# 5. SOILS AND GEOLOGY

## 5.1 Introduction

The geology section of this report was undertaken by Catherine Storey, who studied Environmental geology at University of Sunderland, where her main study areas were open cast mining in the Durham area and the geology of Aran Island in Scotland. She has produced a number of field reports and Environmental Geology Reports as part of EIA over the past 18 years for wind farm, construction and quarry industry.

The quarry has been in operation for 17 years, extracting and providing aggregates and stone within the region.

The "Won" stone is used for stone cladding of block walls and the construction of new walls. In addition, aggregates are the crushed stone products that are produced within the on-site plant to standard scale size for the different aggregate use, different sizes of chip stone, and gravels; that are used for site preparation in building construction and road building.

A survey was carried out during the summer of 2014 to access the quarry face and establish the geological context of the area of quarry (QWA) Quarry Working Area. Since that time no further extraction has been carried out at the site except for the removal of already extracted stone from the quarry site.

**Plate 5. 1 Photo of the Quarry Working area (QWA) with crushing and screening plant**

## 5.2 Methodology

This assessment comprises of a desk-based study of relevant documents and a site investigation in August 2012 and was carried out according to the methodology specified by the following documents:-

- *The EPA`s "Guidelines on Information to be contained in Environmental Impact Statements" (2002).*
- *The EPA`s "Advice Notes on Current Practice - in the preparation of Environmental Impact Statements" (2003).*
- *The Institute of Geologists of Ireland (IGI) document "Recommended Collection, Presentation and Interpretation of Geological and Hydro-geological Information for Quarry Developments" (2007).*

The work undertaken during the study identified and retrieved readily available geological and soil information in respect of the study area.

This desk top study included consultation of the following information sources: -

- Geological Survey of Ireland (GSI) (Web site: www.gsi.ie)
- Environmental Protection Agency (EPA) (Web site: www.epa.ie)
- Institute of Geologists of Ireland (Web site: www.igi.ie)
- Ordinance Survey Ireland www.osi.ie
- Teagasc
- Met Eireann
- The Heritage Council
- Department of Communication, Marine and Natural Resources
- Department of the Environment and Local Government

## 5.3 Description of the Existing Quarry Operations.

### 5.3.1 Health and Safety

- The quarry holds an up to date "Health and Safety Statement" for quarrying operations. An Accident report book is kept in the sites office to record time and date of "at Work" accidents occurring during the working day at the quarry.
- A basic First Aid Kit is always retained on site
- All site personnel to wear Hard hats on site and protective foot ware.
- All visitors to the site must report to the site office, no general public visitors, to be allowed beyond this point.
- Site notices have been placed in clear view of the workers and public at the site entrance.

### 5.3.2. Stone extraction and grading.

To "win" the stone from the quarry face the quarry is blasted every 6 month by a competent explosives company. Once the required stone is broken away from the quarry face it is removed by a dump truck to the crushing plant area. Here the stone is crushed into the required grades as specified by clients. A mobile crusher is also used within the QWA. The graded stones are stock piled according to grade to await dispatch by lorry.


**Plate 5.2** **Recent excavated stone from 2015**

**Plate 5.3** **Crushing plant. Static and mobile crushing plant**

### 5.3.3 The Geology of Gortletteragh

A review of the Geological Survey of Ireland's South Donegal Geological map conducted and shows that the quarry is located between two faults that are part of the north Barnes lough Fault. The short KT fault line shows the geological movement that occurred within the local underlying geology.

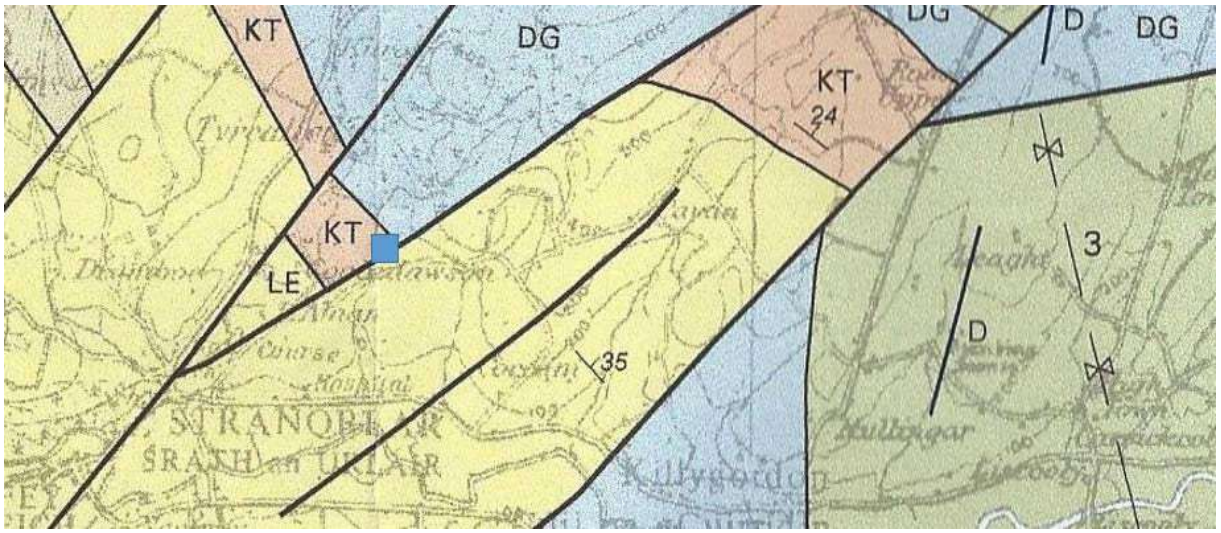



**Plate 5.4. shows the underlying geology of quarry at Gortletteragh. Blue rectangle shows the approximate quarry location**

The quarry is mainly located with KT Killeter Quartizite formation, with association of LE Lough Eske Psammites and DG Killygordon and Aghyaren Limestone groups. This is noted within sections of extracted stone, within the quarry.

The following geological description of the local bedrock has been extracted from the 'Geology of South Donegal', Geological Survey of Ireland by Long, C.B and McConnell. B.J. et.al.

*There was much dynamic upwelling Palaeoproterozoic to Mesoproterzoic, pre Cambrian period 1780 to 1100 Ma as magma erupted, followed by further intrusion and deformation of the country rock during the Silurian 438 Mya to form the main pluton (magma) to form the Donegal granites to the west North west of Gortletteragh and the formation of the BarnesMore Granite pluton to the west. Much of Donegal's is located within Contact and regional contact of the Pluton zones, a period of immense geological trauma within the earths crust, as (lava) magma reached the earths surface.*

*The bedrock continued to change through time with the formation of the Cambrianeon: Iepetus sea 345 Ma through the Ordvican a period of regional metmorphism of earlier Dalradian bed rock, Devonian the period of final closure of the Lapetus sea.* See Appendices 5.2 (Events relating to south Donegal.

**Plate 5.5 Metamorphic Limestone**

**Plate 5.6 Quartzite with showing**

**Plate 5.7 "Won" crushed chip stockpile from 2015**

**Plate 5.8 Large chip stockpile (from 2015)**

### 5.3.4 Crushed stone testing

The crushed stone has been tested on a regular basis to meet the standard of road durable stone required by the Local Authority. "Clause 810 Standard". The tests have been carried out by the Materials Test Centre at the Business Development Centre Unit 4, Port Road, Letterkenny.(New address Termon, Letterkenny).

The Test included: -

1. sieve analysis in accordance with B>S 1377 part 2. 1990
2. Plasticity tests In accordance with B.S. 1377 Part 2. 1990
3. Ten percent fines: in accordance with B.S. 810 Part 3 1990

Gortletterragh is located to the SE of the Leannan fault in geological zone D3, within the zone of the Ballybofey Nappe

The underlying bedrock at Gortletteragh: -

**LE - Lough Eske Pssamite**

*The Lough Eske Psammatie formation is identified by typical pale green massively bedded feldspathic psammites with beds generally < 10cm thick interbedded are quartzite, marble and calcareous pelite and subordinate psammitic quartz. Located in area close to QMA Quarry Management Area and entrance to the quarry*

**DG Aghyaren and Killygordon Limestone formation**

*Pritcher and Berger 1972 referred this zone as Convoy group. To include the formations above the Killeter quartizite Formation. Within the map area the KillygordonLimestone occupies a large area, on the eastern right way up limb of the Ballybofey Nappe, and the Aghyaren formation lies on the inverted southern limb. Calcitic and dolomitic marble are associated with the psammite with a tendency to be psephitic. Within this formation White limestone members often alternate with quartzite and pelite within the Killygordon Limestone formation and in the upper part of the Aghyaren formation.*

**KT Killeter Quartzite Formation**

*The Killiter Quartzite formation is present in the area southeast of the Belshade fault where the rock is fine grained, slightly impure quartzite with beds typically c. 50cm thick and occasionally graded pebbly beds. The formation is younger towards the south and becomes absent on the southern limb of the Ballybofey nappe. It is also linked with the upper and Lower Crana quartzite formation"*[1].

[1] [1] Long, C.B. McConnel, B.J. et.al (1999 Geology of South Donegal. Geological Survey of Ireland. Department of Public Enterprise, Dublin

**Plate 5.9 The layering within the bedrock is almost horizontal to the SW section of the quarry face.**

The bed rock shows differential layers of metamorphic limestone with quartzite layering. Bed planes are retained and visible.

**Plate 5.10 Working quarry face (from 2015)**

The bed rock shows a distinct North- south Strike, with easterly dip of approximately 28°. The laminar bedding planes within the bedrock shows the stone to be fine and consist of well sorted meta morphic quartzite with planes of psammite, dolerite and small amounts of pelite with bands of calcite banding.

**Plate 5.11 SE section of the quarry**

This part of the quarry shows well metamorphosed dolerite (D)with extensive calcite (c) banding dipping eastward the upper plane consist of horizontal quartzite (Q) bedding planes.

**Plate 5.12 The NEE section of the quarry face**

The quarry face consists of intermittent sections of KE Quartizite, DG Aghyaran Killygordon Limestone (metamorphic) with frequent seams of calcite banding. Quartzite at this location is horizontal and dolerite dips easterly 4°.

**Plate 5.13 mixed bedding planes (KE, DG, with calcite banding central section of the quarry face**

The quarry's geology is diverse with 3 bedrock types converging within and close to an existing fault line. The demarcation of the geological units is estimated, as seen within this quarry the geological units are intertwined throughout this bedrock unit

Pitcher describes the geology which was first documented (as Ballybofey Anticline) by Pitcher, Shackleton and Wood in 1971. Alsop goes on to state "The axial surface of the Nappe may be around 40Km before truncation by the Lennan fault"[23].

### 5.3.5 Preparation of working area

The quarrying process procedures are carried with the initial stripping of topsoil and sub strata (underlying gravels) to be retained for the future restoration process at the end of the quarry life cycle.

[2] W.S. Pitcher, Shacleton R.M, Wood, R.S.R (1971 )The Ballybofey Anticline: A solution of the general structure of parts of Donegal and Tyrone, Geological Journal (Impact Factor: 1.61). 01/2007; 7(2):321-328.DOI: 10.1002/gj.3350070207

3 (1994) The geometry and structural evolution of a crustal-scale Caledonian fold complex: the Ballybofey Nappe, northwest Ireland .www.research.gate.net

The operation of quarrying is open cast. Extracting stone in layers of 5m-8m in depth using excavators working on the quarry face fitted with a rock break. The harder rock is blasted in 6 monthly cycles. The loosen stone is removed and regular bi-annual water samples from the final discharge pond are carried out twice a year.

pH and Suspended soilds for Lwat 63 trade emission discharge license have been maintained within the permissible levels of discharge by the local Authority and within the EPA guidelines.

With standard excavator buckets and loading onto dump trucks to the storage location. The won or excavated material is loaded into the crusher plant for processing by grading and crushing to deliver the final sizes as required by client.

## 5.4 Mitigation measures for geology

There are no mitigation remedies for the extraction of stone, the geological asset of this site. Mitigation however will be provided to limit visual impact of the site during operation. A Site Restoration plan will also be implemented at decommissioning.

## 5.5 Soils

The soil and substrata (gravels) are clear from the top of the QWA before excavation of the quarry face. An area has been allocated for the storage of soil and substrata until required for restoration.
The soils at Gortletteragh are sandy podzols to immature lithosol with a clay matrix.

### 5.5.1. Hydrology

The surface runoff from the quarry floor is discharge by pipe to settlement ponds for primary and secondary treatment before final discharge to the field drainage channel.

**Plate 5.14. Existing settlement ponds**

## 5.6 Geological Heritage

The Geological Survey of Ireland (GSI) Irish Geological Heritage (IGH) Programme was contacted to determine if any geological heritage issues were present at the site in relation to the proposed development. The GSI IGHc programme has indicated that there are no geological heritage sites within 15km of the quarry.

## 5.7 Impacts

### 5.7.1 Direct Impacts

The nature of the development has entailed the removal of soil and subsoil material at the existing quarry to approximately 18m below the original ground level.

There have been direct impacts on the soil and subsoil material within the extraction area. Some of the extracted soils have been stored on adjacent lands while other soil has been retained in order to be reused in restoration.

There has been a direct impact on soils, subsoils and bedrock at the site which has been extracted; this impact is permanent and irreversible.

There will be no impact on geological heritage at, or in the vicinity of the site.

### 5.7.2 Indirect Impacts

The development has not and will not have an indirect impact on the geological aspects of the environment outside the existing quarry landholding.

Soils and subsoils on adjoining lands have not and will not be impacted as a result of this quarry.

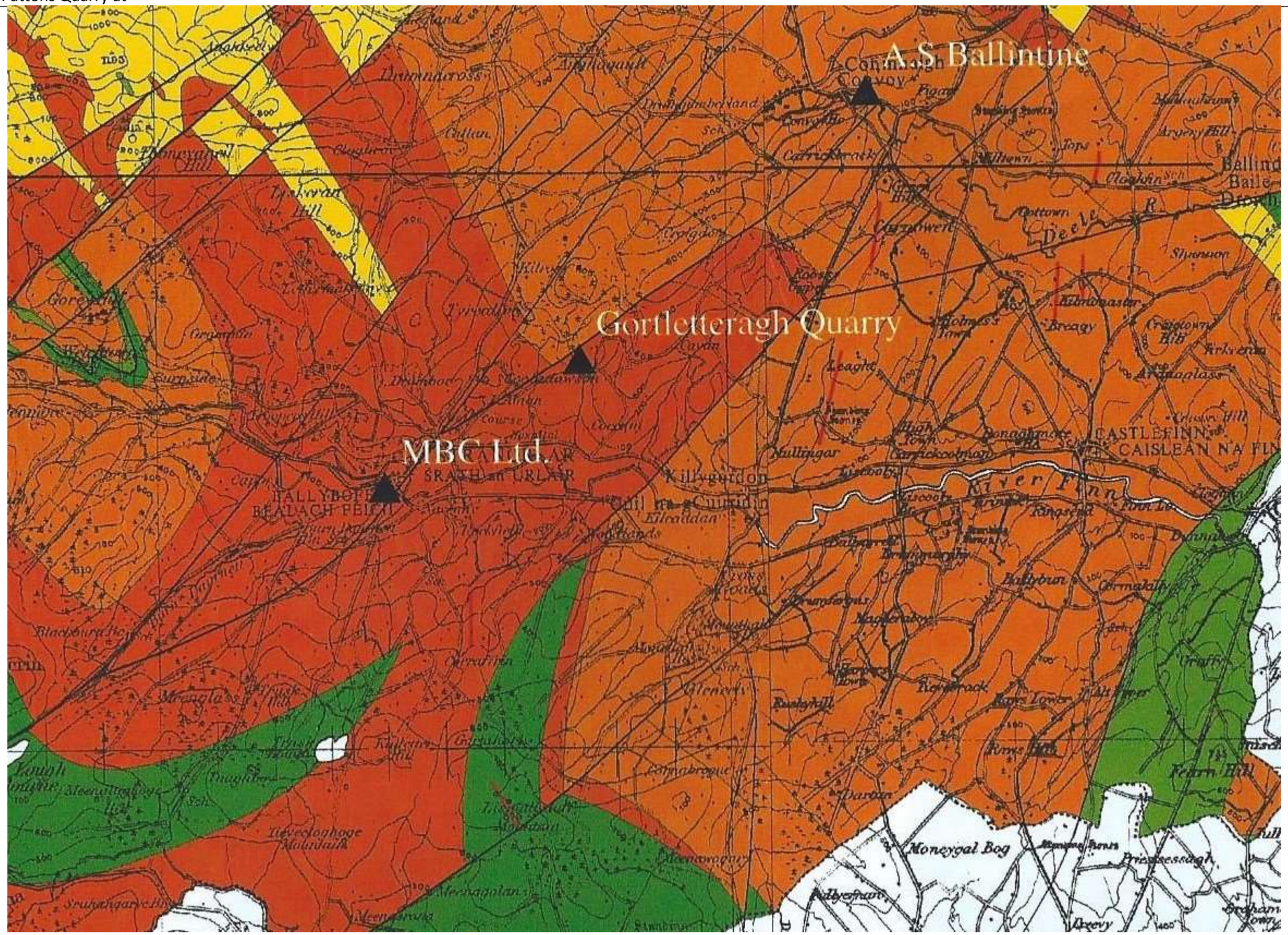
### 5.7.3 Interaction with Other Impacts

The interaction of the various environmental topics has been covered within each of the rEIS Sections, where relevant.

## 5.8 Mitigation Measures

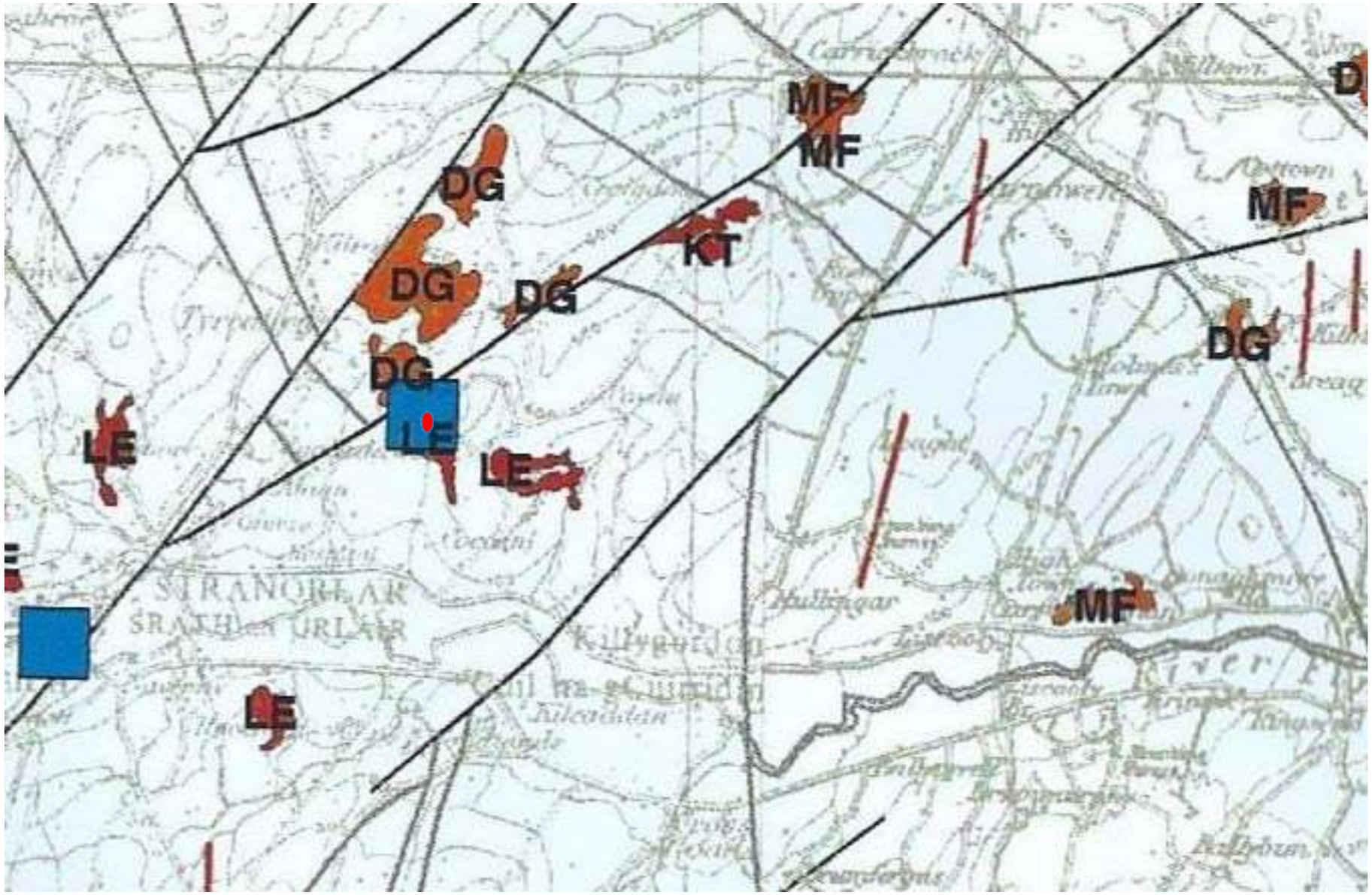
Soil and substrata should to be maintained in separate stock piles Substrata and soil mounds to be no greater than 5m.

Maintain the present discharge water status from the final settlement lagoon within the Ph and suspended solid parameters as defined in trade emission discharge license Lwat 63.




Legend

Crushed Rock Quarries, with Pattons Bros. Gortletteragh Quarry located in area 8 of aggregate Potential. Scale 150000 North




This map shows area of exposed bedrock

Legend

Crushed Rock Quarries

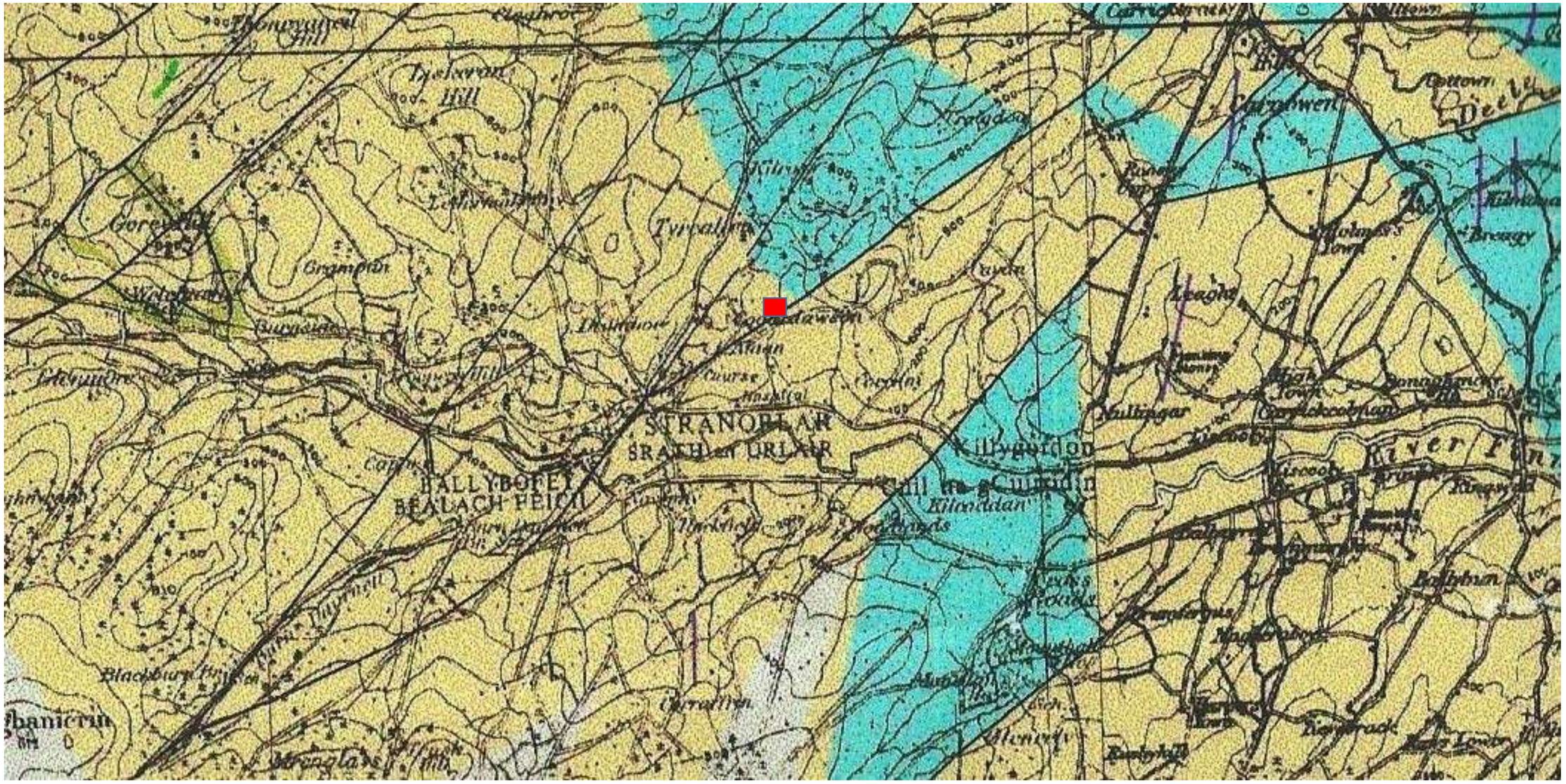
Dimension Stone Quarries

DG

Geological location of Pattons quarry. (Extracted from Map 4 Exposed Bedrock Aggregate Potential. GSI, Dublin)

Scale 150000

North

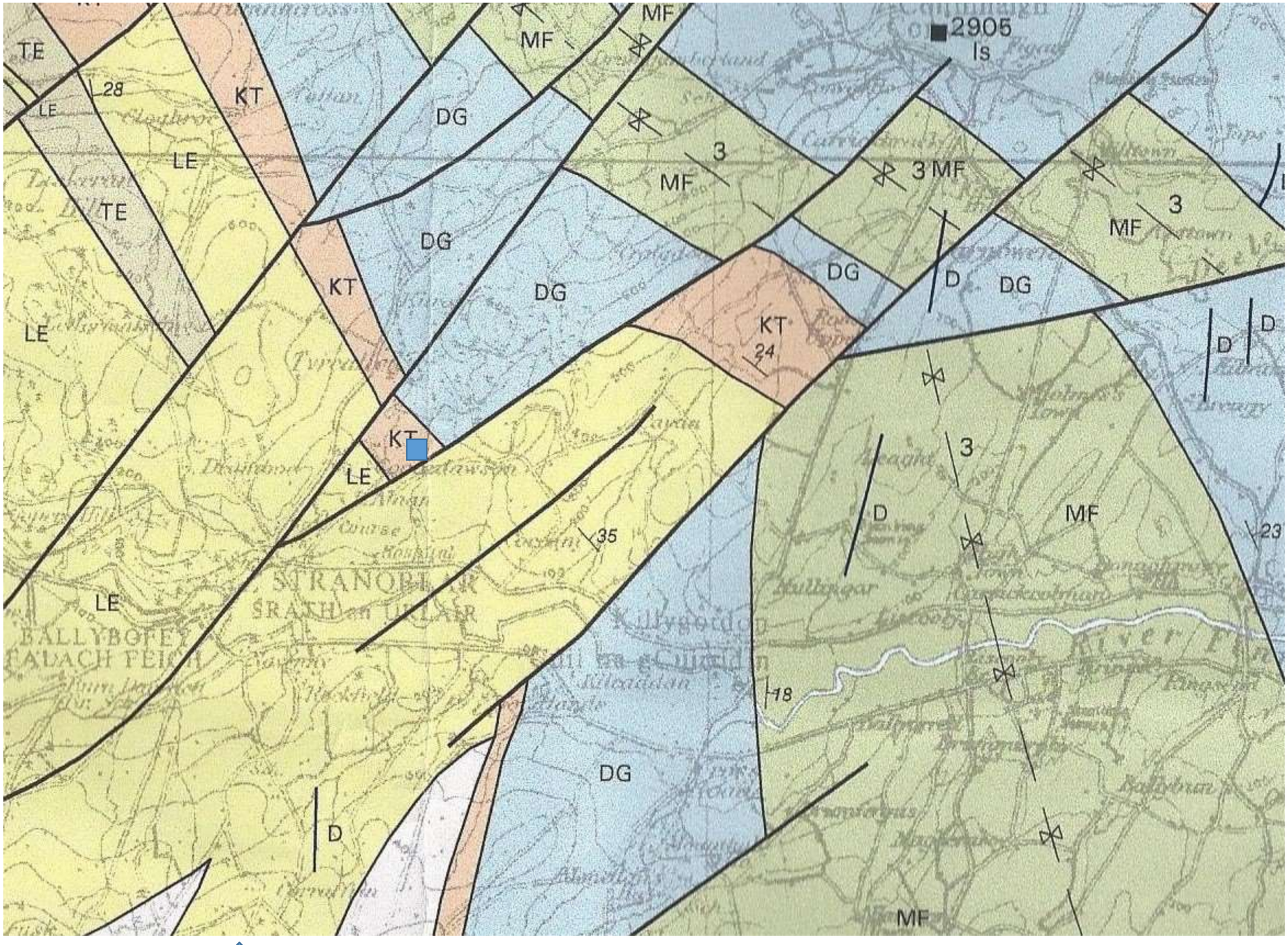



Legend from Map 4 Bedrock Lithology of Donegal

- Pattons Bros. Quarry at Gortletteragh located within area of Metamorphosed sedimentary bedrock
- Sandstone ( metamorphosed to quartzite)
- Limestone
- Breccia (is a rock composed of broken fragments of minerals or rock cemented together by a fine-grained matrix that can be similar to or different from the composition of the fragments).

Scale 1: 150000

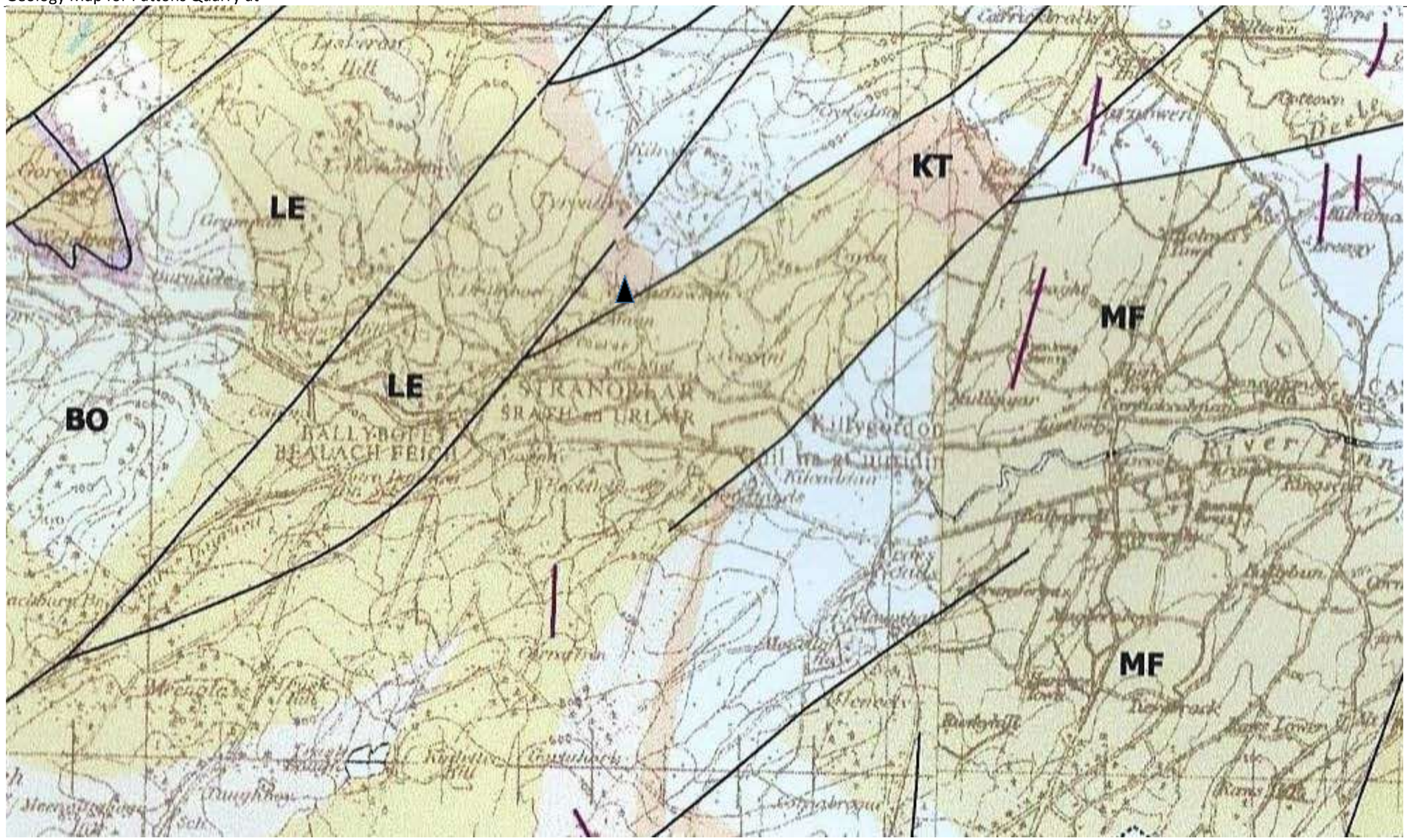
N




Legend Scale 1: 150000 North

Pattons Quarry KT Killiter quartzite LE Lough Eske Sandstone DG Aghyaran and Killygordon Limestone MF Mullyfa and Deele sandstone

Geology Map for Pattons Quarry at




Legend ▲ Pattons Bros. Quarry — Fault

line KT Killiter Quartizite

LE Lough Eske Sandstone

BO Boulty Patrick grits

Scale 1: 150,000

N


Legend

Patton Brothers Operation Quarry from www.bingmaps

Quarry and surrounding

landscape Copied from

www.bingmaps

**Appendix 5.1**

# Soil and Hydrology

## Ballybofey GWB: Summary of Initial Characterisation.

| Hydrometric Area<br>Local Authority | Associated surface water bodies | Associated terrestrial ecosystems | Area ($km^2$) |
|---|---|---|---|
| Hydrometric Area 01<br><br>Donegal Co. Co.<br>(Northern Ireland) | ***Rivers:*** Burn Daurnett, Clogher(Finn), Cross Roads Stream, Cummirk, Elatagh, Finn (Donegal), Reelan, Rough Burn, Stranagoppoge<br>***Streams:*** 773-unnamed streams<br>***Lakes:*** Black Lough, Lough Nambraddan, Castle Lough, Lough Naroon, Croaghanard Lough Lough, Nastackagh, Croagherrib Lough, Lough Shivnagh, Cronloughan Lough Aduff, Illanicrooney Lough, Lough Assoge, Lough Arasy, Lough Doo, Lough Finn,Lough Gibbagh, Lough Glenaboghil, Lough Lilly, Lough Labia, Lough Nagarriokagh, Lough Meenabrack, Lough Nagreal, Lough Muck, Lough Sallagh, Lough Nabastee, Meenlackdoe Lough. | Meentygrannagh Bog, Meenaguse Scragh (O' Riain, 2004) | 468 |

| | | |
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| **Topography** | | Located in the southeast of County Donegal, this GWB (Figure 1) is bounded to the west, north and southwest by topographic divides (Hydrometric Areas 38, 39 and 37 respectively). The eastern and south-eastern boundaries are catchment divide for the R. Finn and the north-eastern boundary represent different aquifer types. The topography comprises higher areas cut by E-W aligned river valleys. Elevations range from c.10 mAOD along the lower reaches of the Finn valley to 680 mAOD along the southwest boundary (Bluestack Mountains). Surface water flows to the east. |
| **Geology and Aquifers** | **Aquifer type(s)** | The GWB is dominated by **Pl:** Poor aquifer which is generally unproductive except for local zones (85%), with two main areas of **Pu:** Poor aquifer which is generally unproductive, in west of the GWB – roughly trending SW-NE – and in several small bands. One area of **Ll:** Locally important aquifer, moderately productive only in local zones, is present in the body (7.5 $km^2$). |
| | **Main aquifer lithologies** | Precambrian Quartzites, Gneisses & Schists is the main rock group (>90%) in this GWB, with two areas of Granites & Other Igneous Intrusive Rocks encompassing: 4.5% of the GWB underlying the Bluestack Mountains along the south-western boundary; 2.2% along the northwest boundary. There are also small areas/bands of Precambrian Marbles. Refer to Table 1 for more details. |
| | **Key structures** | The rocks in this part of Donegal have been significantly deformed, resulting in a large number of approximately SW-NE faults (e.g. Belshade Fault). There are also a number of anticline and syncline folds in the GWB resulting in the rocks dipping in all directions between 25-85°. |
| | **Key properties** | Well yields in the Precambrian Quartzites, Gneisses & Schists range from 10-218 $m^3/d$ with 3 of the 4 wells discharging <35 $m^3/d$. Although there are no specific capacity or transmissivity data for the GWB, they are likely to be low, with the possibility of higher values in faulted zones, especially in the coarser-grained rocks (quartzites and gneisses). Typical specific dry weather flows for this rock group across Donegal are low (0.41-1.1 $l/s/km^2$ at 5 stations), indicating that these aquifers have low storativity (expected to be <1%, possibly c.0.5%).<br>All available groundwater levels (18) are 0-15 m below ground level, with 88% <3 mbgl. Although the data are inadequate to calculate groundwater gradients, these are expected to be greater than 0.01.<br>*(Precambrian Aquifer Chapter; Donegal GWPS)* |
| | **Thickness** | Most groundwater flux is expected to be in the uppermost part of the aquifer comprising a broken and weathered zone typically less than 3 m thick, a zone of interconnected fissuring 10-15 m thick, and a zone of isolated poorly connected fissuring typically less than 150 m. Deeper water strikes are noted at 50 and 76 mbgl, although yields are low. |
| **Overlying Strata** | **Lithologies** | The GWB is predominantly covered by peat (c.50%), with a lesser proportion of till (35%). Just under 10% is recorded as rock outcrop/shallow rock. |
| | **Thickness** | From the Donegal GWPS, subsoil is absent or thin over the higher areas i.e. to the west of the GWB and between valleys. Deposits become thicker (>3 m) to the east, with the deepest deposits limited to the centre of river valleys (5-10 m). |
| | **% area aquifer near surface** | *[Information will be added at a later date]* |
| | **Vulnerability** | The majority of this GWB is classified as Extremely vulnerability, due to the high percentage of thinner subsoil and rock outcrops. Where subsoil is thicker, such as in the valleys, the vulnerability is mainly High, with occasional small areas of Moderate. |
| **Recharge** | **Main recharge mechanisms** | Diffuse recharge occurs via rainfall percolating through the thinner/more permeable subsoil and rock outcrops. Due to the low permeability of the thicker peat deposits and the aquifers, a high proportion of the effective rainfall will quickly discharge to the streams in the GWB. In addition, the steep slopes in the upland areas promote surface runoff. The relatively high stream density is likely to be influenced by the lower permeability rocks. |

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| | **Est. recharge rates** | *[Information will be added at a later date]* |
| **Discharge** | **Springs and large known abstractions** | Sources: None identified.<br>Springs: None identified.<br>Excellent wells: None identified.<br>Good wells: 218 m³/d (Fintown). |
| | **Main discharge mechanisms** | The main groundwater discharges are to the rivers and streams crossing the GWB, reflecting short groundwater flow paths. Small springs and seeps are likely to issue at the stream heads and along their course. |
| | **Hydrochemical Signature** | No data are available within this particular GWB.<br>***National classification:*** Non-calcareous with bi-modal alkalinity distribution, although the higher range is possibly caused by thin bands of marble.<br>Alkalinity (mg/l as $CaCO_3$): range of 14-400; mean of 168 (41 'non limestone subsoils' data points)<br>Total Hardness (mg/l): range of 46-412; mean of 200 (39 'non limestone subsoils' data points)<br>Conductivity ($\mu$S/cm): range of 160-752; mean of 446 (45 'non limestone subsoils' data points)<br>*(Calcareous/Non calcareous classification of bedrock in the Republic of Ireland report)* |
| **Groundwater Flow Paths** | | In the absence of inter-granular permeability, groundwater flow is expected to be concentrated in upper fractured and weathered zones and in the vicinity of fault zones. Of the 18 groundwater levels available, 88% <3 mbgl. Unconfined groundwater flow paths are short (30-300 m), with groundwater generally following the topography and then discharging rapidly to seeps, small springs and streams. Only 2 water strikes are recorded marginally deeper than the estimated interconnected fissure zone, suggesting a component of deep groundwater flow, however the yields of these wells are low and shallow flow is thought to be dominant. Overall, groundwater flow is eastwards, as determined by topography. |
| **Groundwater & surface water interactions** | | The predominantly shallow groundwater is likely to discharge rapidly to surface waters however, the baseflow proportion of total streamflow is expected to be small, as suggested by the regional specific dry weather flow data. Owing to the poor productivity of the aquifers in this body it is unlikely that any major groundwater - surface water interactions occur. |
| **Conceptual model** | | • All GWB boundaries are topographic divides, except to the north-east, which is a change in aquifer type. The topography increases in elevation from east to west, and is generally hilly to mountainous. The areas is incised by large, parallel, W-E trending valleys.<br>• The GWB is composed primarily of low transmissivity rocks. Most of the groundwater flux is likely to be in the uppermost part of the aquifer comprising: a broken and weathered zone typically less than 3m thick; a zone of interconnected fissuring 10-15m thick; and a zone of isolated fissuring typically less than 150m.<br>• Recharge occurs diffusely through the subsoil and rock outcrops, although is limited by any thicker pockets of peat and the low permeability bedrock. Therefore, most of the effective rainfall is not expected to recharge the aquifers.<br>• Flow paths are likely to be short (30-300 m) with groundwater discharging rapidly to the streams crossing the aquifer, and to small springs and seeps. Overall, the flow direction is towards the east. |

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| **Attachments** | Figure 1. Table 1. |
| **Instrumentation** | **Stream gauge**: 01042, 01043, 01044, 01070.<br>**EPA Water Level Monitoring boreholes:** None identified.<br>**EPA Representative Monitoring boreholes:** None identified. |
| **Information Sources** | Lee M. and Fitzsimons V. (2004). *County Donegal Groundwater Protection Scheme.* Main Report. Draft Report to Donegal County Council. Geological Survey of Ireland 58pp.<br>Long, C.B. and McConnell (1999) *Geology of South Donegal: A geological description, to accompany bedrock geology 1:100,000 scale map, Sheet 3, South Donegal*. With contributions by G.I. Alsop, P. O'Connor, K. Carlingford and C. Cronin. Geological Survey of Ireland, 116pp.<br>O' Riain, G. 2004. *Water Dependent Ecosystems and Subtypes (Draft)*. Compass Informatics in association with National Parks and Wildlife (DEHLG). WFD support projects. |
| **Disclaimer** | Note that all calculation and interpretations presented in this report represent estimations based on the information sources described above and established hydrogeological formulae |

**Figure 1. Location and Boundaries of GWB.**

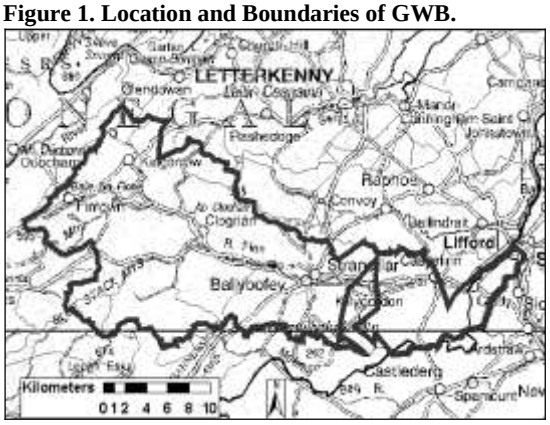


**Table 1. List of Rock units in GWB**

| **Rock Unit Name** | Code | Description | Rock Unit Group | **Aquifer Class.** | % Area |
|---|---|---|---|---|---|
| Lough Eske Psammite Formation | LE | Feldspathic psammite; quartzite, marble | Precambrian Quartzites, Gneisses & Schists | Pl | 20.75% |
| Mullyfa and Deele Formations | MF | Psammite, pebble beds, marble, schist | Precambrian Quartzites, Gneisses & Schists | Pl | 11.85% |
| Termon Formation | TE | Banded semi-pelitic & psammitic schist | Precambrian Quartzites, Gneisses & Schists | Pl | 11.13% |
| Boultypatrick (Grit) Formation | BO | Psammite, graphitic clasts/beds, pebbles | Precambrian Quartzites, Gneisses & Schists | Pl | 9.08% |
| Croaghubbrid Pelite Formation | CH | Graphitic pelite, thin psammite, marble | Precambrian Quartzites, Gneisses & Schists | Pu | 8.49% |
| Lough Mourne Formation | LM | Quartz & feldspar pebbles, green matrix | Precambrian Quartzites, Gneisses & Schists | Pl | 7.46% |
| G2 variety | BaG2 | main granite (adamellite) | Granites & other Igneous Intrusive rocks | Pl | 4.35% |
| Upper Falcarragh Pelite Formation | UF | Pelitic, semi-pelitic, psammitic schist | Precambrian Quartzites, Gneisses & Schists | Pu | 2.98% |
| Upper Crana Quartzite Formation | UC | Psammitic schist with pebbly grit beds | Precambrian Quartzites, Gneisses & Schists | Pl | 2.76% |
| Slieve Tooey Quartzite Formation | ST | Whitish quartzite with pebble beds | Precambrian Quartzites, Gneisses & Schists | Pl | 2.51% |
| Gaugin Quartzite Formation | GA | Pale quartzite, pebble beds, rare schist | Precambrian Quartzites, Gneisses & Schists | Pl | 2.45% |
| Claudy Formation | CY | Psammite, pebbly grit, quartzite, marble | Precambrian Quartzites, Gneisses & Schists | Pl | 2.15% |
| Main Donegal Granite | MdGr | Coarse biotite granite & granodiorite | Granites & other Igneous Intrusive rocks | Pl | 2.08% |
| Knockletteragh Member | TEkg | Pebbly grits | Precambrian Quartzites, Gneisses & Schists | Pl | 1.61% |
| G3 varieties of sheet complex | BaG3 | Leucogranite and porphyritic aplogranite | Granites & other Igneous Intrusive rocks | Pl | 1.44% |
| Glencolumbkille Pelite Formation | GP | Black graphitic pelitic schist | Precambrian Quartzites, Gneisses & Schists | Pu | 1.33% |
| Reelan Formation | RE | Calc schist, pale marble and quartzite | Precambrian Quartzites, Gneisses & Schists | Pl | 1.25% |
| Sessiagh-Clonmass Formation | SC | Quartzite, dolomitic marble & schist | Precambrian Quartzites, Gneisses & Schists | Pl | 1.22% |
| Killeter Quartzite Formation | KT | Slightly impure quartzite | Precambrian Quartzites, Gneisses & Schists | Pl | 0.85% |
| Loughros Formation | LO | Quartzite with semi-pelitic schist | Precambrian Quartzites, Gneisses & Schists | Pu | 0.82% |
| Lower Crana Quartzite Formation | LC | Psammitic schist, some marble beds | Precambrian Quartzites, Gneisses & Schists | Pl | 0.75% |
| Tectonic schist | ts | Mylonitic | Precambrian Quartzites, Gneisses & Schists | Pl | 0.74% |
| Aghyaran & Killygordon Limestone Formtns | DG | Marble, quartzite, psammite; graphitic | Precambrian Marbles | Ll | 0.67% |
| Metadolerite | Md | Hornblendic and sometimes schistose | Precambrian Quartzites, Gneisses & Schists | Pl | 0.37% |
| G1 variety - Cronamuck Granodiorite | BaG1 | Medium/fine porphyritic granodiorite | Granites & other Igneous Intrusive rocks | Pl | 0.23% |
| Croveenananta Formation | CV | Schist, calc schist, quartzite & marble | Precambrian Quartzites, Gneisses & Schists | Pl | 0.22% |
| Microgranite and related rocks | mGr | Porphyritic & non-porphyritic sheets | Granites & other Igneous Intrusive rocks | Pl | 0.18% |
| Appinite suite | Ap | undifferentiated | Granites & other Igneous Intrusive rocks | Pl | 0.09% |
| Glencolumbkille Limestone Formation | GL | Dolomitic marble & semi-pelitic schist | Precambrian Marbles | Pl | 0.06% |
| Port Askaig Formation | PA | Diamictite, schist & quartzite | Precambrian Quartzites, Gneisses & Schists | Pu | 0.05% |
| Falcarragh Limestone Formation | FL | Blue-grey banded marble, pelite partings | Precambrian Marbles | Ll | 0.03% |
| Cranford Limestone Formation | CR | Quartzite breccia & marble | Precambrian Marbles | Pl | 0.03% |
| Metavolcanic green bed | vg | Metavolcanic green bed | Precambrian Quartzites, Gneisses & Schists | Pl | 0.01% |
| Marble unit | DGmb | Marble-rich unit | Precambrian Marbles | Ll | 0.01% |
| Quartzite | qz | Quartzite | Precambrian Quartzites, Gneisses & Schists | Pl | 0.01% |

Quarries National Joint Advisory Committee (QNJAC)

# Geotechnics, Face & Stockpile Operations

***Information Sheet 1***

June 2009

## *Guidance on*
## *Safe Face Management Operations in Quarries*

Approved by the Quarries National Joint Advisory Committee (QNJAC) – Version 1: 22 June 2009










**Kaolin and Ball Clay Association (UK)**






# GUIDANCE ON SAFE FACE MANAGEMENT OPERATIONS IN QUARRIES

## PREFACE

The guidance in this Information Sheet has been endorsed by the Quarries National Joint Advisory Committee (QNJAC). Following this guidance is not compulsory and you are free to take other action. Health and Safety Inspectors seek to secure compliance with the law and may refer to the contents of this Information Sheet as illustrating good practice.

## INTRODUCTION

1. Faces in quarries need managing and may need to be maintained to control or remove loose material or overhangs, for example after blasting or due to the effects of weathering and/or erosion. This Information Sheet gives guidance to those who have control of working quarries on how to ensure safety during face management operations. The guidance will also be of value to managers, supervisors, contractors, health and safety specialists, the workforce and their representatives.

2. This guidance should be read in conjunction with The Quarries Regulations 1999 and Approved Code of Practice "*Health and safety at quarries".* Nothing in this guidance should take precedence over specific advice from Geotechnical Specialists, whose Geotechnical Assessment(s) should be incorporated into the Quarry Design and 'Excavations and Tips Rules'.

## HAZARDS and RISKS

3. It should be presumed that maintenance of rock faces will be necessary in quarries where blasting takes place.

4. Failure to manage faces where a Risk Assessment (being an assessment recorded as part of the health and safety document and required by Regulation 7 of The Quarries Regulations 1999) has identified the need to do so, increases the risks from hazards, which include loose materials falling onto people and plant below. It may also result in an inability to establish a safe stand-off zone at the crest. Where blasting is required, controls must be in place to ensure that a solid, stable face is exposed for the purpose of blast design to prevent associated risks from hazards such as fly rock. Account should also be taken of any changes that could occur in unsupported faces, particularly when re-visiting older faces during quarry development.

5. During face operations the workforce may be exposed to falling materials or to overturning plant if the work is not properly planned and the plant properly positioned and protected, for example by the use of Falling Object Protective Structures (FOPS) and Roll-Over Protective Structures (ROPS). Operators should not rely on FOPS cabs when assessing the level of protection necessary to take into account falling rock and should take into account the relevant standards for such protection.

6. There is also the potential of falls from height, most significantly from the crest or rock pad from which an excavator may operate, and risks arising from slips and trips.

## SAFE METHODS OF WORKING: FACTORS TO CONSIDER

7. When working quarry faces the following should be considered:

    a) Has the Geotechnical Assessment identified planar, wedge, toppling, rotational or any other type of in-bench failure mechanism or rock fall?
    b) Is a rock trap required? If so, has it been incorporated into the Quarry Design and 'Excavations and Tips Rules'?
    c) Does material at the top of the face need to be within the reach or capture capability of the excavator/loader?
    d) Is the excavator/loader always in a safe position, for example is the cab outside of the rockfall / sand engulfment zone?
    e) Is the excavator/loader capable of controlling the largest rock?
    f) Are the excavator/loader, loading pad/platform and rock pile stable?
    g) Is the bench wide enough for loading and long-term maintenance operations including access, drainage, scaling, stand-offs, edge protection and rock traps where needed?
    h) Have faces, benches and stand-offs been designed stipulating widths, heights and angles, and size and type of excavator/loader?
    i) Is the crest susceptible to 'back-break' following blasting operations?

**The objective in maintaining quarry faces is to remove all significant loose material and rocks within the face to prevent danger and to establish a solid, stable rock face. Rocks should be dislodged so that they either fall safely in a controlled manner into the rock trap or are removed in the bucket of the machine**

## ESTABLISHED SAFE METHODS OF WORKING

8. The working methods described below have an established good safety record. A benefit of adopting either of these methods is that this allows a decision to be made in advance concerning the matching of face heights to the plant available to ensure safe working:

    a) In the case of a $360^0$ backacter excavator, the machine selected should be able to reach the face crest from a safe position with a suitably designed rock trap in place. A Site-specific Risk Assessment will determine the actual design of the rock trap but as a rule of thumb it might be expected to be ⅛ of the face height in depth and ¼ of the face height in width *(see diagram below)*.

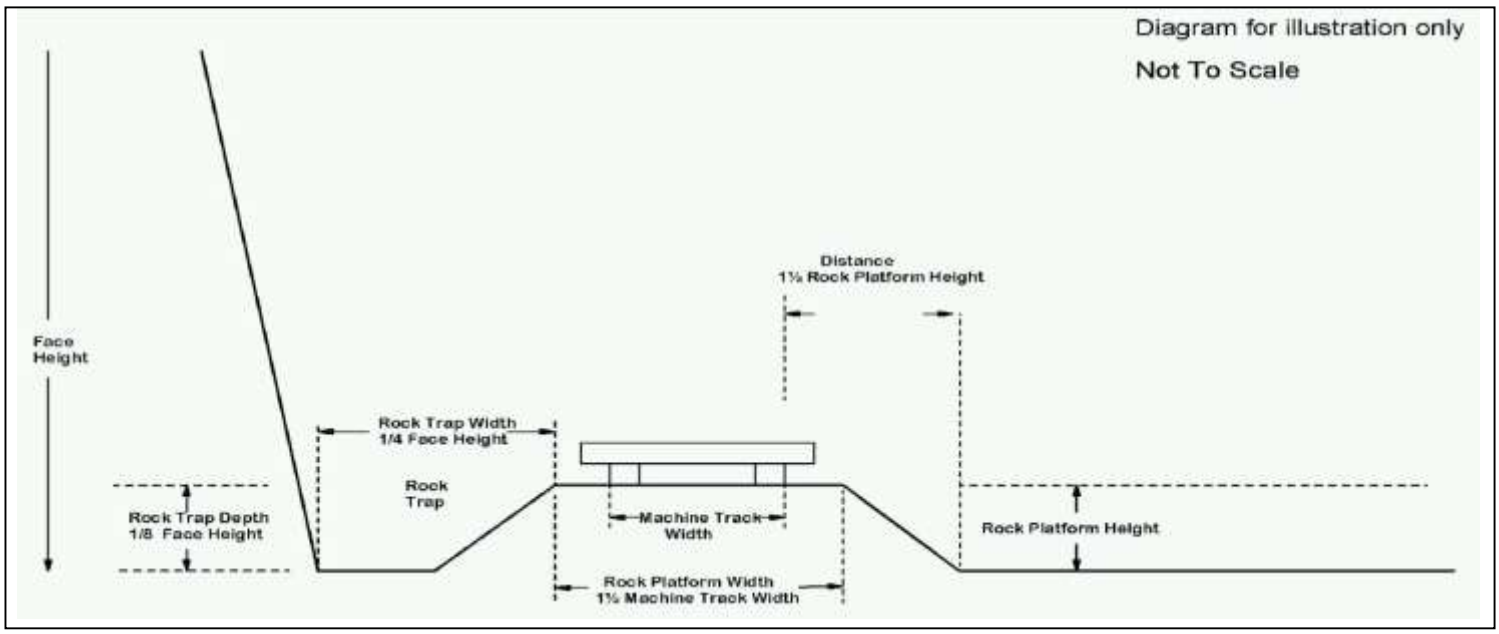
Diagram for illustration only
Not To Scale
Face Height
Distance 1¼ Rock Platform Height
Rock Trap Width 1/4 Face Height
Rock Trap
Rock Trap Depth 1/8 Face Height
Machine Track Width
Rock Platform Height
Rock Platform Width 1¼ Machine Track Width

b) In the case of a wheeled loader or $360^0$ face shovel working from the quarry floor, the crest should be within the safe reach or capture capability of the machine if no other working procedure is available to manage the face above the reach of the machine.

9. Where quarry operators have chosen to adopt either of the above methods they should ensure that:

a) the factors referred to in paragraph 7 have been taken into account
b) the specific requirements are contained within the 'Excavations and Tips Rules', which must be communicated to the workforce
c) the design parameters of the quarry are maintained
d) the working method is supervised, monitored and reviewed

10. Should it be necessary or desirable to operate outside of the above methods, even temporarily, then the guidance in the following section should be considered.

**SAFE METHODS OF WORKING: *ADDITIONAL CONSIDERATIONS***

11. Where the way in which the quarry has been developed makes either of the above methods impracticable, then any alternative method will need to be based on a Geotechnical Assessment which justifies the chosen method of working. This may identify the need for more specialist plant and associated operator competencies, and will almost certainly require greater managerial and workforce involvement in planning and monitoring the chosen method.

12. This guidance cannot deal adequately with all the complexities that the Geotechnical Assessment might identify, or the precautions that the adopted methods might need to cover, but the following summary suggests possible broad scenarios that may arise:

a) The Geotechnical Assessment, or routine inspections (i.e. inspections in accordance with the written scheme required by Regulation 12 of The Quarries Regulations 1999), identify that no face maintenance is necessary (at least in the short term) and face operations can continue.

b) the Geotechnical Assessment, or routine inspections, identify that face maintenance is necessary, the existing plant on site does not have sufficient reach from below and from a safe position to undertake this, but plant with sufficient reach from a safe position can be hired in to undertake the work;

c) The Geotechnical Assessment, or routine inspections, identify that face maintenance is necessary, but the quarry operator is not able to access plant with sufficient reach from below and from a safe position to undertake the work.

Where this occurs, face maintenance may be undertaken from the crest in accordance with a procedure detailed in the 'Excavations and Tips Rules' supported by a Geotechnical Assessment. A key requirement of this procedure will be the identification of a safe stand-off zone at the crest and toe to prevent unauthorised access into these zones, and the full involvement of all relevant workers. This method should be the exception due to the additional risks which have to be controlled and, where practicable, the quarry design should address how the above alternative methods (see paragraph 8(a) and (b)) can be implemented in accordance with documented timescales.

13. Any decisions taken must be consistent with the 'Excavations and Tips Rules', communicated to the relevant workers, and the quarry operator must provide sufficient managerial/supervisory attention to monitor the working methods.

## GEOTECHNICAL SPECIALISTS AND QUARRY DESIGN PLANS

14. Face maintenance methods will depend upon a number of factors including the type of mineral being worked, topography, geotechnical issues, blast design, availability of plant and the competency of personnel, including plant operators. Geotechnical Specialists have a crucial role in helping quarry operators determine suitable methods of face maintenance and formulating quarry designs. The planning of face geometry in a quarry is a strategic quarry design decision and geotechnical advice should be fully considered.

15. The Quarry Design must consider the final faces (including existing, older faces) prior to closure of the quarry. This guidance does not address these matters.

## WORKER INVOLVEMENT

16. This guidance has highlighted the key role that Geotechnical Specialists play in the design and assessment of working quarry faces. Quarry operators are responsible for making and resourcing any decisions made based upon any advice provided. The workforce – employees, their representatives and contractors – has a wealth of practical experience and knowledge to contribute to all aspects of quarry operations including quarry design and methods of working. The workforce can also provide essential feedback on day to day matters such as strata or ground water that could affect face stability. The workforce makes a major contribution to quarry safety. Quarry operators should utilise their capacity to the full and encourage their active participation in managing the risks associated with their work.

End