04	9.82	0.101
2003	<0.003	<0.01	0.41	<0.05	<0.004	<0.001	<0.01	29.52	0.109
2004	<0.002	<0.01	0.61	<0.05	<0.002	<0.001	<0.01	25.36	0.145
2005	<0.002	<0.01	0.53	<0.05	<0.002	<0.001	<0.01	22.67	0.168
2006	<0.002	<0.014	0.48	<0.05	<0.002	<0.001	<0.01	12.81	0.094
2007	<0.002	<0.012	0.44	<0.05	<0.003	<0.001	<0.01	12.87	0.097
2008	<0.002	<0.013	0.43	<0.05	<0.002	<0.001	<0.01	13.66	0.096
2009	<0.002	<0.012	0.67	<0.05	<0.002	<0.001	<0.02	16.76	0.043

*Note- Values given are mean values for the year

Table 8.3 Summary water quality data for the River Boyne

		S. Solids (mg/l)	Nitrate as NO_3 (mg/l)	Sulphate (mg/l)	Zinc (mg/l)	Lead (mg/l)	Iron (mg/l)	Cadmium (mg/l)	Manganese (mg/l)	Arsenic (mg/l)
2001	TOA	6.8	6.9	55.7	<0.03	<0.003	0.0355	<0.002	<0.05	<0.01
	TOB	4.6	6.0	67.8	<0.03	<0.003	0.037	0.002	<0.05	<0.01
2002	TOA	6.1	9.7	61.6	<0.03	<0.003	0.082	<0.002	<0.05	<0.01
	TOB	6.7	15	55.2	<0.03	<0.003	0.096	0.002	<0.05	<0.01
2003	TOA	5.1	11	43	<0.03	<0.004	0.064	<0.002	<0.02	<0.01
	TOB	7.2	11.4	43	<0.03	<0.003	0.067	<0.002	<0.02	<0.01
2004	TOA	6.0	11	48	<0.05	<0.004	<0.027	<0.03	<0.05	<0.01
	TOB	7.0	9.9	57	<0.04	<0.002	0.027	<0.002	<0.05	<0.01
2005	TOA	5.0	8.6	45	<0.03	<0.002	<0.021	<0.002	<0.02	<0.01
	TOB	5.0	8.8	52	<0.03	<0.002	<0.018	<0.002	<0.03	<0.01
2006	TOA	6.0	14.4	54	<0.03	<0.002	<0.041	<0.002	<0.005	<0.01
	TOB	7.0	14.9	59	<0.03	<0.002	<0.039	<0.002	<0.003	<0.01
2007	TOA	8.0	12.6	39	<0.009	<0.003	<0.011	<0.002	<0.003	<0.01
	TOB	8.0	13	44	<0.009	<0.002	<0.014	<0.002	<0.005	<0.01
2008	TOA	9	11.9	42	<0.009	<0.003	<0.086	<0.002	<0.023	<0.01
	TOB	9	13.8	45	<0.016	<0.003	<0.085	<0.002	<0.026	<0.01
2009	TOA	9.0	8.6	39	<0.007	<0.002	<0.04	<0.002	<0.156	<0.01
	TOB	7.0	8.5	40	<0.07	<0.002	<0.039	<0.002	<0.155	<0.01

		Chloride (mg/l)	Phosphorous (mg/l)	Cyanide (mg/l)	Copper (mg/l)	Chromium (mg/l)	Mercury (mg/l)	Potassium (mg/l)	Aluminium (mg/l)	Antimony (mg/l)
2001	TOA	16	0.05	<0.05	<0.002	<0.002	<0.001	2.9	<0.05	<0.01
	TOB	18	0.06	<0.05	<0.002	<0.002	<0.001	2.4	0.17	<0.01
2002	TOA	16	0.05	<0.05	<0.01	<0.002	<0.001	3.23	<0.05	<0.01
	TOB	24	0.06	<0.05	<0.01	<0.002	<0.001	3.38	0.17	<0.01
2003	TOA	15	0.07	<0.05	0.003	<0.002	<0.001	3.5	<0.05	<0.01
	TOB	11	0.06	<0.05	0.002	<0.002	<0.001	3.6	<0.05	<0.01
2004	TOA	20	0.07	<0.05	0.015	<0.003	<0.001	2.7	<0.05	<0.01
	TOB	21	0.06	<0.05	0.008	<0.002	<0.001	3.4	<0.05	<0.01
2005	TOA	12	<0.04	<0.03	<0.002	<0.002	<0.001	3.8	<0.02	<0.01
	TOB	15	<0.02	<0.03	<0.002	<0.002	<0.001	3.2	<0.02	<0.01
2006	TOA	21	<0.05	<0.02	<0.002	<0.002	<0.001	3.2	<0.003	<0.01
	TOB	16	<0.02	<0.02	<0.002	<0.002	<0.001	3.5	<0.005	<0.01
2007	TOA	22	<0.11	<0.01	<0.002	<0.002	<0.001	3.1	<0.002	<0.01
	TOB	24	<0.11	<0.01	<0.002	<0.002	<0.001	3.6	<0.011	<0.01
2008	TOA	19	<0.05	<0.02	<0.004	<0.003	<0.001	3.8	<0.291	<0.01
	TOB	17	<0.05	<0.02	<0.002	<0.002	<0.001	4	<0.024	<0.01
2009	TOA	19	<0.04	<0.02	<0.002	<0.002	<0.001	2.4	<0.077	<0.01
	TOB	18	<0.03	<0.02	<0.002	<0.002	<0.001	2.2	<0.082	<0.01

8.5 Potential Impacts

8.5.1 The extent to which downward leakage will occur from the alluvium along the line of the river.

The northeast part of Liscartan and southwest part of Rathaldron lie in close proximity to the River Blackwater. Conditions during the expansion of the workings beneath the Liscartan and Rathaldron application area are not expected to be any different to conditions experienced at Nevinstown, where virtually no leakage from the river has been observed to date. However, it will be necessary to obtain some additional monitoring data to confirm conditions as part of the planned mining of the extension. In addition, operational monitoring data will also be required to confirm any potential interaction between the Waulsortian and the Pale Beds prior to mining in that area.

Under the current water management system, water from underground is pumped to the surface mine-water pond from which it may be reclaimed for reuse in the plant or discharged via the clear water pond to the river Boyne. Surplus water is discharged to the River Boyne through a storage pond under the Tara IPPC (Integrated Pollution Prevention and Control) licence. The quality of the water is monitored to ensure IPPC compliance. No significant changes to water quality are anticipated following expansion of the workings into the Rathaldron/Liscartan application area.

The current monitoring data indicate that drawdown in the Pale Beds unit in the vicinity of the River Blackwater at Rathaldron is of the order of 30 m. It is therefore expected that losses from the river and the flood plain alluvial deposits will be controlled by the permeability of the superficial deposits, rather than by ongoing drawdown in the Pale Beds.

Observations at *Nevinstown* indicate that the fine-grained nature of the overburden and river-bed materials have minimised downward leakage of river water. Virtually no leakage from the shallow alluvium, the flood plain deposits or the river itself has been observed to date in response to mining beneath the river at Nevinstown. Current losses from flood plain and river are negligible (1.5 l/second or less). Except for hole N00022 (on the floodplain), and the Nevinstown exploration decline (1500NDEX2), both of which are now dry, there has been no chemical indication of river water inflow to the Main Mine or the Nevinstown workings.

Mining at Tara has been carried out close to, or beneath, the River Blackwater for over 30 years. Virtually all stope blocks located in the vicinity of the river are mined with no significant leakage of water from the river or the shallow alluvial water table of the floodplain. The main potential for increased future inflows is likely to be associated with differential movement across structural zones underlying the flood plain. At Nevinstown, this is being monitored by extensiometers placed across the main identified structures.

Given the current dataset, there is no indication that conditions beneath the river will be any different for the Liscartan/Rathaldron extension. However, it should be appreciated that mining below or adjacent to any surface water body needs to be carried out with great care. Additional monitoring holes close to the river are recommended, as discussed in Section 6.4.5. Also, as mining is extended beneath the

River Blackwater, the inflow chemistry should be monitored to detect any chemical signatures similar to river water or shallow alluvial groundwater.

8.5.2 Water Quality during Operation

Any additional groundwater flow from the proposed extension is not expected to alter the overall chemistry of the discharge. It has been demonstrated in table 8.3 above that the existing effluent discharge system to the Boyne is not affecting the chemistry of the water downstream of the discharge diffuser.

The new orebody is geologically and geochemically identical to the orebody in the main Tara Mine and, therefore, there will be no significant difference in the water chemistry. (Ref AMC, Geotechnical Study, section 5). It is therefore predicted that there will no negligible impact associated with discharge of water resulting from this development.

8.5.3 Water Quality after Closure

Following mine closure pumping will cease and the mine will fill with groundwater. This process is likely to take a number of years. Afterwards, the pre-existing groundwater drainage pattern will be re-established.

SECTION 9 FLORA AND FAUNA

9.1 Introduction

Forest, Environmental Research and Services (FERS) Ltd. was commissioned by Boliden Tara Mines Ltd. to carry out a baseline habitat, flora and fauna survey of lands in the vicinity of the town-lands of Liscartan and Ratholdron, Navan, Co. Meath, where there is a proposal to extend ore extraction operations. FERS has conducted professional ecological surveys since its inception in 2005. These surveys have included work on NPWS-funded national projects such as the National Survey of Native Woodlands and the National Semi-natural Grassland Survey, work on LAP's for Meath County Council, surveys for the OPW, surveys for the Heritage Council and surveys for private individuals/companies. The survey area in question is comprised largely of semi-improved agricultural grassland (GA1) and tillage (BC3) with associated hedgerow (WL1) and treeline (WL2) habitat.

9.2 Method

A desk study was undertaken to determine if there were any designated habitats or protected species recorded within this 10 km square (N86). Data held by the National Parks and Wildlife Service was examined in relation to the survey area.

The initial field survey was carried out over two days in January 2010. The survey methodology consisted of systematically walking the site area and recording on a large scale, habitats and vegetation types present utilising a Magellan Mobile Mapper, from which data were transferred into ArcGis 9.2 and a habitat map generated. The primary aim of this survey was to broadly identify habitats, and to observe indications of fauna not easily seen during the growth season (for example trails through vegetation are easier to follow at this time of year). All observations of fauna (or signs thereof such as scat, prey remains, holes, fur etc.) were recorded and any setts, dens, etc. were recorded.

A second walk-over survey was carried out over two days and two nights in June 2010. The purpose of this survey was to more accurately identify vegetation types, and any rare/protected flora, in addition to fauna not observed during the January survey – most importantly bats. Bats were surveyed over 2 warm, humid nights from 30 minutes before sunset until 90 minutes after sunset with an Anabat SD1 bat detector with attached PDA and analook software.

9.3 Results

9.3.1 Desk Study

A review of data held by the National Parks and Wildlife Service indicated that there is a significant area of the site covered by a designated conservation area which makes up a component of the River Boyne and River Blackwater SAC (site code 002299) and this area is indicated in Appendix I. This site is a candidate SAC for alkaline fen and alluvial woodlands, both of which are habitats listed on Annex I of the EU

Habitats Directive. The site is also selected for Atlantic Salmon, Otter and River Lamprey – all of which are listed on Annex II of the Habitats Directive.

There is also an old record of the protected plant "Hairy St. Johns Wort" (*Hypericim hirsutum*) occurring within this 10 km square (N86). Webb describes this as a plant of "*...woods and shady places; locally frequent in the Liffey valley, very rare elsewhere...".* This plant was recorded in 1896 in the 1 km square N8060 and does not appear to have been recorded since.

9.3.2 Field Survey

9.3.2.1 Habitats, vegetation and flora

The survey area comprises largely of semi-improved agricultural grassland (GA1) and tillage (BC3) with associated hedgerow (WL1) and treeline (WL2) habitat. No rare/protected species of flora was observed during the course of the surveys. The most significant ecological feature of the survey site is the river corridor. The different habitats occurring are indicated in the accompanying habitat map (Appendix II).

The principal habitats identified:

- Improved Agricultural Grassland (GA1)

Semi-Improved agricultural grassland is the dominant habitat type within the survey area (approximately 30 Ha of 65). This grassland is grazed by sheep, cattle and horses throughout the survey area. While these areas of grassland contain a high proportion of Perennial Rye Grass (Lolium perenne), there are a number of other grasses present, including Poa pratensis, Poa trivialis, Cynosurus cristatus, Holcus lanatus, Dactylis glomeratus and Phleum pratense with Glyceria fluitans in some of the wetter areas of the fields. The herb layer is relatively poorly developed, dominated by Ranunculus repens, with numerous other agricultural herbs such as Trifolium repens, Trifolium pratense, Taraxacum officinale agg., Urtica dioica, Rumex spp., Cerastium arvense, Stellaria media, Veronica spp. and Cirsium spp. In general, the habitat is of limited ecological value, and is likely regularly reseeded and/or fertilised. In several of the fields, hedgerows have been removed in the recent past further reducing the ecological value of this habitat.

- Dry meadow/Grassy verges (GS2)

This category of grassland applies to unimproved or semi-improved grasslands that are rarely fertilised or grazed and are typically mown only once or twice a year. This habitat is now relatively rare in Ireland and is best represented by grassy roadside verges and on the margins of tilled fields. There is a small area of this habitat occurring along the N3 and around the margins of several tillage fields (areas around the margins of fields are too small to map). Grasses such as False Oat Grass (Arrhenatherum elatius) Cocks-foot grass (Dactylis glomerata), Yorkshire Fog (Holcus lanatus) and Rough Meadow Grass (Poa trivialis) are the main grasses here, with herbs such as Hedge Woundwort (Stachys sylvatica), Creeping Buttercup (Ranunculus repens), Cow Parsley (Anthriscus sylvestris), Hogweed (Heracleum sphondylium), various thistle (Cirsium) species and Knapweed (Centaurea nigra) common. This relatively undisturbed habitat provides a valuable ecological corridor for both flora and fauna in a landscape dominated by intensive agriculture.

- Wet Grassland (GS4)

This type of grassland can be found on flat or sloping ground in upland or lowland areas and occurs on wet or water-logged mineral or organic soils that are poorly drained or subjected to seasonal flooding. A significant area of GS4 habitat occurs on the low-lying areas adjacent to the Blackwater. Although containing many elements of Marsh habitat (GM1) the percentage of grasses and presence of some species typical of drier habitats here indicates that it should be considered as GS4. The habitat is submerged during floods. The habitat is dominated by Iris pseudacorus with Agrostis stolonifera and various other grasses with a high cover of various Juncus species. There are numerous other wet grassland species present also such as Water Mint (Mentha aquatica) and Meadow Sweet (Fillipendula ulmaria).

- Tilled land (BC3)

A large proportion of the survey area consists of tillage (approximately 27 Ha). Given the quantity of fertiliser, herbicides and pesticides typically applied to this habitat type, it is of very limited ecological value – apart from any grassy verges on the margins of fields which may provide a *refugia* for a plethora of flora and fauna.

- Depositing/lowland river (FW2)

This category of habitat includes watercourses in which fine sediment is deposited on the river bed. These depositing conditions are typical of lowland areas in which there is a low gradient and water flow is relatively slow. The river Blackwater is such a body of water and runs through the survey area. This is an important ecological corridor, reflected in the fact that is part of the river Boyne and Blackwater SAC. Vegetation is typical of the habitat, with an abundance of both submerged and emergent macrophytes including Common Reed (*Phragmites australis*), Fools water cress (*Apium nodiflorum*), Flowering rush (*Butomus umbellatus*) Duckweeds (*Lemna spp*), Canary reed grass (*Phalaris arundinacea*), Yellow Flag (*Iris pseudacorus*), Yellow Water Lily (*Nuphar lutea*) and Common Club Rush (*Schoenoplectus lacustris*) all present in the watercourse. The water edge is species-rich, with Water plantain (*Alisma plantago-aquatica*), Common Alder (*Alnus glutinosa*), various Willow (*Salix*) species, Marsh thistle (C*irsium palustre*), Canadian pondweed (*Elodea Canadensis*), Marsh willowherb (*Epilobium palustre*), Water horsetail (*Equisetum fluviatale*), Floating sweet grass (*Glyceria fluitans*), Sweet reed grass (*Glyceria maxima*), Yellow Iris (*Iris pseudacorus*), Yellow loosestrife (*Lysimachia vulgaris*), Amphibious bistort (*Persicaria amphibian*), Canary reed grass (*Phalaris arundinacae*), Marsh yellow cress (*Rorripa palustris*), Curled dock (*Rumex crispus*), Water figwort (*Scrophularia auriculata*), Marsh woundwort (*Stachys* *palustre*), Bulrush (*Typha latifolia*) and Brooklime (*Veronica beccabunga*) all abundant.

- Hedgerows (WL1)

As is typical throughout the country, the most ecologically valuable attribute of the farmland throughout the site is the hedgerows and un-kempt verges associated with field boundaries. The hedgerows are typical of the habitat in this part of the country, dominated by Hawthorn (*Crataegus monogyna*) and Ash (*Fraxinus excelsior*) with some Beech (*Fagus sylvatica*), Sycamore (*Acer pseudoplatanus)*, Oak (*Quercus robur*) and even a young Yew tree (*Taxus bacatta*). The most visible species growing in the understorey of the hedgerow were ferns such as Harts Tongue Fern (*Phyllitis scolopendron*) and Male Fern (*Dryopteris filix-mas*) with Bramble (*Rubus fruticosus agg),* Ivy (*Hedera helix*), Herb Robert (*Geranium robertianum*), Herb Bennet (*Geum urbanum*), Cow Parsley (*Anthriscus sylestris*), Burdock (*Arctium minor*) and Nettle (*Urtica dioica*) abundant. Numerous mosses and liverworts such as *Atricum undulatum* and *Pellia endivifolia* also occur in the shelter of hedgerows.

- Treeline (WL2)

There is a significant area of treeline habitat lining an avenue between N 84194 69135 and N 84457 69283. This treeline is composed of both coniferous and deciduous trees – but of more importance ecologically is the fact that many of these trees are ivy-covered and of a sufficient age to have rotten limbs and crevices. These trees could provide a significant habitat for several species of bat during different stages of their life cycle.

- Semi-natural woodland/scrub

There are several small pockets of semi-natural woodland throughout the site. There is a small linear area of naturally regenerated oak-ash-hazel (WN2) woodland located to the north west of the survey area that occurs on a raised earthen bank (that at one time may have the rail-link between Oldcastle and Navan). This area, consisting largely of Ash, Hawthorn, Blackthorn, Holly and Elder provides an invaluable resource to the fauna of the locality and is an important ecological feature. A pair of Buzzard was observed to be nesting here during the June surveys. There are also several areas of wet willow-alder-ash (WN6) woodland, dominated by various Willows (Salix spp), Alder (Alnus glutinosa) with some Poplar (Populus spp), Ash (Fraxinus excelsior), Blackthorn (Prunus spinosa) and Holly (Ilex aquifolium) adjacent to the Blackwater. These provide a valuable semi-natural habitat adjacent to the river corridor. On the edges of several of these wooded areas there are small patches of Blackthorn (Prunus spinosa) scrub, providing good cover for nesting birds.

- Built Land (BL3)

Here, this category of habitat is utilised for the N3 road, in addition to several houses and small areas around these houses.

9.3.2.2 Fauna

9.3.2.2a Mammals

The mammal diversity observed was typical of that one would expect to occur in a largely agricultural setting, with Fox (*Vulpes vulpes*), Badger (*Meles meles*) Brown Rat (*Rattus norvegicus*) and Rabbit (*Oryctolagus cuniculus*) all abundant, with plentiful faeces and/or burrows observed of all four species in the hedgerows and small areas of woodland associated with field boundaries. Numerous Badger setts were located throughout the survey area. It is likely that other Irish mammals common throughout this part of the country such as Hedgehog, Pygmy Shrew, Hare and Grey Squirrel are also present throughout the survey area. Bat surveys were carried out on the nights on the 10th and 17th of June and five species of bat were recorded – Daubentons, Soprano Pippistrelle, Common Pippistrelle, Brown Long-eared and Leislers bat. There were particularly high numbers present foraging around the various wooded areas and there was a high concentration of bat-activity along the river corridor as would be expected. Otter spraint was located within the survey area on both sides of the river – Otter is one of the species for which the Boyne and Blackwater SAC is designated.

9.3.2.2b Amphibians and Reptiles

Several specimens of the Common Frog (*Rana temporaria*) were observed during the surveys carried out in June. While none were observed, it is likely that the Common Lizard (*Lacerta viviparia*) also occurs within the survey area.

9.3.2.2c Avifauna

During both the January and June surveys, all birds in the study area observed (utilising 10 X 42 Opticron Oasis DBA binoculars) were recorded. A typical range of bird species associated with open farmland and hedgerows was observed over the majority of the site and included Sparrow Hawk (Accipiter nisus), Buzzard (Buteo buteo), Woodpigeon (Columba palumbus), Hooded Crow (Corvus corone), Rook (Corvus frugilegus), Jackdaw (Corvus monedula), Robin (Erithacus rubecula), Chaffinch (Fringilla coelebs), Snipe (Gallinago gallinago), Blue Tit (Parus caeruleus), Pheasant (Phasianus colchicus), Magpie (Pica pica), Bullfinch (Pyrrhula pyrrhula), Starling (Sturnus vulgaris), Wren (Troglodytes troglodytes), Blackbird (Turdus merula), Song Thrush (Turdus philomelos), Red Wing (Turdus iliacus) and Fieldfare (Turdus pilaris). All these species, excluding the Redwing and Fieldfare (which are winter migrants) are likely to breed within the survey site.

The River Corridor within the survey area supports a wealth of wetland bird species. On the survey days, Kingfisher (*Alcedo atthis* – which is listed on Annex II of the EU Habitats Directive – there are currently plans underway to designate the Boyne and Blackwater as an SPA for Kingfisher), Mallard (*Anas platyrhynchos*), Grey Heron (*Ardea cinerea*), Dipper (*Cinclus cinclus*), Moorhen (*Gallingula chloropus*), Pied Wagtail (*Motacilla alba*), Grey Wagtail (*Motacilla cinerea*) and Little Grebe (*Tachybaptus rufficollis*) were observed. The local wintering population of Whooper Swan (*Cygnus cygnus*) is known to frequent fields adjacent to the Blackwater for foraging purposes.

9.3.2.2d Fish

The water quality as indicated by the EPA on the Blackwater just above the survey area, where the Blackwater joins the Yellow River has a Q-value of Q2/Q3 indicating a poor status. Despite the poor water quality, the Eastern Regional Fisheries Board states that the ..."*river Boyne and its tributaries hold extensive stocks of Wild Brown Trout..."* and that "*...the River Boyne has a run of Atlantic Salmon and Sea Trout...*". There are no issues with regard to the impact of this development on surface waters (see hydrologists report).

9.4 Discussion

9.4.1 Assessment of ecological significance of the survey area.

The vast majority of the site consists of semi-improved agricultural grassland and tillage, and is of limited ecological value. The associated hedgerows and tree-lines are of relatively high ecological significance given the intensively farmed land in the area. Species composition of both flora and fauna are typical for hedgerows in the County and for the most part the hedgerows are intact and well developed. The small pockets of semi-natural woodland scattered throughout the site are of high ecological significance, providing islands of semi-natural habitat in an intensively farmed landscape.

The river Blackwater and the associated habitats are of great ecological significance (as would be expected give its status as an SAC), and evidence of Otter (an Annex II species) is indicative of this. A Kingfisher (also an Annex II species) was observed during the June surveys. The river provides an invaluable ecological corridor in an otherwise intensively farmed and increasingly urbanised Co. Meath.

9.4.2 Assessment of potential impacts of the development.

The ore extraction will take place deep below ground, there will be no above-ground structures and there will be no impact on local hydrology (please see hydrologists report). The proposed development will not result in any disturbance to the surface of the site, and operations will take place far below the zone of biological interaction with the surface. It is therefore concluded that there will be no significant impacts on the ecological interests of the survey area.

Plates The principal habitats identified

Plate 9.1 Semi-Improved Agricultural Grassland (GA1)

Plate 9.2 Dry meadow/Grassy verges (GS2)

Plate 9.3 Wet Grassland (GS4)

Plate 9.4 Tilled Land (BC3)

Plate 9.5 Depositing/lowland river (FW2)

Plate 9.6 Hedgerows (WL1)

Plate 9.7 Treeline (WL2)

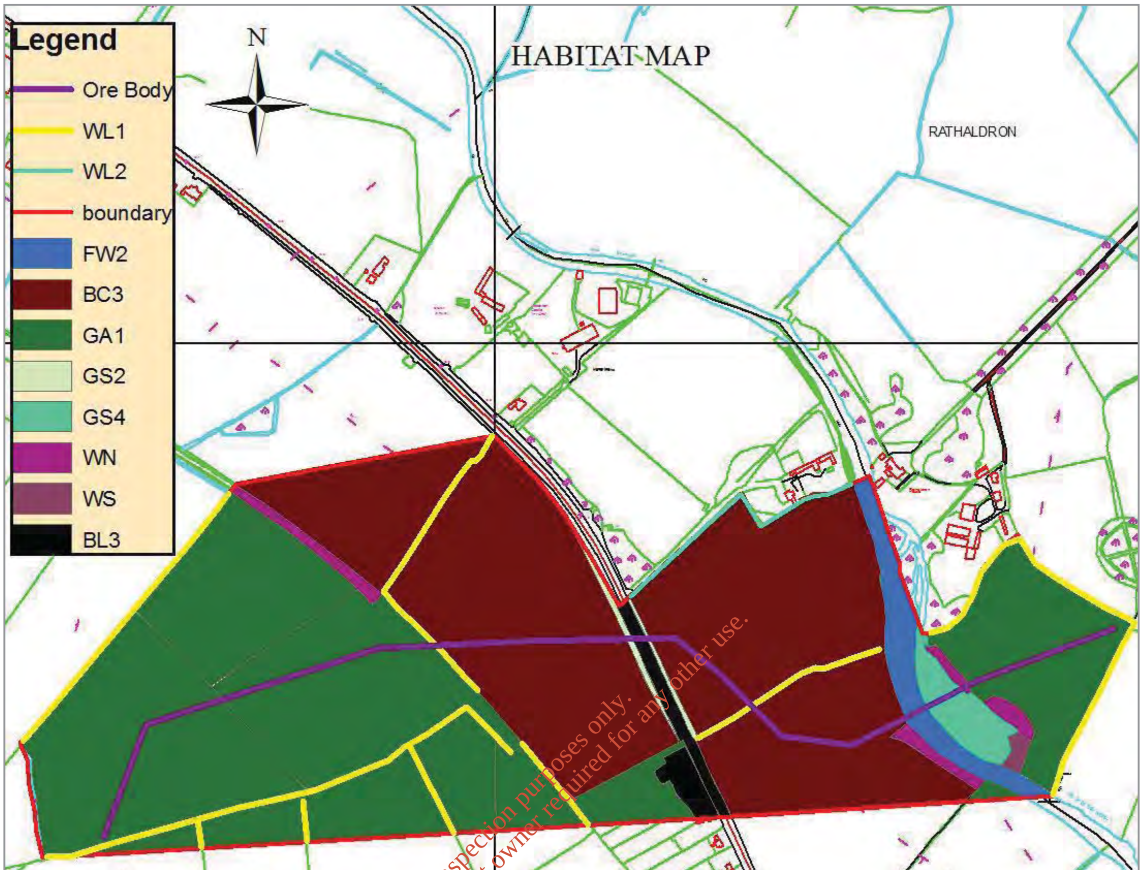
Plate 9.8 Semi-natural woodland/scrub

Plate 9.10 Built Land (BL3)

Figure 9.1 Site map indicating designated areas

Area of survey site outlined in yellow, Boyne and Blackwater SAC indicated by red lines.

Figure 9.2 Habitat Map



Habitat map of the survey area, indicating the approximate position of the ore limit in addition to the habitats present.

References

www.npws.ie – website of the National Parks and Wildlife Service
www.epa.ie – website of the Environmental Protection Agency
www.fishingireland.net
Fossit, J (2000) A guide to habitats in Ireland. Heritage Council

SECTION 10 LANDSCAPE AND VISUAL IMPACT

10.1 Visual Impacts on the Existing Landscape

Since there is no surface structures / infrastructure required for the extension into Liscartan/Rathaldron it is therefore proposed that there will be no further descriptions on visual impacts on the existing landscape in the EIS.

SECTION 11 AIR

11.1 Impacts of proposed development on Air Quality

All air intake / output required for the extension of mining works will be from existing facilities there will be no additional surface structures, or air emission sources. All access to the proposed development will be underground via the Knockumber Mine site. Accordingly, no likely impacts on air quality are anticipated. Furthermore, no odour sources are anticipated.

Ambient air quality and dust deposition have been monitored extensively in the environs of the existing mine site, since development commenced in 1973. The monitoring protocol in place as part of our IPPC Licence will continue.

Since there is no surface development associated with the planned extension it is therefore proposed that there will be no further descriptions of impacts on air quality.

SECTION 12 MATERIAL ASSETS

12.1 Introduction

This archaeological report was undertaken at the request of Boliden Tara Mines Ltd., Knockumber, Navan, Co. Meath, as part of the Environmental Impact Statement on the impact of the proposed extension of mining operations into new areas of Liscartan and Rathaldron.

The proposed development is situated 2km northwest of Navan town in the townlands of Liscartan and Rathaldron, on the west and east sides of the River Blackwater. The Liscartan-Rathaldron orebody is located to the north of the existing Tara Mines development.

The development site is located in an area that is rich in archaeological monuments ranging in date from the Neolithic to the Post-Medieval periods. There is one Recorded Monument within the application area, a mound (ME025-012), though this is not situated directly over the orebody. Between 1975 and 2004 archaeological excavation have taken place in the adjacent townlands of Nevinstown, Simonstown and Randalstown on sites affected by earlier stages of the mine development. There is also a strong likelihood of the existence of further archaeological sites in the area of which there are no surface indications.

The proposed extension to the existing mining operations into Rathaldron and Liscartan will be solely by underground means with no associated surface developments. Therefore, the development should not have any impact on the archaeological heritage of Rathaldron and Liscartan.

12.2 Methodology

This 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 The Department of the Environment, Heritage and Local Government. The purpose of the Survey is to identify, on a county by county basis, all monuments and places of archaeological importance. 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*, are given statutory protection under the 1994 Act. An extract from sheet 25 of the 1996 *Record of Monuments and Places: County Meath* for the relevant area is attached as Figure 12.1 below.

- The 1st edition of the O.S. six-inch map (1:10560) Meath Sheet 25, 1837.
- 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 any further possible features of archaeological or historical interest.

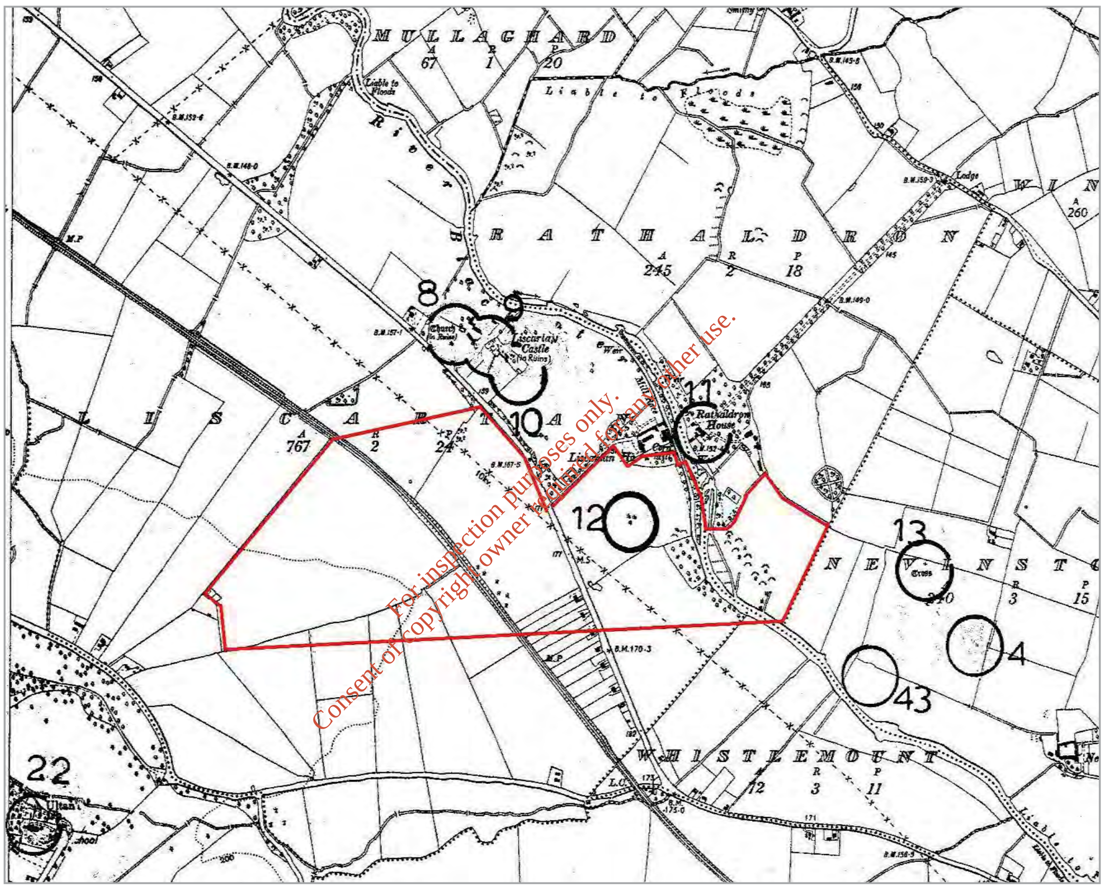


Figure 12.1 Location of application area on extract from Sheet 25 of *Record of Monuments and Places, County Meath.*

12.3 Archaeological and Historical Background

The development site is located in an area which has produced evidence of human settlement from at least the Neolithic period onwards. Evidence of early settlement is present in the form of upstanding monuments and was attested by the sites uncovered during development of the Tara Mines Ltd. tailings dam at Simonstown and

Randalstown. In 1977, excavations at Nevinstown by Mary Cahill of the National Museum of Ireland uncovered archaeological deposits dating to the Early Bronze Age, Early Christian, Medieval and Post-Medieval periods. These excavations took place in advance of a proposed open-cast mining operation which did not proceed.

Prehistoric period

At Simonstown in 1975 E.P. Kelly of the National Museum recorded pits and hearths of Neolithic date (*c.* 4500-2200 BC) under the banks of an Early Christian period ringfort. More recently, in 1998, Cóilín Ó Drisceoil partially excavated the remains of a large rectangular structure which may have been destroyed by fire. A Neolithic date, at first indicated by the finding of a leaf-shaped arrowhead on the site, was later confirmed by radiocarbon dating (*pers comm* C. Ó 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 (Ó Drisceoil's Area 6) and at Randalstown, where four such sites were excavated by D. Murphy in 1999. At Simonstown, Ó Drisceoil also uncovered 61 circular pits containing burnt stone, charcoal and occasional cremated bone, suggesting a Bronze Age date. In Liscartan townland, a tumulus or earthen mound is likely to be of prehistoric date, but without excavation is impossible to assign it to a particular period.

In 2003 seven probable prehistoric archaeological sites, including two *fulachta fiadh*, were identified by K. Campbell during monitoring of topsoil-stripping in the 'Northern Borrow Area' associated with Stage 4B Tailings Dam Extension at Randalstown. Three of the sites were excavated in 2004 by CRDS Ltd.

Early Christian period

Large-scale excavations of settlement sites of the Early Christian period have taken place at Nevinstown, Simonstown and Randalstown. Kelly excavated a large ringfort (75m diameter) at Simonstown in 1975 and an enclosure with a cemetery at St. Anne's Chapel, Randalstown, in 1975-6 and 1981-2. On this latter site, Iron Age settlement was indicated by the finding of a 1st century AD Roman brooch.

Souterrains, associated with unenclosed settlements, have been excavated at Nevinstown and on two sites at Randalstown. There is a record of a souterrain with two beehive chambers at Ardbraccan. There is annalistic and archaeological evidence for Early Christian period churches at Ardbraccan, 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.

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 1186 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 1.8km south-east of Liscartan. 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.

Rathaldron House on the east bank of the River Blackwater was originally built as a four-storey tower house, possibly by the Cusacks in the 14th century. Another medieval tower house stands at Liscartan, "Liscartan Castle (in ruins)" on Figure 2, in company with the ruins of a gatehouse and a later stone house, of 16th or 17th century date. West of the castle are the ruins of the medieval church, still in use into the 18th century. At Ardbraccan, a 15th-century church tower stands beside the church of 1770s.

The late medieval cross at Nevinstown, marked "Old Cross" on the 1837 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 by the National Museum in 1977 when the remains of 7-8 infants were uncovered around the plinth.

In addition to recognised medieval monuments in the area, material of medieval date has also been found in the excavations 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.

Post-Medieval period

In the *Civil Survey of County Meath*, compiled in 1654-6, Sir Robert Talbot and Adam Missett are listed as the proprietors of 'Liskartan'. There were two castles, a church and a weir in the townland. Patrick Cusacke was in possession of 'Rahaldron' which contained one castle, one mill and one weir. A wing was added to the Cusack castle at Rathaldron in the 17th century, the whole edifice being gothicised *c.* 1800 with further alteration by new owners in 1843. The present-day field pattern of large rectangular fields was probably laid out in the 18th century. The former branch railway line from Navan to Kells and Oldcastle passes through Liscartan, parallel with the N3 road. This line was built by the Dublin and Drogheda Railway and was opened to Kells on 11 June 1853. From 1876 until closure it formed part of the GNRI network. Passenger services ended in 1958 and the line was lifted in 1964.

12.4. RECORDED ARCHAEOLOGICAL SITES

The relevant RMP sheet for the proposed development site is Meath Sheet No. 25 (Figure 2). Listed below are the archaeological sites in Liscartan and Rathaldron and adjoining townlands as recorded by RMP and the *Archaeological Inventory of County Meath.* The details of each site are arranged in the order as follows:

Inventory No.	**Site type**
RMP No.	Description
Townland	
National Grid Ref	

Table 12.1 Recorded Archaeological Sites in Liscartan Townland

189 **025:012** 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.
1443 **ME025:008** Liscartan 28397 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.
1748 **ME025:009** 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**).
1749 **ME025:010** Liscartan 28411 26945	**Gatehouse** A barrel-vaulted gateway, with murder hole over the entrance, is situated 100m from the tower house at Liscartan (**1748**)
1772 **025:011** Rathaldron 28458 26932	**Tower House** A four-storey medieval tower house, still inhabited. The castle has been extensively remodelled but retains some original features.

Table 12.2 Recorded Archaeological Sites in Adjacent Townlands

1329 **ME024:022** Ardbraccan 28288 26832	**Church** This site dates back to the 7th-century foundation of Bishop Braccan although there are no visible Early Christian period remains. Beside the church of 1770 is a free-standing four-storey medieval church tower of 15th-century date, topped with a belfry of 18th-century date. In the graveyard is a monument to George Montgomery, Bishop of Meath who died 1620.
152 **ME024:013** Ardbraccan 28262 226797	**Tumulus** Earthen mound, 2m high, with diameter of 24m at base, 14m diam at flat top.
392 **025:043.1** Nevinstown 28504 26875	**Early Christian Occupation Site** Excavated as Site I by Mary Cahill in 1977 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.
287 **025:043.2** Nevinstown 28504 26875	**Pit burial** An Encrusted Urn and a Vase Food Vessel were excavated at Site I by Mary Cahill in 1977. 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.
441 **025:004** Nevinstown 28520 26883	**Souterrain** The souterrain, Cahill's Site II excavated in 1977, consisted of a 12m length of destroyed souterrain passage leading to a beehive chamber. Souterrains date to the Early Christian period. No evidence was found for an enclosure around the souterrain.
1547 **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 1977, her Site IV, uncovered the remains of the plinth which had been constructed of cut-limestone blocks. A *cillín*, or burial ground for unbaptised children, was found at the base of the cross.
1600 **025:013.2** Nevinstown 28518 26900	***Cillín*** Excavated as Site IV by Mary Cahill in 1977, this burial ground contained the remains of 7 or 8 infants and young children at the base of the late medieval wayside cross (**1547** above).

1646 **025:023** Moathill 28598 26765	**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 37m diameter and 6.8m high.
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.
1817 **025:025** Abbeylands South/Townparks 28700 26770	**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.

12.5 Field Survey

The field walking survey was carried out in the application area in January 2007, in dry, bright and sunny conditions. The fields are numbered 1-12 on Figure 12.2.

The River Blackwater flows north-west to south-east through the application area, with Rathaldron on the east bank and Liscartan on the west. The N3 Navan-Kells road runs approximately south-north through Liscartan where road-widening has encroached onto the fields on either side. Within the application area, the northern end of the former line of the Navan-Kells railway remains as an overgrown cutting, while the southern end has been incorporated into the neighbouring fields. The general surrounding topography is of flat to undulating farmland set out in large rectilinear pasture and tillage fields. The field boundaries consist of traditional banks and ditches with tall hedges and mature trees. No new archaeological features were noted during the field survey.

Relatively few changes have occurred in the landscape between the 1837 1st edition O.S. six-inch map and the present-day. Changes are limited to the removal of some field boundaries, the building of the railway line and of County Council houses by the N3.

Field 1

This is a large pasture field surrounded by hedgerow. The field is level over the southern two-thirds of its area before sloping down to the corner at the north end. Temporary post and wire fences subdivide the field. A leveled bank, *c.* 10m wide and 03m high, is evident on the ground running south-north from the southern boundary, continuing the line of the western boundary of Field 7. This bank is a leveled field boundary which is shown on the 1837 map and was probably removed when the railway line was built. The 1837 map shows a house and garden at the extreme west end of the field. The railway line has now been incorporated into the south east side of Field 1. Between Fields 1 and 2, the railway cutting is overgrown with bushes.

Field 2
This is a large pasture field bounded by the line of railway on the west and the N3 on the east. The field has an overall gentle slope from south to north.

Field 3
This large tillage field, bounding the west side of the N3, is level in the southern half before sloping down to the northern corner. The field boundary by the road is a concrete post and rail fence. There is a small overgrown quarry at the dog-leg in the northern field boundary. There is a stony spread, *c.* 40m in diameter, in the ploughed soil adjacent to this quarry.

Fields 4-7
The northern ends of four flat pasture fields are included within the application area. The line of railway has been incorporated into the east side of Field 7.

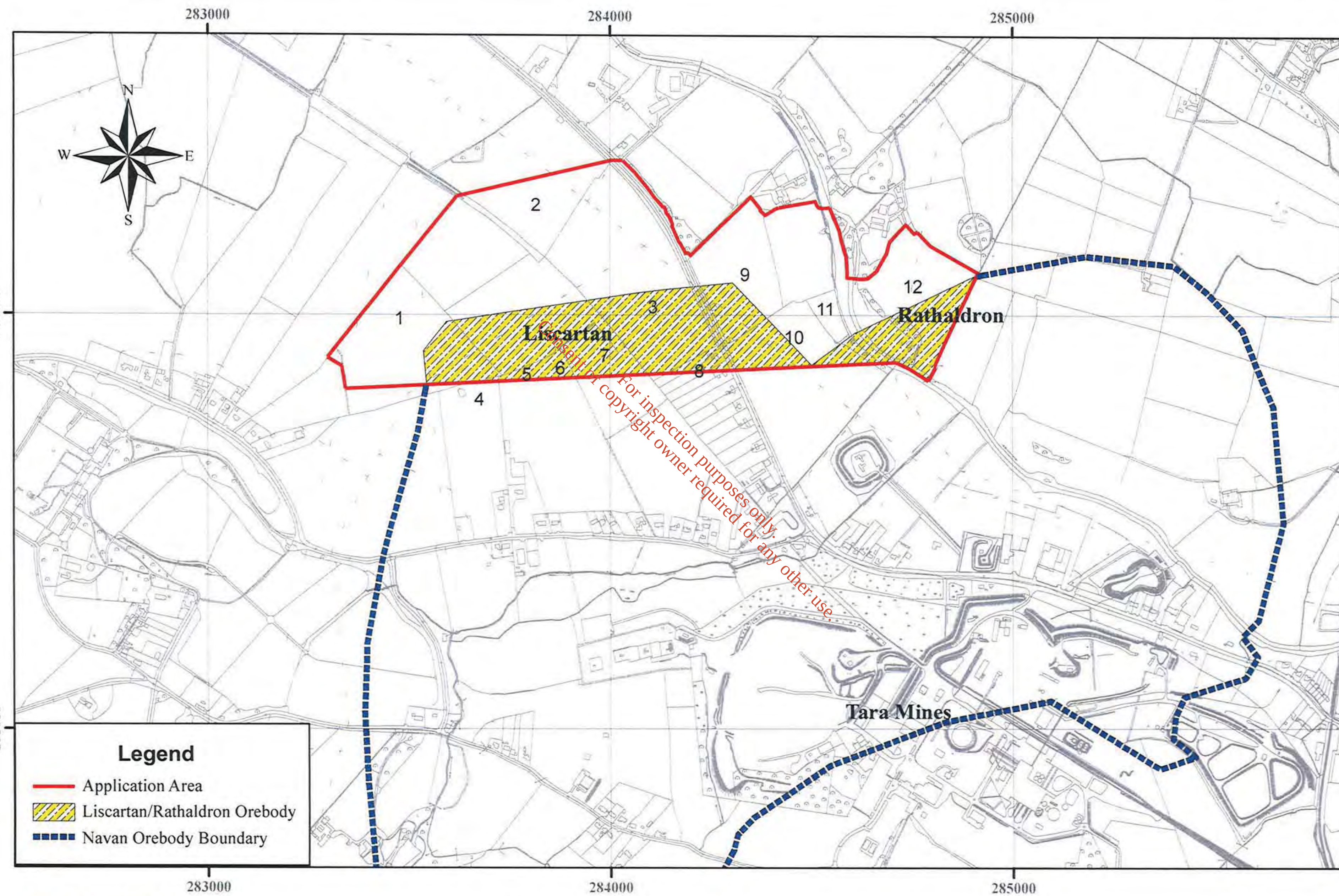
Field 8
The designation ‘Field 8’ has been applied to two pairs of semi-detached houses and their long back gardens. The four County Councils houses, of mid-twentieth century date, are intact but uninhabited. The back gardens form one pasture field where cattle are grazing.

Field 9
This is a large pasture field sloping down from the N3 towards the River Blackwater. The slope levels off mid-field and has a moderate slope down to the river edge. The tumulus (Recorded Monument ME025-012) is at the centre of the field. A wooden post and rail fence runs north-south by the tumulus and divides the field. The southern field boundary bank is stone-faced.

Field 10
This is a large tillage field, in stubble at the time of the survey. A gentle slope from the road levels mid-field then drops steeply to the river edge. Apart from the boundary between Fields 10 and 11, the river edge is not now wooded as it appears on the OS map. An overgrown area by the road at the north-west corner is marked ‘Quarry’ on the 1837 O.S. map.

Field 11
This small pasture field has a moderate slope to the river edge. A wide drainage ditch and hedgerow forms the northern boundary with Field 9.

Field 12
This large pasture field in Rathaldron townland is shown divided into four fields on the 1837 O.S. map, with two buildings at the northwest edge. The northern half is level; the southern half, sloping to the river, is somewhat overgrown with trees and bushes. A strip by the water’s edge is flat.



BOLIDEN Figure 12.2 Location of application area Liscartan and Rathaldron with fields numbered 1-12.

1:12,500

Map reporduced from O.S.digital maps by permission of The Ordnance Survey Ireland.

12.6 Characteristics of the Proposed Development

It is proposed to develop the Liscartan – Rathaldron orebody, solely by underground means. No surface developments, e.g. return air raises / ventilation facilities, or other ground works are currently proposed.

12.7 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 in Liscartan and Rathaldron townlands.

12.8 Remedial and Mitigative Measures

The development as proposed should 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 ground surface, Tara Mines Ltd should be prepared to be advised by the Heritage and Planning Division of the Department of the Environment, Heritage and Local Government with regard to any necessary mitigating action.

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 Section, DEHLG, of any work proposed at such monuments or places.

12.9 Bibliography

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SECTION 13 ROADS AND TRAFFIC

13.1 Access to the new development

Access to the Liscartan and Rathaldron orebody will be from within the existing main mine plant site. There will be no other access point from surface to the new development. No additional transportation infrastructure is therefore required. The new development will not lead to any additional surface traffic.