

Appendix 10.1

Slochd Geodiversity Assessment

Transport Scotland

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Technical Glossary

- Alluvium:* Consists of silt, sand, clay, and gravel and often contains a good deal of organic matter, is unconsolidated (loose and not cemented together) soil or sediments, which has been eroded, reshaped by water in some form, and redeposited in a non-marine setting.
- Amphibolite:* A medium-grained, dark-coloured, regional metamorphic rock composed of hornblende and plagioclase with minor epidote, sphene, biotite, and quartz.
- Biotite:* A black, dark brown, or greenish black micaceous silicate mineral occurring as a constituent in many igneous and metamorphic rocks. A member of the mica group of minerals which have a sheet like crystal structure. The general chemical composition for the biotite group is $K_2(Mg,Fe)_{2-3}Al_{1-2}Si_{2-3}O_{10}(OH,F)_2$.
- Crenulation:* A fabric formed in metamorphic rocks.
- Dalradian:* Series of metamorphic rocks typically developed on high ground to the south east of the Great Glen of Scotland.
- Deglaciation:* The melting (ablation) and receding of ice sheets and glaciers, which uncovers the land beneath.
- Diamicton:* Dia – Greek for two. Term for unsorted, unstratified rock debris that is composed of a fine and coarse particle sizes which is typically associated with glacial deposits.
- Ductile:* Material which can sustain large plastic deformations without fracture, as occurs in metals that are capable of being hammered thin without breaking, or drawn into a thin shape such as a wire.
- Facies:* The characteristics of a rock, such as fossil content, or chemical composition, which distinguish it from other formations and give some indication of the environmental conditions under which it was formed.
- Feldspar:* Group of common rock-forming minerals that all contain aluminum, silicon and oxygen, but with varying proportions of potassium, sodium and calcium. They are essential constituents of igneous rocks.
- Fluvioglacial:* Refer to 'Glaciofluvial'.
- Formation:* The unit used in lithostratigraphy. Specific features distinguish one rock formation from another. A formation can be sub-divided into members, sets and beds.
- Gelifluction:* Seasonal freeze / thaw action on materials on slopes that induces downslope movement.
- Geodiversity:* This term encapsulates the variety of rocks, minerals, fossils, landforms, sediments and soils in an area, together with natural processes, such as erosion and landslips, that may still be active. For example, The River Spey, which carries sand, silt and other sediment eroded from the Grampian Mountains into the Moray Firth, is an example of Grampian's dynamic geodiversity.
- GAP:* Geodiversity Action Plan – a document with objectives, targets, and indicators to measure, maintain or enhance the geodiversity of an area. GAPs often include an audit of the geological features of an area such as but not limited to the geological stratigraphy, structure, geomorphology, paleontology, mineral resources and its anthropological influence.
- GCR:* The Geological Conservation Review, undertaken by the Joint Nature Conservation Committee (JNCC), selected the very best and most representative geological and geomorphological features of Britain. These are features of national and international importance that are considered to qualify for designation as SSSIs. The geological features

selected by the GCR range from rocks, minerals and fossils, to landform features formed during the Ice Age, modern rivers and coasts.

- Geomorphology:* The scientific study of the land-forms on the Earth's surface and of the processes that have fashioned them.
- Glacial:* Relating to a glacier, or a period when ice sheets expand, and global climate is colder and drier, i.e. an ice age.
- Glaciofluvial:* Relates to meltwater coming from a glacier, which creates such features as eskers and kames, outwash plains, pro-glacial lakes, and meltwater channels. Also known as fluvio-glacial.
- Gneiss:* A banded metamorphic rock corresponding in composition to a feldspathic plutonic rock (such as granite).
- Head:* Deposits consisting of fragmented material which have moved downslope through solifluction after having been weathered.
- Hornblende:* Black or green mineral found in igneous and metamorphic rocks. It is the commonest form of amphibole, and contains iron and silicates of calcium, aluminum and magnesium.
- Iapetus Ocean:* An ocean that existed in the late Neoproterozoic and early Paleozoic eras of the geological timescale where the earth's landmasses were in a different configuration from that which they are in now.
- Igneous:* A rock type that is formed through magma or lava cooling and becoming solid.
- Intercalated:* Layering of rock with different characteristics but a very similar deposition.
- Intrafolial fold:* A thinned and modified, tight to isoclinal fold which commonly shows a fold hinge with only vestiges of detached limbs. Such folds are caused by intense deformation which causes bedding to be transposed along zones of shear and solution.
- Intrusions:* A formation of igneous rock that cooled and solidified within the crust of the earth and not at the surface.
- Isoclinal fold:* A fold in which the two limbs are parallel.
- Laminate:* Comprising layers of material.
- LiDAR:* Light Detection and Ranging. LiDAR survey uses the well-established principle of measuring distance by calculating the time taken by a pulse of light to reach a target and return.
- Lineations:* Any linear feature that appears on the surface of a rock.
- Lithology:* The description of the physical properties of a rock that are visible at outcrop, in small samples, or in thin section.
- LGAP:** Local Geodiversity Action Plan - It highlights priorities for, and focuses resources on the conservation and promotion of geodiversity in a region. It can involve a wide range of groups, organisations and individuals who agree priorities and actions for geodiversity in order to make more effective use of the limited resources available.
- Matrix:* The finer grained mass of material in which larger grains, crystals, or clasts are embedded in a rock or superficial deposit.
- Meltwater:* Glacial meltwater is produced by the melting of glacier ice at the surface, or by pressure and geothermal heat at the base, forming subglacial streams.
- Metamorphic:* A rock formed by a change in minerals or texture through changes in temperature, pressure, or volatile content.

- Metamorphism:* The process of changing the characteristics of a rock in response to changes in temperature, pressure, or volatile content.
- Mica:* Group of common rock-forming minerals characterized by a platy or flaky appearance. All contain aluminum, potassium and water; other metals, such as iron and magnesium, may be present. Micas are made up of the muscovite and the biotite groups.
- Migmatite:* Rock composed of a metamorphic (altered) host material that is streaked or veined with igneous rock of granitic composition; the name means “mixed rock.” Such rocks are usually gneissic (banded) and felsic rather than mafic in composition; they may occur on a regional scale in areas of high-grade metamorphism.
- Migmatization:* The process whereby a rock undergoes partial melting during extreme metamorphism, producing a migmatite.
- Montane:* Relating to mountains or mountainous.
- Moraine:* A depositional landform generated directly by a glacier.
- Mylonite:* Rock produced in zones of tectonic dislocation, e.g. fault and shear zones. Mylonite is well laminated and often hard and splintery. The name literally means ‘milled rock’ from the Greek mylon, a grinding mill.
- Orogeny:* Mountain building event, forms when a belt of the Earth's crust is compressed by lateral forces to form a chain of mountains.
- Palaeontology:* The study of fossil flora and fauna. Information thus gained may be used to establish ancient environments and evolutionary lineages.
- Paraglacial process:* The non-glacial earth-surface processes, sediment accumulations, landforms, land systems, and landscapes that are directly conditioned by glaciation and deglaciation.
- Pelite:* An aluminium-rich, metamorphic rock formed by the metamorphism of clay-rich sedimentary rocks, e.g. shales and mudstones.
- Periglacial:* Characteristic of a region adjoining a glacier or ice-sheet affected by the action of freezing and thawing.
- Phyllonite:* A slate-like, dynamic metamorphic rock formed in fault zones and containing a penetrative cleavage orientated parallel to the fault plane. The cleavage is formed by the recrystallization and alignment of sheet silicates during faulting.
- Plagioclase:* Type of feldspar which occurs in igneous and metamorphic rocks. Off-white, or sometimes pink, green or brown, they are composed of varying proportions of the silicates of sodium and calcium with aluminium.
- Plunging fold:* A fold where the axis is not horizontal.
- Psammite:* Metamorphosed sandstone, arkose, or quartzite, extremely rich in the mineral quartz.
- Preglacial:* Before glaciation or before an ice age.
- Quaternary:* Traditionally a sub-era of the Cenozoic Era of geologic time that began approximately 1.8 million years ago and continues to the present day; it can be known as the Pleistocene Period and includes the Pleistocene and Holocene epochs, during which there have been numerous ice-sheet advances in the northern hemisphere.
- Quartz:* Rock-forming mineral, the natural form of silicon dioxide (silica), SiO₂. It is widely distributed, occurring in igneous and metamorphic rocks, clastic sediments and mineral veins. Pure quartz is clear and colourless but the mineral may be coloured by impurities. It is commonly white.

- Reclined fold:* A dipping neutral fold in which the axial plane dips between 10° and 80° and the pitch of the hinge line on the axial plane is more than 80°.
- SSSI:* Site of Special Scientific Interest (SSSI) – legally protected site or area of national or international importance for wildlife and / or geology.
- Sedimentary:* Rock formed through deposition and cementation of materials on the earth's surface and under water.
- Slopewash:* The material transported down a slope by rain.
- Stratigraphic unit:* A body of rock forming a discrete and definable unit.
- Stratigraphy:* A branch of the geology concerned with the study of stratified rocks in terms of time and space. It deals with the correlation of rocks from different localities.
- Structural:* The geometric relationships between and within rock units.
- Synform:* A basin or trough-shaped fold whose younger strata may be above or below older ones.
- Tabular:* Applied to the form of a mineral when it occurs in broad, flat, often rectangular surfaces resembling the top of a table. The form may be due to the presence of a prominent cleavage direction.
- Talus:* Material formed by the accumulation of broken rock debris at the base of cliffs.
- Till:* Sediments laid down by the direct action of glacial ice without the intervention of water.
- Tor:* Large free-standing rock outcrop that rises abruptly from the surrounding gentle slopes of a more rounded summit.
- Unconformity:* Surface of contact between two groups of strata where there is a gap in the formation of geological beds, where older rock beds underlie significantly younger rock beds. This is caused by a break in the geological record due to a combination of erosion and an interruption in sedimentation.

Executive Summary

The Atkins Mouchel Joint Venture (AMJV) is advancing the A9 Dualling Northern Section through the Design Manual for Roads and Bridges (DMRB) Stages 2 and 3. The Northern Section includes the 25km Dalraddy to Slochd scheme. Much of the Dalraddy to Slochd scheme is located in the Cairngorms National Park.

The special qualities of Britain's National Parks include their geology and geography. These are both intrinsic components of Geodiversity; the variety of rocks, fossils, minerals, natural processes, landforms and soils that underlie and determine the character of our landscape and environment.

Slochd Summit forms the entrance to the Cairngorms National Park. Extensive engineering will be required to facilitate dualling through this area therefore it was concluded that there would be merit in undertaking a more detailed appraisal of the geodiversity of this area.

Slochd extends from the road bridge at Slochd Beag that crosses the Highland Main Line railway and the U2400 to Slochd Summit. It is a high and exposed mountain pass that is characterised by exposures of natural rock and manmade cuttings in rock. This area includes the Slochd Geological Conservation Review (GCR) site which is of interest due to the bedrock geology.

The geology at Slochd is ancient and complex. The bedrock has been disturbed by multiple phases of deformation which has given rise to a complex structure. The superficial geology is dominated by glacial deposits. Over a relatively small area a wide variety of superficial deposits are represented from peat to talus. Slochd is an area of active geomorphological processes.

The AMJV has identified several features which are considered to be of key geodiversity value at Slochd. These are:

- Geoheritage
 - Rock cuttings.
- Geomorphology
 - Slochd Mor rock slopes.
 - Slochd meltwater channel.
- Superficial geology
 - Assemblage of superficial deposits.
- Bedrock geology
 - Non-gneissose rocks and the contact with gneissose rocks.
 - Rockhead profile.

This assessment has shown that the features that are of geodiversity interest extend beyond the Slochd GCR site and encompass more than simply the bedrock geology. Dualling the A9 through Slochd will result in some diminishment in the geodiversity value of some of these features; however, it is concluded that the geodiversity value of many is likely to be enhanced as a result of dualling. Further steps may be taken, such as engagement with local communities, in order to ensure that the geodiversity is fully realised. It is considered that A9 dualling at Slochd represents an opportunity to learn more about the geomorphology and geology. This can be achieved through advance works such as Ground Investigations as well as through the construction process itself. The geodiversity value of the features identified above is likely to increase as more is learned about them.

1. Introduction

1.1 Background

- 1.1.1 As part of the Scottish Government's Infrastructure and Investment Plan 2011, a commitment has been made to complete the dualling of the A9 trunk road between Perth and Inverness by 2025. The A9 forms an important part of the trunk road network and is a strategic link between Perth and Inverness, which is vital to the economy of the north of Scotland.
- 1.1.2 Atkins Mouchel Joint Venture (AMJV) was appointed by Transport Scotland (TS) to advance the design of the Northern Section from Dalraddy to Inverness through Design Manual for Roads and Bridges (DMRB) Stages 2 and 3. The Northern Section comprises two schemes that require upgrade to dual carriageway: Dalraddy to Slochd which is approximately 25km in length, and Tomatin to Moy which is approximately 9.5km long.
- 1.1.3 Most of the Dalraddy to Slochd scheme falls within the Cairngorms National Park (CNP), with Slochd Summit forming CNP's northern gateway. A National Park is protected for its beautiful landscape, wildlife, and cultural heritage. Landscape, people, and their cultural heritage are linked through geodiversity. All National Parks in Scotland, Wales, and England have an aim and purpose to promote understanding of the "special qualities" of their area. The special qualities of National Parks include there:
- Landscape and views.
 - Geology and geography.
 - Biodiversity and rare species.
 - Archaeology and history.

1.2 Geodiversity in Scotland

- 1.2.1 Geodiversity is the variety of rocks, fossils, minerals, natural processes, landforms and soils that underlie and determine the character of our landscape and environment. It is considered that geodiversity influences the way we live, the resources we need and use, and how the world changes around us.
- 1.2.2 The importance of geodiversity, particularly in the Scottish context, is described in Scottish Natural Heritage (SNH) Commission Report No. 417 "Scotland's geodiversity: development of the basis for a national framework" which was published in 2011 (Reference 1) and cited the following as the importance and benefit of geodiversity to Scotland:
- Achieving the Scottish Government's Strategic Objectives (for a smarter, safer and stronger, wealthier and fairer, greener, and healthier Scotland) and National Outcomes.
 - Achieving SNH's Corporate Strategy and strategic priorities which link to the Government's Strategic Objectives.
 - Implementation of an integrated approach to conservation across a variety of sectors.
 - Linking the earth, its people, and their culture as exemplified by the Global Geoparks Network.
 - Strategies for managing the impact of climate change on landscapes.

- 1.2.3 2011 also saw the establishment of the Scottish Geodiversity Forum. Promotion and raising the profile of Scotland's geodiversity is the Forum's aim. In doing so, the Forum seeks to influence national and local policies. The Scottish Geodiversity Forum is Scotland's national forum for promoting "the role and value of geodiversity in education, community involvement and health, the development of tourism and the wider economy" (Reference 2).
- 1.2.4 In 2012, the Scottish Geodiversity Forum launched Scotland's Geodiversity Charter. The signatories to the Charter include the Cairngorms National Park Authority. The Charter signatories' vision is that geodiversity be "recognised as an integral and vital part of our environment, economy, heritage and future sustainable development, to be safeguarded and managed appropriately for this and future generations". Scotland's Geodiversity Charter was relaunched in 2017 to cover the period from 2018 to 2023 (Reference 3). The Cairngorms National Park Authority remains a signatory to this relaunched Charter.
- 1.2.5 Scotland's Geodiversity Charter suggests actions for the following sectors that will enable the signatories' vision to be realised such that Scotland continues to benefit from its geodiversity:
- Individuals and communities.
 - Land owners and managers and Non-Governmental Organisations.
 - Developers, industry and business.
 - Local authorities, public agencies and government departments.
 - Education and research.

1.3 Geodiversity and the A9 dualling

- 1.3.1 Scotland's Geodiversity Charter states that developers, industry, and the business sector should seek to "ensure that new developments aim to maintain and enhance geodiversity and provide long-term, safe access to local sites of interest for education and enjoyment". It was therefore considered appropriate for the AMJV to consider the A9 dualling in the context of geodiversity.
- 1.3.2 It is recognised that there is geodiversity interest throughout the Dalraddy to Slochd and Tomatin to Moy schemes. The impact that dualling may have on the geodiversity of these schemes is considered as part of the Environmental Statement. Noting the significance of Slochd Summit as the entrance to the Cairngorms National Park and the extensive engineering that will be required to facilitate dualling through this area it was concluded that there would be merit in undertaking a more detailed appraisal of the geodiversity of this area.
- 1.3.3 This assessment will:
- Introduce the area of interest around Slochd.
 - Describe the geomorphology and geology of Slochd.
 - Discuss the geodiversity at Slochd.
 - Consider potential enhancements to the geodiversity.

2. Site Setting

- 2.1.1 This assessment is focused on the geodiversity of the A9 around the Slochd area as shown on Drawing 1. Whilst the assessment focuses on the geodiversity features along the dualling corridor, it also has considered the geodiversity outside of the corridor to put it into context. Geodiversity features and their many attributes should be contextualised and so assessed as part of their regional and local system.

2.1 Location

- 2.1.1 In context of AMJV's work on the A9 dualling, Slochd is considered to extend from the Slochd Beag structure at Chainage 21,800 (Grid Reference NH 85170 23887) to Slochd Summit at Chainage 24,400 (NH 83495 25659) which represents the northern extent of the Dalraddy to Slochd scheme. This assessment covers an area that extends approximately 0.5 km to the north east and south west of the A9 at Slochd. The approximate study area is shown on Drawing 1.

2.2 Description

- 2.2.1 Slochd is a high and exposed mountain pass in Strathspey. In the 17th century, General Wade's military road was constructed through the narrow pass (Reference 4). At present, three transportation corridors weave through Slochd: the A9 which partially follows General Wade's route, the Highland Main Line, and National Cycle Network (NCN) Route 7 which follows the route of the old A9.
- 2.2.2 At Slochd Beag the A9 is carried on a bridge over a narrow, deep gorge and two transportation routes: the Highland Main Line railway and the U2400 road (Figure 1). The Highland Main Line runs along the base of this valley, sweeping towards the west before curving towards the north and Slochd Summit. The minor road, U2400, crosses above the Highland Main Line before following the approximate level of the 420m to 430m contour around the base of Carn nam Bain-tighearna (Figure 2 and Figure 3). Through this area the U2400 forms part of NCN 7.
- 2.2.3 Between Slochd Beag and the area of Slochd Mor, the A9 is on sidelong ground on the steep, smooth flanks of Carn nam Bain-tighearna (
- 2.2.4 Figure 4). Aside from the heather cover these slopes are largely bare. In places patches of head is visible. Below and to the west of the A9 the valley floor opens. Between the A9 and the Highland Main Line, the valley floor is largely covered with deciduous woodland and pockets of rough grazing. A small watercourse runs through the valley and converges with the Allt Ruighe an t-Sabhail before flowing towards the south.
- 2.2.5 At Slochd Mor the A9 is carried on embankment over a large hollow (Figure 5). The hillside gives way to a steep and rugged slope with exposed crags (Figure 6). The locally significant feature, the Soldier's Head can be seen on the southern part of these crags (Figure 7). There is significant build-up of scree at the toe of this steep, natural rock slope (Figure 8). The ephemeral watercourse, Sputan Dubha, issues as a waterfall down these slopes following rainfall or snow melt.
- 2.2.6 Towards Slochd Summit the A9, the Highland Main Line, and NCN 7 weave through a narrow gap between Carn nam Bain-tighearna and Tòrr Mòr (Figure 9). The transport corridors are characterised by rock faces, exposed due to manmade cuttings formed to accommodate the infrastructure. Rockfall protection mesh covers most of the cut face

beside the southbound lane of the A9 (Figure 10). Similarly, there has been extensive use of netting in the railway cutting.

2.2.7

Both hillsides are covered with dense heather. A watercourse drains from Carn nam Bain-tighearna and down under the rockfall meshed face beside the A9. Although not shown on maps, this watercourse is clearly identified on the ground and in aerial photos (Figure 11).



Figure 1 View to the southeast of the Slochd Beag structure with the U2400 below



Figure 2 View to south west of the Highland Main Line from the U2400.



Figure 3 View to the west of the U2400 bridge over the Highland Main Line with the A9 above.

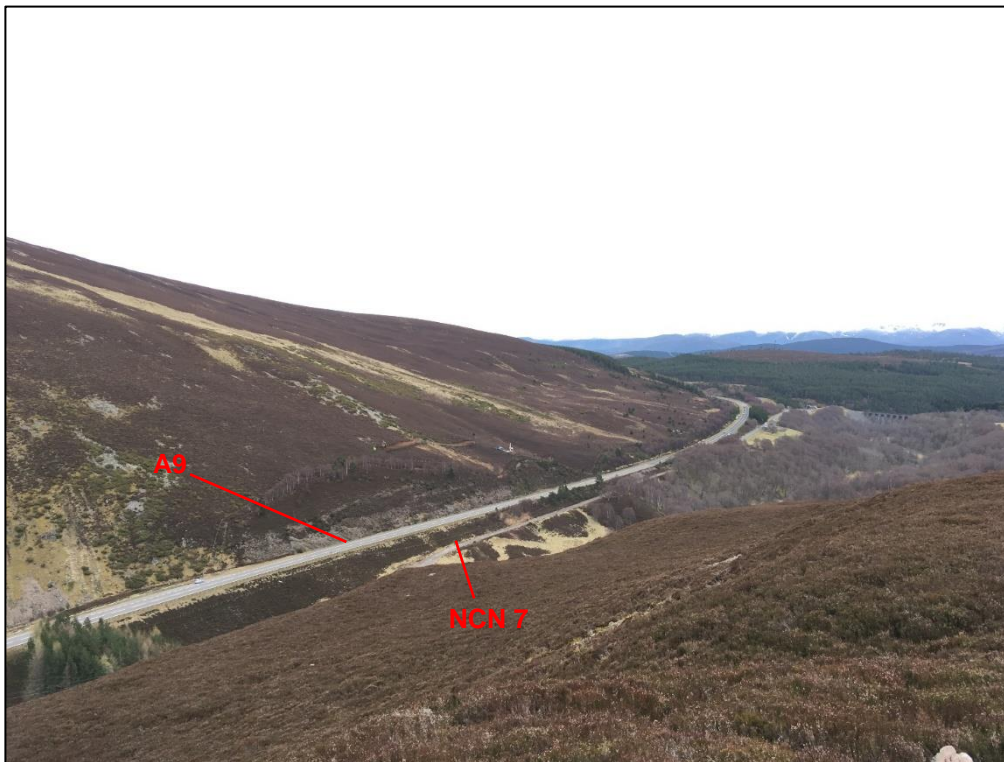


Figure 4 View to the southeast of the slopes of Carn nam Bain-tighearna. The A9, Highland Main Line, and NCN 7 are all visible.



Figure 5 View to the northwest of the glacial hollow at Slochd Mor and the embankment that the A9 is carried upon.



Figure 6 View to the southeast of the natural rock slopes above the hollow at Slochd Mor.



Figure 7 View to the east of the A9 of the Soldier's Head at Slochd Mor.



Figure 8 View to the southeast of the scree below the natural rock slopes at Slochd Mor.



Figure 9 Looking southeast from Slochd Summit. The A9, Highland Main Line, and NCN 7 converge at this point.



Figure 10 View southeast of the cutting at Slochd Summit with rockfall protection mesh.

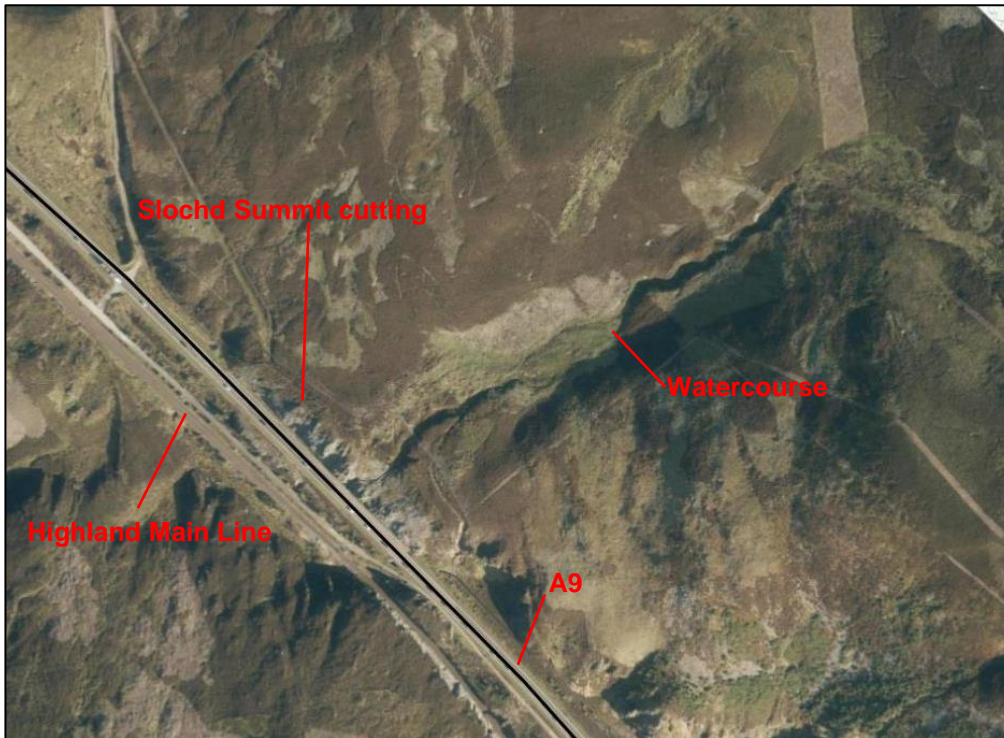


Figure 11. Aerial photography showing the stream system above the rock cutting at Slochd Summit.

2.3 Designations at Slochd

2.3.1 A number of locations within the study area have been designated for their particular characteristics. These designations are discussed below.

International Designations

2.3.2 At Slochd there are no protected areas with an international designation.

National Designations

2.3.3 There are two protected areas with a national designation at Slochd. Additionally, there is a third location that should be considered as having a candidacy designation.

Cairngorms National Park

2.3.4 Most of the Slochd area is located within the boundaries of the Cairngorms National Park. The boundary of the National Park is at Slochd Mor, as shown on Figure 12. While it does not fall within the jurisdiction of the National Park, it is noted that Slochd Summit is significant as the northern gateway to the Park.

Allt na Feithe Sheilich SSSI

2.3.5 A geological Site of Special Scientific Interest (SSSI) is located near the summit of Carn nam Bain-tighearna: Allt na Feithe Sheilich (Figure 13). At approximately 900m from the A9 it falls outside of the detailed study area; however, this site offers a significant contribution to the wider geodiversity value at Slochd. Allt na Feithe Sheilich was designated as a site for Quaternary geology and geomorphology as research at this location has enabled interpretation of the local and regional Holocene vegetational

history of the Highlands. This is a large area of blanket bog and the peat sequence contained is one of the oldest in Britain. (Reference 5)

The Slochd GCR

- 2.3.6 A Geological Conservation Review (GCR) site is located within the study area and is referred to as The Slochd. This GCR site has been important in developing ideas and understanding of the bedrock geology in older strata in the Northern Grampian Highlands. The extents of the GCR site is shown on Figure 13. Much of the bedrock exposures in the GCR site are scattered outcrops or in stream sections; however, the rock cuttings at Slochd Summit forms a large exposure which has been studied in detail. (Reference 6). It is understood that while this GCR site has not been notified as a SSSI, it should be treated as a Candidate SSSI due to its national importance (Reference 7).

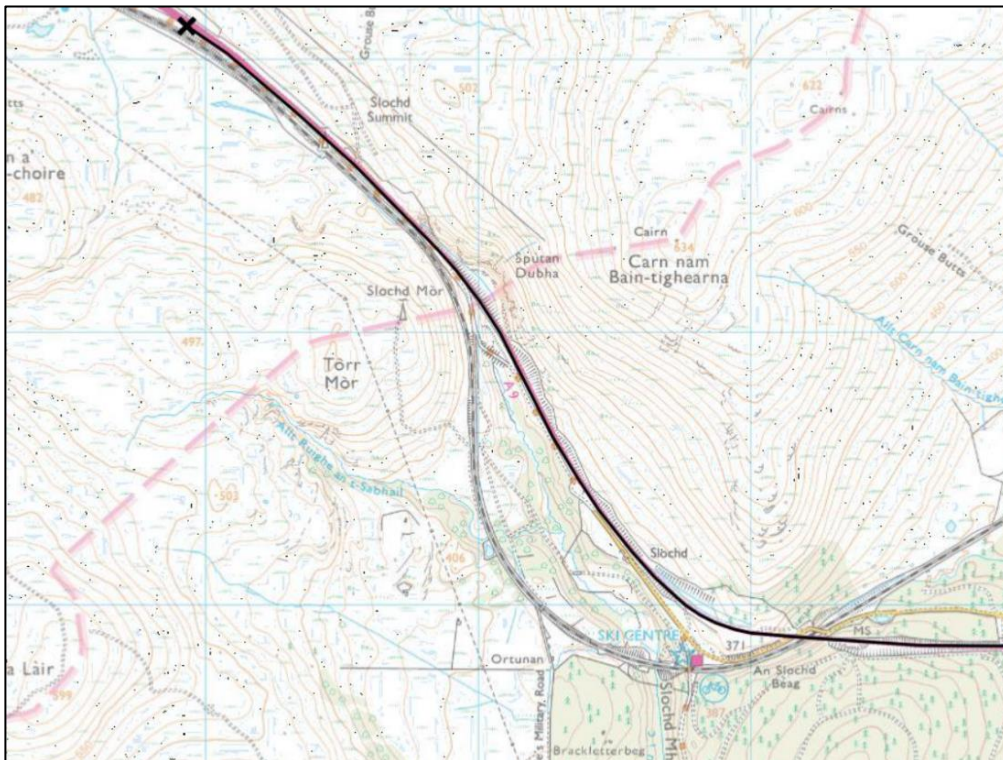


Figure 12 Boundary of the Cairngorms National Park (pink dashed line). Slochd is widely termed the "Northern Gateway" to the National Park.

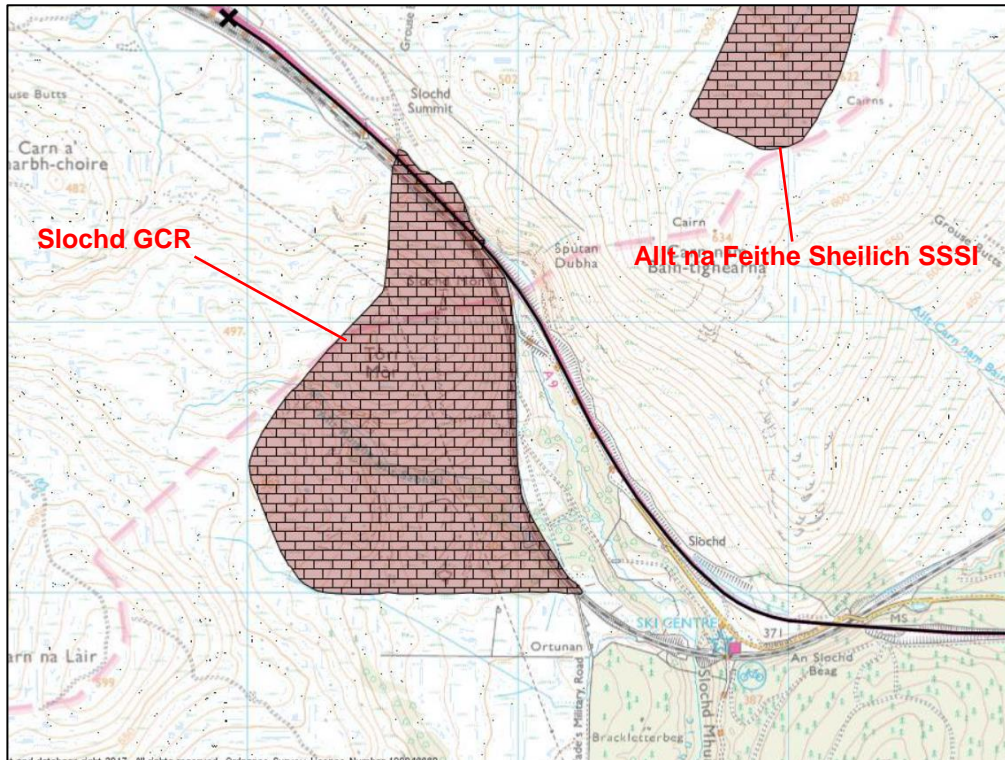


Figure 13 Extents of the Slochd GCR site. Note that part of the Allt na Feithe Sheilich SSSI is also shown.

Local Designations

2.3.7 There are no protected areas with local designations in the study area.

2.4 A9 dualling at Slochd

2.4.1 Predominantly southbound widening was identified as the preferred option for A9 dualling at Stage 2 of the DMRB process. At Slochd, this avoids significant impact to the Highland Main Line and residential properties.

2.4.2 The A9 through Slochd is predominantly on sidelong ground or through areas of cut near the base of hillsides. Widening to facilitate the southbound dualling will require extensive engineering including cutting into rock and superficial deposits. The engineering will be significant with rock cuttings up to approximately 35m in overall height beneath superficial (soil) cuttings several meters high.

2.4.3 Considering the above, dualling through Slochd will result in dramatic changes to the A9 corridor; existing cuttings will need to be modified and new exposures of rock will be formed. Dualling represents an opportunity to expose, record and interpret valuable geological features and information thus creating an opportunity to enhance the geodiversity value.

3. The Geodiversity of Slochd

3.1 Background

- 3.1.1 The geodiversity of any place is shaped by its geological history. Landforms, exposures of different soils and rock, fossils, and many other features offer a glimpse of the geological past.
- 3.1.2 Slochd is located in an area known as the Grampian Highlands. This area is bound by two major geological faults: the Highland Boundary Fault and the Great Glen Fault. These faults form spectacular landscape features in their own right. The Grampian Highlands is characterised by widespread metamorphic and igneous rocks. These are the eroded remains of an ancient, vast mountain chain called the Caledonian Mountain Belt. The metamorphic rocks represent older sedimentary rocks that have been subsequently altered by heat and pressure associated with the mountain building events. The geology of the Grampian Highlands is simplified in Figure 14 below.
- 3.1.3 In the more recent geological past, the Grampian Highlands has been altered by numerous episodes of glaciation. These have carved out the landscape through the erosive action of the ice. Extensive glacial deposits have been laid down and reworked over time.
- 3.1.4 In recent centuries, humans have exploited these geological deposits and modified them to suit their needs. We should not underestimate the anthropogenic footprint that, in some places, significantly contributes to the geodiversity value.
- 3.1.5 In this Section, the geodiversity of Slochd will be explored through its geoheritage, geomorphology, and geology (superficial and bedrock).

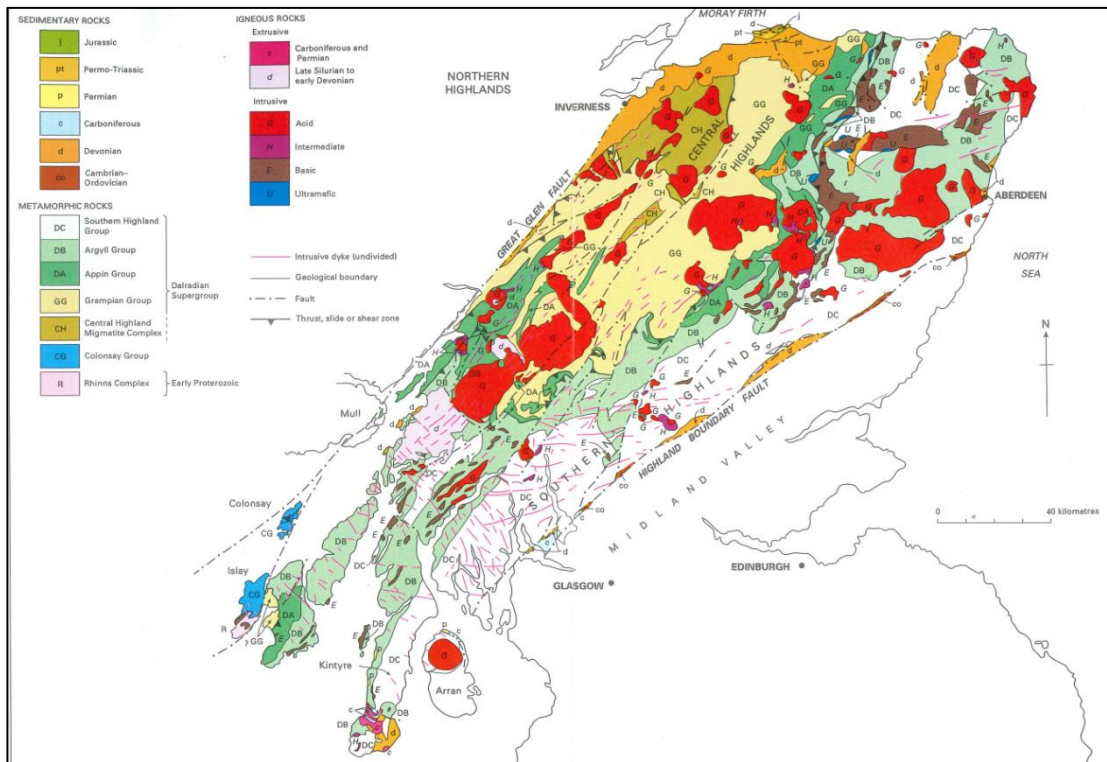


Figure 14 Regional geology of the Grampian Highlands (Reference 8)

3.2 Geological History

3.2.1 A summary table of key geological events which have shaped the Cairngorms and surrounding area is provided in Table 3.1 below. The geological time periods highlighted in green correspond with the age of the superficial and bedrock geology recorded for the study area.

Table 3.1: Key geological events which have shaped the Cairngorms and the surrounding area (References 9, 10, and 11, * relates to periods of deposition that formed the stratigraphy at Slochd)

Geological Time (Ma: million years ago)	Summary of geological activities affecting the Cairngorms National Park region
Pre-Cambrian Before 542 Ma*	<p>More than 850 million years ago the rocks exposed at Slochd were starting to be deposited as sediments in a shallow ocean known as the Iapetus Ocean which at that time was near the south pole. The sediment being deposited are what geologists refer to as the early Dalradian sediments.</p> <p>Once the Dalradian sediments had formed a thick layer of sedimentary rock, a major phase of early deformation occurred that affected the bedrock at Slochd. This phase of deformation is interpreted to have occurred between 850 Ma and 800 Ma. The earliest deformation phases are understood to have occurred as 'peak-amphibolite-facies metamorphism' (extreme heat and pressure) which created 'gneissose' (banded) and 'migmatitic' (mixed) fabrics during pre-Caledonian mountain building (orogenesis). The cause of the early deformation could be attributed to deep metamorphism within an accretion wedge formed on the edge of the Iapetus oceanic plate. The ancient deformation fabrics are interpreted to have been strongly reworked later as part of the 'Grampian Shear-zone'.</p>
Cambrian 542 to 488 Ma	Dalradian sediments continued to be deposited in the Early Cambrian. During the Late Cambrian, the Iapetus Ocean began to close.
Ordovician 488 to 444 Ma	The Caledonian mountains were formed as the Iapetus Ocean closed and a chain of volcanic islands (The English Lake District and Snowdonia) collided with Laurentia (the continent on which Scotland was located). The collision resulted in the second major deformation event causing further metamorphism and folding of the Dalradian sediments.
Silurian 444 to 416 Ma*	The continents of Baltica (Scandinavian Europe) and Eastern Avalonia (containing England) collided with Laurentia (North America) and so completely closed the Iapetus Ocean. The colliding of the two continental plates caused the melting of deep crust and so the Cairngorm granite rose as a molten mass from deep in the Earth's crust to within several kilometres of the then earth's surface. By 427 million years ago, the Cairngorm granite had cooled and solidified.
Devonian 416 to 359 Ma*	Scotland at this time had migrated north to 10° south of the equator creating semi-arid conditions. Intensive erosion of the Caledonian mountains produced vast thicknesses of sand and gravel which were deposited by rivers in semi-arid basins within the mountains and in adjacent areas within the Midland Valley. After the Cairngorm granite became exposed at the earth's surface, rivers cut into weaker areas of bedrock, laying the route of present glens.



Geological Time (Ma: million years ago)	Summary of geological activities affecting the Cairngorms National Park region
Carboniferous 359 to 299 Ma	Scotland continued to drift north into the equatorial latitudes. Deposits of coal formed in low-lying coastal swamps in the Midland Valley but the Cairngorms remained an upland area. Rivers continued to exploit paths of weakness in the granite.
Permian 299 to 251 Ma	The Cairngorms remained an upland area and desert sands accumulated along the present-day margins of Scotland.
Triassic 251 to 200 Ma	The Cairngorms remained an upland area but due to the millions of years of erosion had a much reduced relief being surrounded by arid continental plains. Scotland had by this time migrated further northward to around 20° to 30° north of the Equator.
Jurassic 200 to 145 Ma	The Cairngorms remained an upland area with rivers that ran out into the east and so formed deltas in the North Sea basin.
Cretaceous 146 to 65 Ma	This time represents a period of earth temperature rising resulting in high sea levels due to ice cap melting, and so warm, shallow seas covered most of Scotland. The Cairngorms were probably a low area rising above sea level.
Palaeogene 65 to 23 Ma	During this period the earth's temperature was significantly warmer than it is today and so resulted in significant chemical weathering of the granite due to the humid, sub-tropical conditions. Periods of uplift and erosion of the glens and straths took place and the plateau surfaces formed. The Cairngorms were re-established as an upland area. The North Atlantic Ocean opened to the west of Scotland.
Neogene 23 to 1.8 Ma	Earth temperatures were cooling towards current temperatures and so weathering continued under warm, temperate conditions. Further uplift of the area and erosion of the glens occurred. Cooling of the climate intensified after approximately 3 million years ago.
Quaternary – The Ice Age 1.8 Ma to present*	<p>1.8Ma to 30,000 years ago: onset of the Ice Age occurred approximately 2.6Ma. There were many glacial (cold) and interglacial (warmer) episodes with associated expansion and contraction of glaciers. These were mainly mountain glaciers before 750,000 years ago and thereafter a succession of large ice sheets. The some of the main features of glacial erosion include glacial troughs, breached watersheds and corries. Shallow weathering of bedrock occurred with stripping of the weathered rock and exposure of the present tors.</p> <p>29,000 to 15,000 years ago: Scotland underwent the main Late Devensian glaciation during which an ice sheet expanded quickly overland. Ice on the plateaux is understood to have been 'thin, dry and cold-based' and resulted in minimal glacial erosion because it flowed predominantly by internal deformation.</p> <p>Ice on the major glens and across valleys is understood to have been 'wet-based' which led to basal sliding and enhancing rates of glacial erosion.</p> <p>22,000 years ago: at the end of the Last Glacial Maximum a slow glacial retreat occurred under 'Siberian' conditions where ice sourced in the western Highlands retreated in a westerly direction, exposing mountaintops and glens in the east before those in the west. There were complex interactions between the retreating ice-sheet and ice sourced locally over the Cairngorms. The retreat was punctuated by one major glacial re-advance involving Strathspey ice.</p>

Geological Time (Ma: million years ago)	Summary of geological activities affecting the Cairngorms National Park region
	<p>14,700 years ago: the tundra vegetation was replaced by birch and juniper scrubland when the climate warmed abruptly.</p> <p>12,500 years ago: arctic conditions returned and small glaciers formed in the high corries of the Cairngorms. Most of the region remained unglaciated, however repeat freezing and thawing destabilised the cohesive glacial deposits resulting in the material creeping and sliding downslope in the glens.</p> <p>11,500 years ago to present: the warm, interglacial climate of the Holocene began abruptly. By 10,000 years ago, birch woodland had returned followed later by pine. From 4,300 years ago the climate has gradually become colder and wetter.</p>

3.3 Geoheritage

- 3.3.1 The activities of mankind have left their mark on the landscape at Slochd. Such features form part of the area's geoheritage which have significantly contributed to its geodiversity value. In its original natural form, the landscape around Slochd would have been challenging to traverse; as evidenced by the scale of earthworks associated with the various transport routes that pass through Slochd, which in turn have made it an iconic focal point for the journey north towards Inverness.
- 3.3.2 Informal trade routes are likely to have existed long before; however, General Wade's campaign in the 18th century led to a military road being taken through Slochd and the pass at the Summit. Thereafter, the route of the current U2400 (which was the original A9) required modification in order to allow passage – historical maps suggest that rock cutting was required near Slochd Beag and at Slochd Summit.
- 3.3.3 Routing the Highland Main Line through Slochd has resulted in what is probably one of the most iconic views from the current A9. A narrow cutting, wide enough only to accommodate a single track, was formed just south of Slochd Summit. This striking view is questionably unique to not only the A9 but to the UK (Figure 9).
- 3.3.4 The creation of the current A9 in the late 1970s / early 1980s resulted in further, extensive rock cutting. The large rock face at Slochd Beag was formed to allow the route to move from the path of the U2400 to its current alignment (Figure 15). To accommodate the new road the current southbound rock face at Slochd Summit was created (Figure 16, note this cutting was originally formed without the rockfall netting).
- 3.3.5 It is noteworthy that much of the bedrock exposures at Slochd are in these manmade cuttings. Due to the long period of erosion the CNP has limited rock exposure for a mountainous region and so these rock cuttings make for a rare opportunity to see the bedrock. Indeed, the road cutting at Slochd Summit has been the subject of much study by geologists which has helped develop modern hypotheses on the formation of the Grampian Highlands.



Figure 15 Existing Slochd Beag rock cutting formed in the late 1970s / early 1980s during construction of the A9



Figure 16 View to the east of the Slochd Summit rock cutting (before rockfall protection mesh installed). The Highland Main Line can be seen in the foreground. Photograph supplied to AMJV by the BGS, ©BGS

3.4 Geomorphology

- 3.4.1 Geomorphology is the study of landforms on the earth's surface and the processes by which they have formed.

3.4.2 The landscape at Slochd bears the legacy of glaciation including glacial as well as periglacial and paraglacial landforms. Locations which have been identified by the AMJV as being of particular geodiversity interest are discussed in the following sections.

Slochd Mor Rock Slopes

3.4.3 The natural rock slopes and the deep hollow at Slochd Mor are impressive features that are distinct from the surrounding landscape and less characteristic of the CNP. The slopes are formed at a much steeper angle than the surrounding rounded hillsides and are characterised by extensive, natural exposures of rock above a large scree slope.

3.4.4 It is in these rock slopes that the Soldier's Head can be seen (Figure 7). While this feature is not designated it is of local interest. Local folklore has it that the feature was hand carved; while an appealing story this is unlikely to be the case. Notwithstanding this, the story and the local interest demonstrates the importance of geodiversity to communities.

3.4.5 The steep rock slopes at Slochd Mor were formed as a result of glacial action plucking the rock away from its head as it flowed down the valley. The plucking has left an unstable overstep rock arcuate face from which has supplied the debris which has formed the scree slope beneath. A number of geomorphological processes are active in this area as follows:

- Release of unstable blocks as rockfall. Many large failed blocks and smaller debris is present at the foot of these rock slopes (Figure 17). This can be most clearly seen along the access track from the layby to the southern end of this feature. In viewing the rock slopes, there are many areas where blocks appear to have the potential to collapse.
- Accumulation of scree at the toe of the slope (Figure 8). The scree that has built up is of varying block size and is anticipated to be of substantial thickness in places. Scree is continuing to collect when smaller blocks becoming detached from the slopes above. Vegetation has become established on some areas of the scree cones; however, these slopes are generally vegetation-free with limited lichen growth as new debris has accumulated quicker than vegetation and a stable soil could form. This indicates that these slopes have not yet stabilised and movement (by accretion of deposits or by downslope actions) is still occurring.
- Erosion of scree and the shallow superficial deposits on the upper slopes, most likely as debris flows (Figure 18).

3.4.6 This is one of the most geomorphologically active areas along the entire Dalraddy to Slochd scheme. Many processes are ongoing; however, existing engineering interventions have significantly modified some of these natural processes. Of note is the lined channel that was constructed along the toe of the A9 embankment which prevents the watercourse from finding its natural path at Slochd (Figure 5). Site visits have shown that some sediment transportation persists through this engineered structure, albeit presumably much reduced from that of the watercourse in its natural state. The construction of the embankment and the watercourse channel have both impacted on the fluvial regime and geomorphological processes at Slochd.

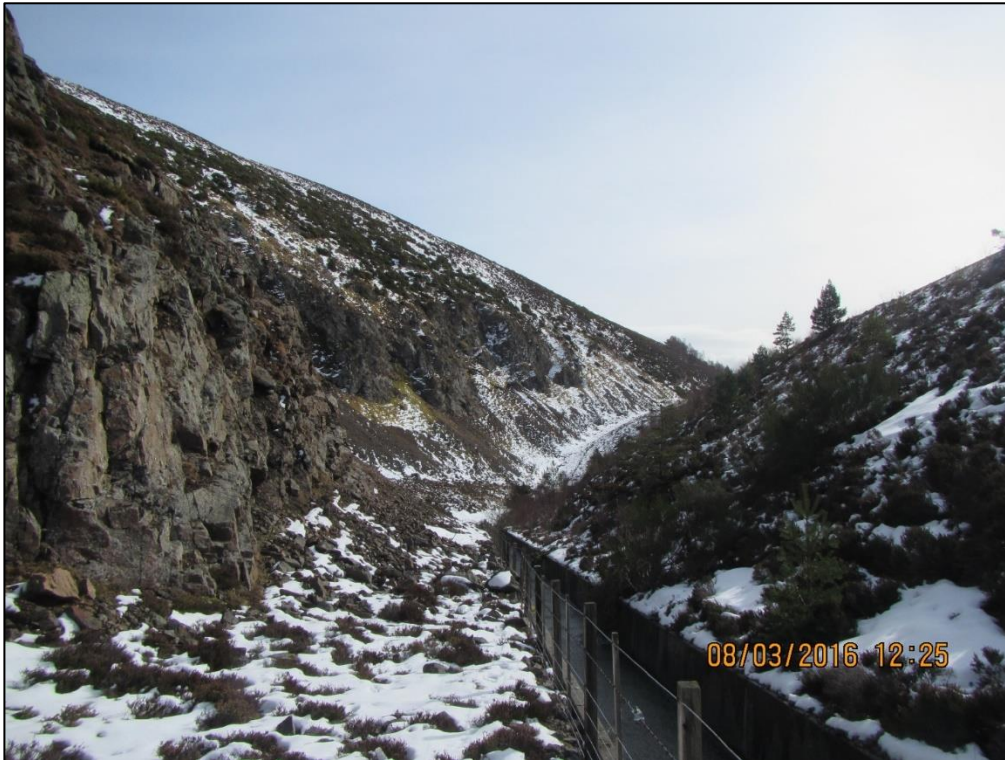


Figure 17 View southeast towards the southern limit of the Slochd Mor rock slopes. Note the prevalence of rockfall



Figure 18 Erosion of the thin soil slopes at Slochd Mor. Note the large block which has failed from the crags above (circled)

Slochd Meltwater Channel

- 3.4.7 A distinctive but relatively small valley (Figure 19) can be found to the west of Slochd Summit, centred at approximately NH 83406 25413 which is approximately 230 m south

west of Chainage 24,200. This is a v-shaped valley with a sharp deviation in orientation that was formed by a subglacial meltwater channel (Reference 12). A subglacial meltwater channel is a channel that formed beneath an ice mass and is typically oriented roughly parallel to the main ice flow direction.

- 3.4.8 Steep slopes have been formed due to the erosive nature of the meltwater that flowed in the channel and the resultant cone is shown as alluvium on the geological maps (Drawing 2). The stream and catchment that currently flows in the channel is too small to have formed such a feature. The stream that we currently see is therefore known as a “misfit stream”.
- 3.4.9 There are few examples of subglacial meltwater channels in close proximity to the Dalraddy to Slochd scheme. At Slochd, this landform is unique and the landscape juxtaposition is obvious.



Figure 19 V-shaped valley formed by a glacial meltwater channel. This is the only such landform that has been identified at Slochd.

Slochd Col

- 3.4.10 A desk-based geodiversity audit of the CNP was completed by the British Geological Survey (BGS) and published in 2011 (Reference 13). A potential Quaternary geodiversity site was identified in the Slochd area and referred to as “Slocht Mor”. Given the lack of the use of “Slocht” in the area it is considered that this may be a typographic error.
- 3.4.11 The feature of interest was given as the col along which the current A9 runs. Although the location plan is unclear and grid references have not been given for the feature; however, it may include the subglacial meltwater channel that is described in the preceding section. There is a lack of clarity on the nature and extents of this feature.
- 3.4.12 Regardless of the BGS definition, Slochd Col is a feature of interest, as before the modern transport routes were formed, the col would likely have been higher than its current position. The Highland Main Line cutting indicates that it was formed through

rock on both sides. The A9 has rock cuttings on both the north and southbound sides, and as such has artificially lowered the col. The southbound cutting which was widened to accommodate the current A9, has intercepted both the bedrock (exposed rock slopes) and a weaker either weathered rock or superficial deposit which has been cut back at a slacker slope to accommodate its reduced strength. The col and its associated earthworks therefore creates a cross-section through the head of the valley exposing the upper geological profile.

3.5 Superficial Geology

- 3.5.1 The distribution of superficial deposits at Slochd, as obtained from published geological maps, is shown on Drawing 2. It should be noted that as part of the Design Manual for Roads and Bridges process, a preliminary ground investigation has been completed and, at the time of writing, a detailed ground investigation is under way. Ground investigations consist of a variety of geological, geophysical and geotechnical techniques deployed to gain a better understand the ground and its engineering condition. These are often intrusive in nature where boreholes and trial pits are excavated so that the deposits encountered can be described and recorded with samples taken for laboratory testing. The discussion contained herein relates primarily to available published information on the geology at Slochd. The detailed ground investigation will enhance the understanding of the type, distribution, and character of superficial deposits at Slochd.
- 3.5.2 The most recently deposited materials in the study area are alluvium and talus. Alluvium is generally associated with existing, small watercourse in the area such as Allt Slochd Mhuic. The distribution of alluvium gives an indication of the extents to which these watercourses have meandered and flooded over time.
- 3.5.3 Talus is concentrated in those areas beneath rock exposures, such as the hollow at Slochd Mor. Although development of these scree slopes is ongoing, as noted previously, it is likely that much of the talus was deposited shortly after de-glaciation. Glaciers when advancing tend to strip debris from the upper parts of valleys and deposit it lower down the valley when retreating. In places talus has become vegetated which indicates that the system at Slochd Mor is partly relict. Relict talus can include horizons that have been reworked by debris flows and may be intercalated with buried soils or slopewash deposits – the material can be complex and highly variable.
- 3.5.4 The lower ground through Slochd is characterised by superficial materials deposited by the meltwater of glaciers. These deposits tend to predominantly comprise gravel, sand, and silt; along much of the Dalraddy to Slochd scheme, glaciofluvial deposits are known to include a high proportion of cobbles which demonstrate the high-energy nature of these ancient fluvial systems. Glaciofluvial systems can be highly dynamic with turbulent flow and a high sediment load as can be seen in contemporaneous glacial landscapes. This results in deposits that can be of considerable thickness and extend over significant distances laterally – such deposits can be stratified and may include some deposition-related structure.
- 3.5.5 On slopes and high ground through Slochd the predominant mapped deposit is diamicton (glacial till). This glacial deposit can be of variable composition and generally consists of unsorted material in a clay matrix. The sediment that forms these deposits was released directly from the glacier by pressure melting and / or released from the substrate, broken up, and then homogenised by the shearing caused by the glacier's movement.
- 3.5.6 Blanket head is shown in areas on the slopes of Carn nam Bain-tighearna and Torr Mòr. Head comprises rock debris often in a sandy to silty matrix which was deposited by

gelifluction which is a periglacial process where the upper soils flow downslope due to freeze-thaw action of ice crystals. Considering Scotland's current climate, there is unlikely to have been any significant movement in these deposits since the end of the last glaciation. The clasts that form much of the head can have a strong downslope alignment owing to the cyclic freeze-thaw process which formed it.

- 3.5.7 The geological maps show peat to be present in the north of the study area. The A9 bisects an area of peat deposits and is carried on embankment through that area. Construction of the A9 is likely to have had considerable impact on these peat deposits. It is presumed that the peat is not as significant as the more extensive blanket peat deposit towards the summit of Carn nam Bain-tighearna (the Allt na Feithe Sheilich SSSI) as it has not been designated as an area of geological interest.
- 3.5.8 There are areas at Slochd where bedrock is either at surface, such as the craggy slopes of Slochd Mor, or the superficial deposits are less than 1m thick and so were not mapped by the BGS.
- 3.5.9 The superficial lithologies deposited at Slochd are representative of the following:
- Glacial processes: Till and glaciofluvial materials were deposited by glacial action.
 - Periglacial processes: Materials such as head and talus were formed during periods of extreme cold climate but are not glacially derived.
 - Paraglacial: Talus is an example of a material that continues to accumulate as highly unstable, glacially shaped landforms degrade back to a stable condition. The talus slopes at Slochd Mor appear to be active with material accumulation and movement ongoing and in places partially relict.
- 3.5.10 Considered individually, the geodiversity value of each superficial deposit is unlikely to be high; however, the combination of deposits and the range of processes across a relatively small area is of higher geodiversity interest.

3.6 Bedrock Geology

- 3.6.1 Passing through Slochd, visitors are struck by the extents of rock that is exposed. As discussed in Section 3.2 some of the impressive exposures are natural while many are manmade. These manmade exposure, or cuttings, were formed to allow passage of the Highland Main Line and the A9. The cuttings are impressive in their own right and form the most extensive exposures of rock at Slochd.
- 3.6.2 The distribution of bedrock geology at Slochd is shown on Drawing 3. Metamorphic rock is widespread across the area with minor igneous intrusions shown such as the dyke (a sheet like igneous intrusion which is vertical or crosses bedding) near the crest of Carn nam Bain-tighearna. The rock types generally comprise psammite, quartzite, and semipelite.
- 3.6.3 Most of the metamorphic rocks at Slochd have gneissose and migmatitic fabrics. That is, they show evidence of having been altered by high-grade regional metamorphism causing partial melting that has resulted in banding of light and dark minerals in the rock. An example of gneissose rock at Slochd is shown in Figure 20. The rocks that have been affected by this metamorphism include:
- Beinn Bhreac Psammite Formation.
 - Creag Buidhe Semipelite Formation.
 - Slochd Psammite Formation.

- 3.6.4 These gneissose metamorphic rocks belong to the Dava Subgroup, which was deposited sometime in the Precambrian before 850 million years ago. Thereafter, these rocks were subject to multiple phases of intense heat and pressure which resulted in deformation of the units through folding and faulting, and alteration of the parent material. It is thought that the development of gneissose and migmatitic fabrics occurred some 810 million years ago (Reference 6). Igneous intrusions can also be found within these rocks and whilst are younger are also estimated to be Precambrian in age, probably associated with the deformation event.
- 3.6.5 The absence of gneissosity in some of the metamorphic rocks at Slochd is the reason why this area is of wider geological interest and the GCR site designation. The distribution of non-gneissose metamorphic rocks belonging to what is identified as the Dalradian Supergroup is shown on Drawing 3. Based on the best available evidence and by correlating with other sites, geologists have determined that these non-gneissose rocks are likely to belong to the Dalradian Supergroup, and more precisely, the Grampian Group. The Dalradian Supergroup, which also consists of sedimentary and igneous rocks, was deposited in the late Precambrian between around 800 and 510 million years ago.
- 3.6.6 It has been postulated that the geological history of the Grampian Group differs to that of the Dava Subgroup due to the lack of gneissose fabric. That is, they have not been subject to the same level of metamorphism that would result in partial melting and the development of a gneissosity. It was originally considered that the contact between the gneissose and non-gneissose rocks at Slochd was evidence of an orogenic unconformity. An unconformity represents a break in the geological record which can be caused by a hiatus in deposition and / or erosion of material. The inclusion of “orogenic” indicates that the unconformity was a result of an episode of mountain building in the geological past. This theory is becoming accepted by the geological community on a regional scale. There is regional evidence of shearing having occurred along such an unconformity to form what is called the Grampian Shear-zone; however, it is considered that the contact between the gneissose and non-gneissose rocks at Slochd is unlikely to represent this unconformable surface. (Reference 6)
- 3.6.7 Instead, the textural difference between the gneissose and non-gneissose rocks may simply be due to variations in the bulk composition of these rocks. Microcline-rich feldspathic psammities of the Slochd Psammite Formation, for example, will tend to preferentially develop gneissose and migmatitic textures. By contrast, the rocks that form the Grampian Group at Slochd tend to be more plagioclase-rich which causes them to be less reactive and therefore likely to remain non-gneissose. It is also possible that the non-gneissose rocks at Slochd may represent rocks that belong to the Dava Subgroup but whose particular type has not been recorded elsewhere. (Reference 6)
- 3.6.8 In the wider Slochd area there are a number of other rock types as shown on Drawing 3 which are less prevalent, and of less geological interest than those discussed above. These rocks include:
- Quartzite of the Kincaig Formation and psammite and semipelite of the Loch Laggan Psammite Formation. Both formations belong to the Corrieyairack Subgroup which is part of the Grampian Group.
 - Metamorphosed igneous intrusions that originated in the Neoproterozoic. The lithology of these is given as metagabbro and metamicrogabbro.
 - Ordovician and Siluro-Devonian age igneous intrusions. The lithology of these intrusions is pegmatite, microdiorite, and felsite. These represent the youngest of the rocks at Slochd.

- 3.6.9 The stratigraphy at Slochd, as based on current understanding, is presented in Table 3.22. The rock units identified at Slochd are presented in the table from the oldest (at the bottom) to the youngest along with information that relates to their formation and description.
- 3.6.10 The GCR designation for the bedrock geology at Slochd Summit demonstrates the geological importance at this location. While work still has to be done in to better understand the complex geological history of these rocks it is clear that the presence of the non-gneissose, Grampian Group rocks is of geodiversity interest as is their contact with the older rocks that belong to the Dava Subgroup. In time, the true nature of the relationship between these non-gneissose and gneissose rocks will become better understood.



Figure 20 Gneissose banding in rock exposed at Slochd Beag.

Table 3.2: Stratigraphic Sequence (Reference 6)

Geochronology							Lithology	Commentary
Era	Period	Ma	Activity in UK	Group	Sub-group	Formation		
Cenozoic	Quaternary	2.6 to 0.01	UK climate cooled as the landmass drifted north. Glaciers covered middle & north Britain, shaping the landscape we see today. The first people appeared in Britain.	n/a	n/a	-	Various superficial deposits that are usually sandy, silty clay with pebbles, but can contain gravel-rich, or laminated sand layers, varied colour and consistency.	Extensive deposits were formed during the Quaternary as a result of successive glaciations and the action of glaciers. The landscape that we currently see at Slochd is largely as a result of glacial action, be it through erosion or deposition of materials.
Palaeozoic	Silurian to Devonian	385 to 359	Evolution of major fish groups. Shallow marine environment. Development of plants. UK located near the equator.	Stratigraphical affinity Unknown	Stratigraphical affinity Unknown	North Britain Siluro-devonian Calc-alkaline Dyke Suite	Felsite and Microdiorite.	These rocks were formed from silica-rich magma intruded into the earth's crust. It cooled to form intrusions ranging from large, coarse-crystalline, often granitic, batholiths to smaller, fine to medium crystalline, often rhyolitic, dykes and sills.
		444 to 416	Britain located south of the equator. Earth movements at the End of Silurian closed Iapetus Ocean & formed mountains in Scotland, Wales & north England.					
Neoproterozoic	Stratigraphical affinity unknown but relationship with other rocks at Slochd indicate these to be late Neoproterozoic.					Unnamed Metamorphic Rocks	Metagabbro and Metamicrogabbro	Originally igneous rocks formed by intrusions of silica-poor magma. Later altered by low-grade metamorphism.
	Tonian	1000 to 850	End of period of relative inactivity of earth's atmosphere and geology.	Grampian Group	Stratigraphical affinity unknown	Shown as Dalradian Supergroup in Drawing 3.	Psammite, semipelite, and calc-silicate. Generally non-gneissose.	Originally deposited as sedimentary rocks and subsequently subject to multiple phases of metamorphism and deformation.

Geochronology							Lithology	Commentary
Era	Period	Ma	Activity in UK	Group	Sub-group	Formation		
			Atmosphere largely devoid of oxygen.		Corrneyairack Subgroup	Loch Laggan Psammite Formation	Psammite and semipelite. Limited presence at Slochd.	Originally deposited as sedimentary rocks that were subsequently subject to high-grade metamorphism. The generation of gneissose and migmatitic textures indicates that the heat and pressures associated with this metamorphism were high enough to result in partial melting of the rock.
			Supercontinent Rodinia began to break up.			Kincraig Formation	Quartzite. Limited presence at Slochd.	
			The first recorded ice age began towards end of Tonian Period.	Badenoch Group	Dava Subgroup (stratigraphical affinity of Formations undetermined)	Creag Buidhe Semipelite Formation	Gneissose semipelite; migmatitic semipelite, locally muscovitic and garnetiferous; minor and local lenses of quartzite and units of micaceous psammite.	
						Slochd Psammite Formation	Gneissose to migmatitic psammite and siliceous psammite, potash feldspar rich, thin bands of quartzite (metamorphic bedrock).	
						Beinn Bhreac Psammite Formation	Gneissose interbanded psammite, micaceous psammite and siliceous psammite. Locally migmatitic.	

Source: BGS Online viewer and Leslie et al. (2013).

Rockhead Profile

- 3.6.11 As discussed, much of the exposures of rock currently seen at Slochd are as a result of human intervention which was required in order to create routes through the challenging terrain of this part of the Highlands. The natural rock exposures are typically concentrated in and around Slochd Mor.
- 3.6.12 Considering the landscape presently seen at Slochd it would be reasonable to assume that rock is at relatively shallow depths beneath the superficial deposits on the hillsides that dominate the area. Early indications from the preliminary and Stage 3 Ground Investigations are that the depth to rockhead is highly variable across the flanks of Carn nam Bain-tighearna which located between Slochd Beag and Slochd Mor (Figure 21). The depth to rockhead has not yet been fully resolved through this area but investigating This forms an important part of the Stage 3 Ground Investigation. It could be the case that a buried valley, buried hollow, or an infilled tunnel valley is present in this area which would be of geological interest.



Figure 21 The approximate area where the depth to rockhead is currently uncertain. The extents are indicative only.

Structural Geology

- 3.6.13 The structural geology in this part of Scotland is complex. This reflects the multiple phases of deformation that have affected the ancient rocks in this area. Most of the deformation events occurred as a result of the Caledonian Orogeny which resulted in the development of mountain ranges extending from Scandinavia, through north and west Britain, and into North America.
- 3.6.14 Slochd is located in a north west trending deformation zone which is dominated by south west verging reclined folds and fabrics. This is part of a structure known as the Foyers-Cairngorm Lineament (Reference 8). Detailed geological mapping at Slochd has been undertaken by the BGS as part of their field mapping programme and as part of the Slochd GCR site designation process. By recording the evidence for the structural

geology in the field, BGS and others have been able to decipher the deformation history of the site.

- 3.6.15 The structural complexity at Slochd is evident in the extract of the 1:10,000 scale geological map for the Tomatin area which includes Slochd Summit. Over a relatively small area there is a concentration of a variety of mapped geological features. The key is not included in the figure below and the reader is encouraged to view BGS sheet NH82NW in order to better understand the detail of the structural geology.
- 3.6.16 The following text summarises the deformation that the rocks at Slochd have been subjected to and the type of evidence that has been imprinted upon them as a result and is based on information in Reference 6.

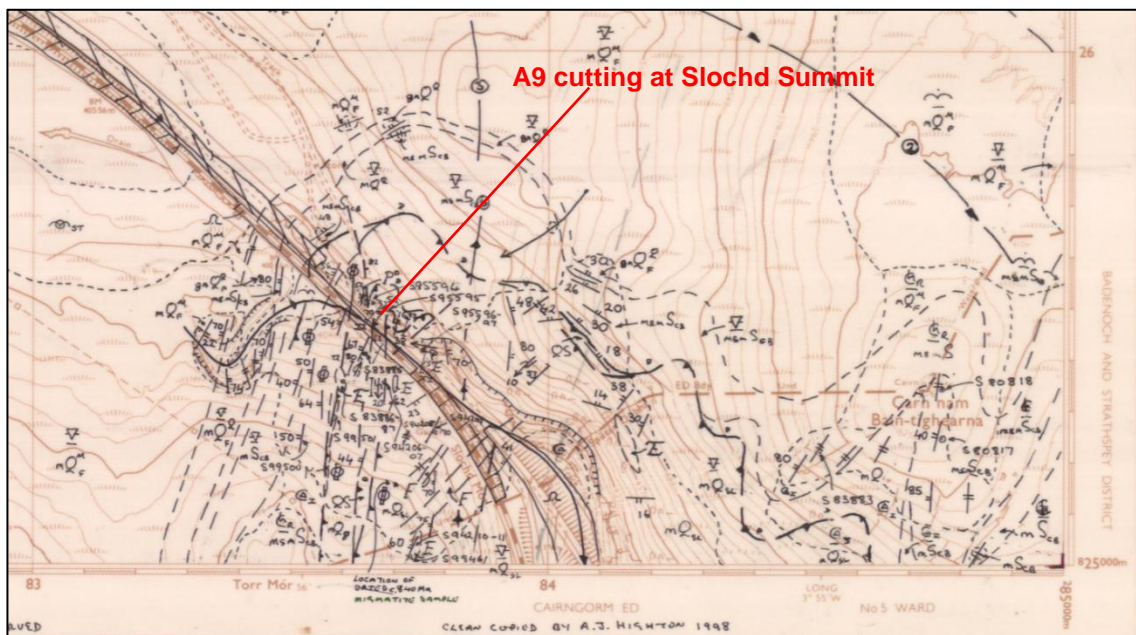


Figure 22 Extract of geological map sheet NH82NW (1:10,000 scale) that highlights the complexity of the structural geology in the area of Slochd Summit, ©BGS.

Ductile Structures

- 3.6.17 Rocks can bend and stretch in response to earth movements such as the Caledonian Orogeny. This results in permanent changes to the rock. A number of phases of ductile deformation have occurred at Slochd and left their legacy on the bedrock geology as discussed below.

Foliation 0 (S0)

- 3.6.18 In rock, foliation is a planar fabric which can form in a number of ways. We know that the rocks at Slochd are meta-sedimentary. That is, they were originally sedimentary rocks that have been changed through metamorphic events. Sedimentary rocks are formed of layers of units, or beds. This gave rise to the development of the first foliation in the rocks at Slochd: bedding. This primary foliation is designated S0. Evidence suggests that little, if any, evidence of this original sedimentary structure remains due to the many deformation phases that have overwritten it.

Deformation event 1 (D1) and Foliation 1 (S1)

- 3.6.19 With the exception of minor igneous intrusions, all of the rocks at Slochd have been subject to amphibolite-facies metamorphic conditions. That is, intermediate grade

metamorphism which resulted in changes to the original sedimentary rocks that were deposited.

- 3.6.20 Although preservation is rare, evidence of an early gneissosity has been identified in places. This gneissosity is described as most likely relating to the original compositional layers of the rocks.

Deformation event 2 (D2) and Foliation 2 (S2)

- 3.6.21 This is the main deformation event that has affected the bedrock at Slochd. Large scale, shallowly plunging, tight to isoclinal reclined folds were formed during this phase. Additionally, the early gneissose foliation was reworked as part of this deformation. At Slochd an associated map-scale fold is seen which has the Slochd Psammite Formation at its core. The axial plane trace of this fold is shown on Drawing 3.
- 3.6.22 The D2 deformation resulted in widespread shearing and reworking along fold limbs and also along lithological boundaries. This led to the development of the second deformation-related foliation which is an intense shear fabric. Zones of sheared rock are shown on Drawing 3.

Deformation event 3 (D3) and Foliation 3 (S3)

- 3.6.23 The folds formed during the D2 deformation were then refolded during the third deformation event. Locally this resulted in the map scale fold (formed as part of the D2 event) being refolded by an upright, north to south trending fold.

Brittle Structures

- 3.6.24 Brittle deformation is the permanent change that occurs as a result of the propagation of fractures and / or due to movement along such fractures once they have formed. As well as the ductile deformation at Slochd there is evidence of brittle deformation having occurred and left its mark on the rock masses. Brittle structures tend to form over ductile structures when the rock is cooler and the rate of deformation is higher than the ability for the rock to deform without fracturing.
- 3.6.25 A fault is a broadly planar fracture surface formed due to brittle deformation in a rock mass along which displacement has occurred. The location of the most significant faults at Slochd are shown on Drawing 3.
- 3.6.26 While geological maps typically show the location and nature of the most significant faults in any given area, it should be noted that subsidiary faults will be present. A fault is usually defined on a geological map as a single line; however, faults are complex being made up of many smaller faults as discontinuous features which are not readily mappable at a regional scale and so are normally simplified to reflect the scale of mapping undertaken.
- 3.6.27 Another feature associated with brittle deformation relates to deformation event 3. On those folds that were formed during this deformation event a crenulation has been observed. Crenulation is the formation of a set of fractures along closely spaced, parallel surfaces in rock due to a fabric alignment within the rock caused by pressure and heat acting on the rock.

3.7 Palaeontology

- 3.7.1 Given the multiple phases of deformation that have occurred at Slochd which have significantly altered the original structure of the rocks it is highly unlikely that any fossils

are present in the bedrock. More recent fossils may be found within the superficial deposits, but these are likely to be of less interest.

3.8 Mineralogy

3.8.1 The current information suggests that there are unlikely to be any particularly unusual mineral assemblages at Slochd as the mineralogy is common throughout this area of Scotland.

4. Key Geodiversity Features at Slochd

4.1 Background

4.1.1 The beauty and interest in a landscape can be appreciated with or without knowledge of its geomorphological and geological history. Slochd is an excellent example where the geodiversity affects everyone who can see its landscape. Whilst the whole landscape is of interest several features, or assemblages of features, that relate to the geomorphology and geology of Slochd enhance the experience of those who visit this location.

4.1.2 The features that the AMJV considers offer the greatest geodiversity value at Slochd are:

- Geoheritage
 - Rock cuttings.
- Geomorphology
 - Slochd Mor rock slopes.
 - Slochd meltwater channel.
- Superficial geology
 - Assemblage of superficial deposits.
- Bedrock geology
 - Non-gneissose rocks and the contact with gneissose rocks.
 - Rockhead profile.

4.1.3 The geodiversity value of these key features, potential enhancements as a result of A9 dualling, and factors that may reduce the geodiversity value are discussed in Table 4.1.

Table 4.1: Key geodiversity features at Slochd

Geodiversity Feature No. 1 – Geoheritage: Rock Cuttings		
Geodiversity value	Potential enhancements to geodiversity value through A9 dualling	Potential diminution to geodiversity value through A9 dualling
<p>Much of the character of Slochd is owed to the existing rock cuttings that were formed to facilitate passage through this high, mountain pass. At Slochd Summit, the convergence of the Highland Main Line and the A9 gives rise to a unique and striking view of two major transportation corridors hewn into bedrock and separated by a slither of rock.</p> <p>These road and rail cuttings represent the largest, continuous exposures of bedrock geology through the Slochd area. The cuttings are also the most readily accessible areas of exposed bedrock at Slochd – this is particularly the case for the A9 road cuttings. Investigation of these exposures has provoked dialogue with the BGS and so resulted in a greater understanding of the geological history of the region.</p> <p>These rock cuttings are of geodiversity value as they help to tell the story of not only the bedrock geology but the engineering challenges at Slochd.</p>	<p>In order to dual the A9 between Slochd Beag and Slochd Summit a number of new rock cuttings will be created. Predominantly southbound widening will be undertaken through Slochd. Current plans show minimal impact to the pinnacle of rock that separates the A9 from the Highland Main Line which means that the most striking rock cutting from a landscape prospective will be retained.</p> <p>The current understanding of ground conditions at Slochd Mor suggest that dualling will result in a more significant rock cutting being formed at this location. The current cutting is in a less than ideal condition for accessing the area to study the geodiversity and so the works could enable safer access to the area.</p> <p>The proposed new rock slope design at Slochd Summit has evolved by working closely with AMJV Landscape Architects and through incorporating feedback from stakeholders such as the CNP Authority, SNH and BGS. The AMJV design for Slochd Summit has been developed to enhance the aesthetics of this rock cutting by introducing features of interest such as ledges at variable heights. There is potential to create a rock cutting at this location that offers more to the geoheritage of the site by working with the rock mass to create a visually appealing striking feature whilst maximising the exposure of key features within the rock face.</p> <p>While measures to enhance this geodiversity feature are limited it should be noted that LiDAR scanning has been undertaken as part of the geological assessment at Slochd. The current cuttings are therefore preserved, digitally, for posterity and potentially for future study. There may be an opportunity in the future to undertake further scans during and post construction and so this data can be utilise to assist in telling the story of creating a passage through Slochd Summit.</p>	<p>The corridor through which the A9 passes will be widened and a new rock cutting created adjacent to the southbound lane. Dualling will result in a particularly significant change at Slochd Summit. The overall sense of constriction of the landscape at this location is likely to be reduced although retention of the pinnacle between the A9 and Highland Main Line and high rock faces on the southbound side will act to reduce this impact.</p>

Geodiversity Feature No. 2 – Geomorphology: Slochd Mor Rock Slopes		
Geodiversity value	Potential enhancements to geodiversity value through A9 dualling	Potential diminution to geodiversity value through A9 dualling
<p>The natural rock slopes and associated features at Slochd Mor are the most extensive natural exposures of bedrock at Slochd which, in itself, means that they are of geodiversity interest.</p> <p>The Soldier's Head is a truly unique feature in the natural rock slopes. This feature is of local interest and represents the way in which people subconsciously engage with and benefit from geodiversity.</p> <p>Much of the geodiversity value at Slochd Mor also relates to the variety of ongoing geomorphological activities that are concentrated in a relatively small area. As discussed earlier, there is evidence of current rockfall activity, continued development of scree slopes, and erosion and reworking of these scree slopes.</p> <p>These rock slopes are of geodiversity value for the following reasons:</p> <ul style="list-style-type: none"> • They are the only natural bedrock exposures at Slochd. • They include a unique rock formation (Soldier's Head). • The area is geomorphologically active. 	<p>The current dualling proposals show minimal impact to the natural rock slopes at Slochd Mor. The inclusion of a lay by and the routing of the National Cycle Network (NCN) Route 7 are an opportunity to safely view and engage with this area of geodiversity interest. The AMJV has observed drivers stopping at the lay by to the immediate south of Slochd Mor and walking along the verge to view and photograph the slopes and, in particular, the Soldier's Head. The proposed lay by and the re-routed NCN 7 both offer significant opportunities for increased engagement with geodiversity.</p> <p>Subject to the wider strategy for enhancements and safe design of lay bys, there may be opportunity to provide features such as an interpretation panel that offers insight to the geology of Slochd Mor for lay by users.</p> <p>A high resolution LiDAR scan of Slochd has been captured as part of the AMJV's work. All of the features at Slochd Mor have been captured digitally. Without the A9 dualling it is unlikely that such data would have been captured for this area. The data could be used by academic institutes for research purposes and well for educational purposes at numerous levels.</p>	<p>Significant engineering works are required in order to facilitate dualling past Slochd Mor. This will include widening the existing A9 embankment towards the natural slopes, modifying the channelised watercourse at the toe of the embankment, and excavating rock at either side of the natural hollow. In general, the impact to the rock slopes is considered to be minimal; however, there is likely to be impact to the active talus slopes below.</p> <p>Due to the increased footprint of the widened embankment and watercourse there is likely to be some loss to the toe of the scree deposits and an alteration to associated geomorphological processes at this location.</p> <p>Disturbance and vibration associated with construction in and around Slochd Mor may result in an adverse impact to the Soldier's Head. It should be noted that this natural feature is at risk of ongoing, natural slope degradation processes which may be exacerbated during construction. Construction control measures should be considered to reduce any impact on the Soldier's Head.</p>
Geodiversity Feature No. 3 – Geomorphology: Slochd Meltwater Channel		
Geodiversity value	Potential enhancements to geodiversity value through A9 dualling	Potential diminution to geodiversity value through A9 dualling

<p>The v-shaped valley that was formed by glacial meltwater is a striking legacy of glaciation in the Slochd area. There are no other such unmodified features at Slochd therefore this one is of geodiversity value.</p> <p>By comparing this channel to current watercourses the volume and flow of glacial meltwater runoff can be appreciated.</p>	<p>The A9 dualling has little impact on this feature given its location to the south west of the Highland Main Line. The geodiversity of the channel is enhanced simply by recognising its value and promoting it as being of interest.</p> <p>Should there be scope to include an interpretative panel at the Slochd Mor lay by there would be merit in including this meltwater channel and the wider glacial context of Slochd. This would enhance the geodiversity value by raising awareness and educating the public about the feature.</p>	<p>A9 dualling is unlikely to have any adverse impact on this geodiversity feature.</p>
<p>Geodiversity Feature No 4. – Superficial Geology: Assemblage of Superficial Deposits</p>		
<p>Geodiversity value</p>	<p>Potential enhancements to geodiversity value through A9 dualling</p>	<p>Potential diminution to geodiversity value through A9 dualling</p>
<p>A relatively broad range of superficial deposits are present across a small area at Slochd. These represent a variety of depositional mechanisms which have taken place in different climatic conditions.</p> <p>The geodiversity value of the superficial deposits is in the variety of deposits present in a relatively small area.</p>	<p>Ground Investigations completed as part of the work to facilitate design of the A9 dualling will be of benefit in increasing understanding of the distribution, thickness, and type of superficial deposits at Slochd. The geodiversity value will be increased by learning more about the nature of these deposits.</p>	<p>While A9 dualling will result in an increased footprint for the mainline alignment and associated junctions etc it is considered unlikely that this will have an adverse impact on the geodiversity value of the assemblage of superficial deposits. Those deposits that A9 dualling will have a direct impact on are sufficiently widespread across the area that the overall geodiversity of this feature is unlikely to be significantly compromised.</p>
<p>Geodiversity Feature No 5. – Bedrock Geology: Non-gneissose rocks and the contact with gneissose rocks</p>		
<p>Geodiversity value</p>	<p>Potential enhancements to geodiversity value through A9 dualling</p>	<p>Potential diminution to geodiversity value through A9 dualling</p>
<p>The presence of the non-gneissose rocks as well as their contact and relationship with the gneissose rocks is the main justification for the designation of the GCR site at Slochd. The designation alone indicates that the area around Slochd Summit is of high geodiversity interest and value.</p>	<p>Ground Investigation across Slochd represents an opportunity to learn more about the lithology of the bedrock at Slochd and its distribution.</p> <p>The creation of new cuttings to facilitate widening is an opportunity to view large, fresh exposures and undertake detailed assessment of the faces as they are formed. There is potential to contribute to wider scientific research into the</p>	<p>Dualling the A9 will result in considerable cut adjacent to the southbound lane at Slochd. This will result in the loss of the current A9 Slochd Summit cutting which has been of importance in developing an understanding of the geology at</p>



<p>There is some uncertainty around the geological history of the non-gneissose rocks which provokes continued geological interest. The differences between the gneissose and non-gneissose rocks may be due to a break in the geological record or simple compositional variation.</p> <p>The geodiversity value is in:</p> <ul style="list-style-type: none"> • The potential for future research to aid in greater understanding of Scotland's geological history. • The non-gneissose rocks at Slochd may represent a formation that is not present or has not been found elsewhere. • Greater understanding of the site may result in the structural geology having greater geodiversity interest. 	<p>geology at Slochd. An increased understanding of the bedrock at Slochd may help contribute to improve theories on the geological history of this part of Scotland.</p> <p>Through works associated with the A9 dualling there is potential for the Slochd GCR site to not only be better understood but to be expanded. The GCR site boundary currently extends behind the existing Slochd Summit A9 cutting; however, the geology that is exposed by the new cuttings may justify an extension of the boundary. It is also feasible that the GCR site may be upgraded to a geological SSSI.</p> <p>There is also potential for other features of geological interest to be identified elsewhere at Slochd through the course of the GI and excavation of rock.</p> <p>The design of rock cuttings is currently being progressed to avoid the use of rockfall protection mesh or stabilisation measures. The existing A9 cutting at Slochd Summit is largely obscured by rockfall protection mesh and other measures that have been implemented to protect road users. It is widely agreed that the mesh is unsightly, detracts from the geology, and hinders further study of this rock cutting. Having rock faces that are free from mesh offers greater opportunity for people to study and enjoy the engineered cutting as well as the geology.</p> <p>There are opportunities to enhance the geodiversity interest by making it more accessible to the public. The southbound lay by at Slochd Mor may be a safe place for people to view these areas of geological interest. The inclusion of an interpretation panel would be an opportunity to disseminate information on the GCR site – it is considered likely that the majority of people are unaware of the GCR designation at Slochd and the site's contribution to the development of concepts about Scottish geology.</p> <p>As the rock faces will be worked back into the hillside it creates an opportunity to gather more geological data. Geologists are restricted to the data they can collect by the amount of exposure. By sequentially taking slices of rock away it is possible to make a 3D model of the geology. Data capturing through fieldwork and surveying techniques such as</p>	<p>Slochd and designation of the GCR site.</p> <p>There is a risk that the geology exposed behind the existing Slochd Summit cutting may not be of comparable interest. While many of the key GCR exposures are located in stream sections to the west of the Highland Main Line there is potential for the overall value of the GCR site to be reduced with the loss of the Slochd Summit face. Consideration should be given to the preservation of the geological value of the current face through techniques such as LiDAR. The face has already been extensively mapped by the BGS, so this information had already been preserved. The opportunity to gain new exposures, remove the rockfall netting and apply modern recording techniques significantly outweighs the risk of losing any geodiversity value from the current cuttings as they are now.</p>
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	LiDAR enable the geodiversity value of each slice of rock to be preserved. The combination of further fieldwork and progressive surveying would enable a wealth of geological data to be collected and so significantly enhancing the opportunity to preserve, learn and study this important piece of geology.	
Geodiversity Feature No 6. – Bedrock Geology: Rockhead Profile		
Geodiversity value	Potential enhancements to geodiversity value through A9 dualling	Potential diminution to geodiversity value through A9 dualling
<p>The findings of the preliminary Ground Investigation in 2017 indicate that the depth to rockhead through Slochd is far more variable than might be assumed considering that bedrock is at or near the surface in many areas. The cutting at Slochd Beag is a particularly dramatic and extensive exposure of rock; however, the ground investigation findings suggest that only a short distance to the north west of this point the depth to rockhead increases significantly.</p> <p>This suggests the potential presence of a feature such as a buried valley, buried hollow, or an infilled tunnel valley may exist at this location. This would be an exciting development in understanding the Quaternary history of this part of Scotland. The rockhead profile at Slochd therefore has high geodiversity potential.</p>	Both the Ground Investigations and the construction of the dualled A9 offer opportunities to learn more about the rockhead profile through Slochd. A9 dualling and associated activities have been responsible for this potential feature being identified.	Given that this feature was unknown and has yet to be definitively proven there are unlikely to be any negative impacts to its geodiversity value through A9 dualling.

4.2 Enhancing and promoting geodiversity value at Slochd

4.2.1 There are a variety of ways in which the geodiversity value of Slochd can be enhanced and promoted. These range from preparation of formal documents such as a Geodiversity Action Plan to less formal initiatives such as sharing knowledge with local communities. A number of potential measures are discussed below.

Slochd Geodiversity Action Plan

4.2.2 A Local Geodiversity Action Plan (LGAP) sets out actions to conserve and enhance the geodiversity of a particular area. In Scotland, the overarching document all such plans would fall under is Scotland's Geodiversity Charter 2018-2023. The Charter sets out a vision for ensuring that geodiversity is adequately considered and conserved such that Scotland continues to reap the benefits of its geodiversity.

4.2.3 As well as including a description of the facets of geodiversity at Slochd, a site-specific LGAP would set out a number of objectives with actions to be taken in order for them to be achieved. Partners would be assigned against each action drawn from a variety of stakeholders such as the relevant Local Authority and the BGS. A timescale for completing each action would also be defined.

4.2.4 A Geodiversity Action Plan therefore becomes a formal, live document. This would require to be managed to ensure that actions are being undertaken and all parties are liaising. An organisation or group of organisations would need to take responsibility for monitoring this progress and ensuring adherence to the stated timescales. In the case of LGAPs prepared for counties, the responsibility for managing progress will typically rest with the Local Authority.

4.2.5 Preparation of a GAP would allow a formalised process to be established for geodiversity at Slochd. The options discussed below could be included in a GAP and developed further to enable objectives to be met.

Dissemination of Findings with Stakeholders

4.2.6 A ground investigation is an essential part of the DMRB process through which the Dalraddy to Slochd scheme is being advanced. By interrogating the ground in order to develop a robust design for the dualled A9 a large quantity of information has been gathered that relates to the geology and geotechnical properties of the ground. The findings of the ground investigation have suggested that previously unknown aspects of the geology at Slochd have potentially been identified through the course of these investigations.

4.2.7 There is potential to enhance and promote the geodiversity value of Slochd by sharing these records and findings with organisations such as the BGS to facilitate further work and research in this part of Scotland. This has potential to contribute to research and understanding on a national scale. Similarly, findings could be shared with the CNP Authority to compliment the geodiversity audit that was completed by BGS. With Slochd Summit forming the northern gateway to the CNP there is widespread interest in the area.

Raise Local Awareness of Slochd's Geodiversity Value

4.2.8 There are numerous initiatives that could be implemented locally to promote geodiversity at Slochd and thus enhance the area's geodiversity value. Slochd and its geodiversity value is a potential local resource that could be utilised and enjoyed by

many in a variety of ways. It is considered likely that many people in the local area do not currently appreciate that the Slochd and surrounding area is of significant geological interest. Three examples are offered below for ways in which community interaction with geodiversity can be encouraged:

- Local museums and visitor centres could be supported in developing or updating exhibitions on the local geomorphology and geology with a focus on why it is of value. Samples of rock obtained during ground investigation and / or construction could be donated to these organisations to assist in developing an interactive component of the exhibition. Inclusion of gneissose as well as non-gneissose rock samples would be an opportunity to introduce visitors to the Slochd GCR site.
- Activities could be developed building upon the existing Academy9 and wider STEM initiatives in order to educate local school children on the geodiversity at Slochd and its value. A variety of geological topics could be expanded upon to engage children of different levels and these could be aligned with the national curriculum. These may include how rocks are formed and glacial features; both of these are well represented at Slochd.
- A number of community and geological interest groups are active across the Strathspey area. There is an opportunity to share knowledge of Slochd, its geology, and its geodiversity with such groups through presentations. This could raise awareness of the importance of Slochd and its geodiversity and might open up opportunities to reach other interested parties eager to learn more about its geodiversity value.

5. Conclusions and Recommendations

- 5.1.1 The geomorphology and geology at Slochd is highly complex. The bedrock geology is ancient and has been subject to a complex geological history. It has been altered several times through metamorphism as well as been disturbed through several episodes of folding and faulting. The geomorphology and superficial geology has been shaped by glaciation. In recent years, the influence of mankind has further modified the landscape at Slochd with the creation of large iconic cuttings in rock to create transportation corridors.
- 5.1.2 There remains uncertainty around the geological history at Slochd. Evidence that decisively proves the nature of the relationship between the non-gneissose and gneissose rocks has not yet been found. Furthermore, findings from the AMJV's ground investigations suggest that the evolution of the landscape in this area is not yet fully understood. The possibility of a buried valley or similar between Slochd Beag and Slochd Mor makes the geomorphology and geology at Slochd all the more interesting.
- 5.1.3 The AMJV has identified several features which are considered to be of key geodiversity value at Slochd. These are:
- Geoheritage
 - Rock cuttings.
 - Geomorphology
 - Slochd Mor rock slopes.
 - Slochd meltwater channel.
 - Superficial geology
 - Assemblage of superficial deposits.

- Bedrock geology
 - Non-gneissose rocks and the contact with gneissose rocks.
 - Rockhead profile.

- 5.1.4 The features identified above are representative of the gamut of geological interest at Slochd. The variety of features selected demonstrate the general high geodiversity value of the location. The Geological Conservation Review site relates to only one of the features listed above (non-gneissose and gneissose rocks). This assessment has highlighted the much wider geodiversity value of the area. It could be argued that the geodiversity at Slochd is not currently being actively promoted and, as a consequence, the geodiversity value has not been fully realised.
- 5.1.5 Dualling the A9 through Slochd will be a major engineering challenge that will unavoidably result in changes to the area. This assessment demonstrates that while there will be some adverse impacts to the geodiversity value of the features listed above, by and large though good management and process the changes could be very beneficial. These beneficial measures could serve to significantly enhance the geodiversity value in a variety of ways. The greatest enhancement to the geodiversity value is likely to relate to the opportunity to learn more about the geology through the AMJV ground investigation and the creation of new exposures/ cuttings. With the formation of new exposures there is the potential for the GCR site to be expanded which could also lead to new findings and so support it being designated as a geological SSSI.
- 5.1.6 This assessment has also identified additional measures that may be taken to enhance the geodiversity value. These range from preparation and implementation of a Geodiversity Action Plan for Slochd to committing to greater community engagement to raise awareness of the geodiversity value of Slochd.
- 5.1.7 Should there be a desire to further promote geodiversity at Slochd and more fully realise its value it would be recommended that the relevant organisation be commissioned to prepare a site-specific Geodiversity Action Plan. This could be used to set out a strategy for engaging with community groups and stakeholders with task managers identified and timescales for completion set. A GAP can be prepared for a defined timeframe and should be reviewed at appropriate milestones.
- 5.1.8 The geomorphology and geology at Slochd encompass a range of interesting and unique features. The work associated with the A9 dualling represents an opportunity to build upon and maximise the value that society may derive from the variety of rocks, landforms, soils, and natural processes that underlie and determine the character of Slochd.

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Annex A. Drawings