Report

Access to Argyll & Bute [A83]

DMRB Stage 2 Scheme Assessment Report

Volume 1 - Part 1 The Scheme & Part 2 Engineering Assessment

Transport Scotland

May 2023

A83AAB-AWJ-GEN-SCW_GEN-RP-ZZ-000004

This page is blank.

Notice

This document and its contents have been prepared and are intended solely as information for Transport Scotland and use in relation to the Access to Argyll and Bute (A83) project.

Atkins WSP Joint Venture assumes no responsibility to any other party in respect of or arising out of or in connection with this document and/or its contents.

This document has 204 pages including the cover.

Revision	Status	Purpose description	Originated	Checked	Reviewed	Authorised	Date
P01	A1	Final	AB	CS	IA	RHG	30/05/23

Client signoff

Client	Transport Scotland
Project	Access to Argyll & Bute [A83]

This page is blank.

Contents

Tables

Figures

Part 1: The Scheme

1. Project Background

1.1. Introduction

The A83 Trunk Road is one of two east-west strategic trunk roads that connects Argyll and Bute to the central belt of Scotland, making it a vital link in the region's transportation infrastructure. The A83 is a 98 mile (158km) predominantly single carriageway road originating in Tarbet, where the A82 and A83 meets at the junction on the western side of Loch Lomond. It then terminates in Campbeltown, near the southern tip of the Kintyre Peninsula.

The section of the A83 through Glen Croe, between Ardgartan and the Rest and Be Thankful viewpoint at the A83/B828 junction includes the highest point along the A83 at approximately 265m above ordnance datum and the adjacent hillsides have a history of instability leading to frequent road closures and resultant diversion.

The A83 as it passes through Glen Croe is shown in Figure 1-1, below.

Figure 1-1 - Access to Argyll and Bute (A83) - Scheme Extents

In line with the recommendations of Strategic Transport Projects Review 2 (STPR2) and following major landslide events at the Rest and Be Thankful in August and September 2020, the then Cabinet Secretary instructed Transport Scotland to investigate a long-term, resilient, and sustainable solution to the problem of landslides in Glen Croe. The Access to Argyll and Bute (A83) project team was commissioned with developing a resilient and sustainable road to Argyll and Bute to address the landslide issues at the Rest and Be Thankful.

Through the Preliminary Engineering Services (PES) (Design Manual for Roads and Bridges Stage 1) assessment process, 11 route corridors were assessed. On conclusion of the Design Manual for Roads and Bridges (DMRB) Stage 1 assessment, the Scottish Government confirmed that the existing corridor through Glen Croe was the preferred corridor.

The preferred corridor spans roughly six kilometres of the wider Glen Croe valley, starting from a point approximately 460m south-east of the intersection of the A83 and the Old Military Road (OMR), and generally following the A83 northward as it climbs through Glen

Croe and past Loch Restil. The corridor ends at the eastern extent of Glen Kinglas near Butterbridge.

Transport Scotland commissioned pre DMRB Stage 2 design work to develop possible route options within the preferred corridor. The result was five potential route options which were conceptually based on various iterations of tunnels, viaducts and debris flow shelters.

The Atkins WSP Joint Venture (AWJV) were subsequently appointed in September 2022 to complete the DMRB Stage 2 assessment. The conceptual route options from the pre DMRB Stage 2 design work were further developed and refined into the Scheme Options as presented here, following the formal DMRB Stage 2 assessment process.

The preferred corridor and the five Scheme Options are illustrated in Figure 1-2, and their salient features are described below.

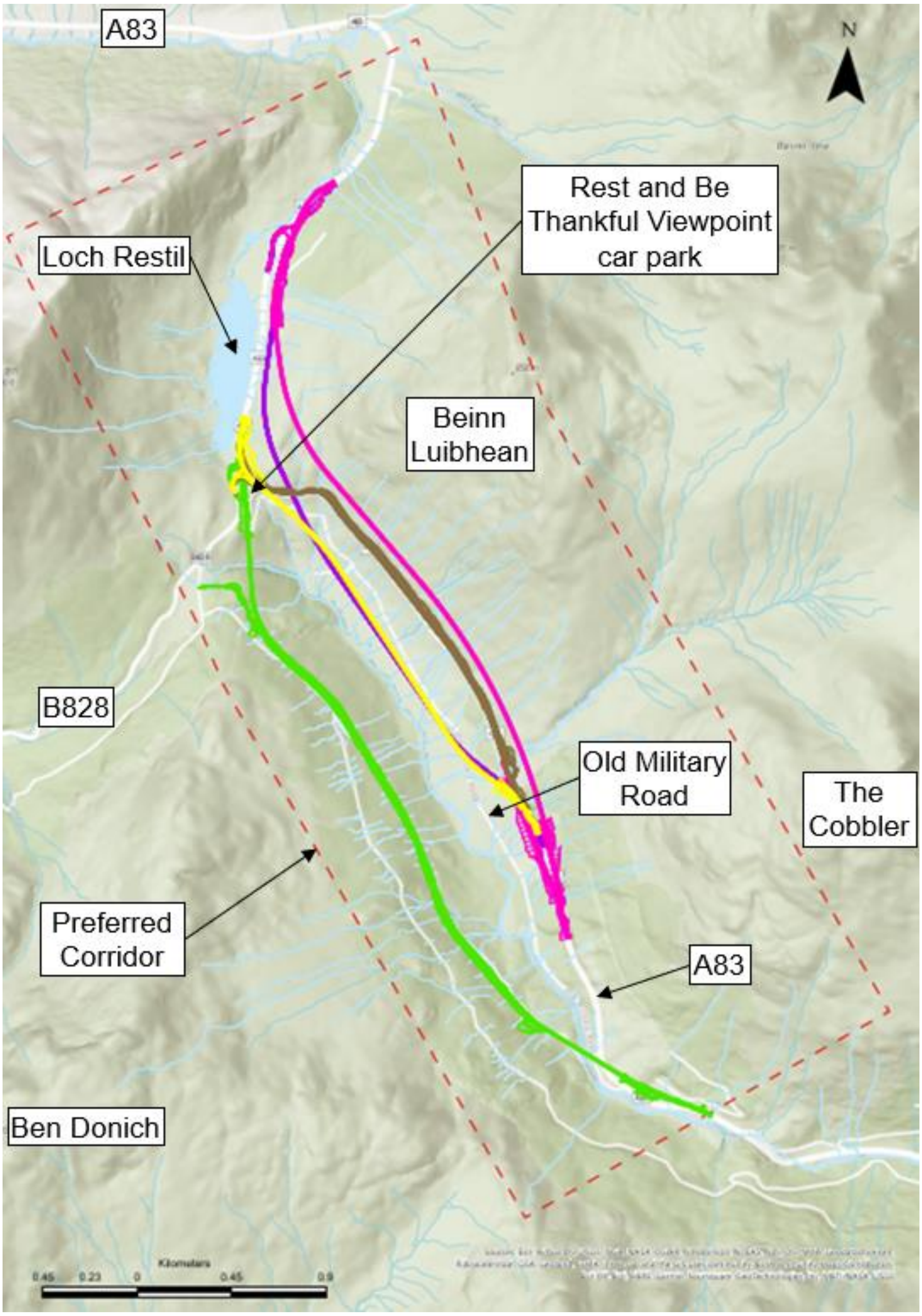

Figure 1-2 - Five Scheme Options to be assessed within the Preferred Corridor

- Yellow Option: An offline option on the east side of Glen Croe below the existing A83 and the OMR consisting predominantly of a viaduct.
- Brown Option: An online alternative to the existing A83, consisting predominantly of a debris flow shelter to protect the road.
- Green Option: An offline option on the west side of Glen Croe consisting of 2 viaducts and a debris flow shelter to protect the road.
- Purple Option: An offline option on the east side of Glen Croe consisting of a viaduct below the A83 and OMR and then into a tunnel.
- Pink Option: An offline option on the east side of the Glen Croe consisting predominantly of a tunnel under the Beinn Luibhean slope.

1.2. Scheme Objectives

The scheme objectives for Access to Argyll and Bute (A83) were defined in the Access to Argyll and Bute (A83) DMRB Stage 1 Assessment Report (Strategic Environmental Assessment (SEA) and Preliminary Engineering Services (PES)). The objectives were developed based on the problems and opportunities relating to the strategic road network through an extensive review of existing studies. Additional cognisance was taken of public and stakeholder feedback obtained through consultation in September and October 2020.

The scheme objectives are:

- Resilience – Reduce the impact of disruption for travel to, from and between key towns within Argyll and Bute, and for communities accessed via the strategic road network.
- Safety – Positively contribute towards the Scottish Government's Vision Zero road safety target by reducing accidents on the road network and their severity.
- Economy – Reduce geographic and economic inequalities within Argyll & Bute through improved connectivity and resilience.
- Sustainable travel – Encourage sustainable travel to, from and within Argyll & Bute through facilitating bus, active travel and sustainable travel choices.
- Environment – Protect the environment, including the benefits local communities and visitors obtain from the natural environment, by enhancing natural capital assets and ecosystem service provision through delivery of sustainable transport infrastructure.

1.3. Previous Studies

Previous studies undertaken by various parties have been significant in shaping the project to date. Key studies are summarised below.

- Scottish Road Network Landslide Study: Implementation, Transport Scotland, 2008.
- A83 Trunk Road Route Study, Jacobs, 2013.
- A83 Glen Kinglas Options Report – 2019 Update, Jacobs, 2019. This report was prepared for BEAR Scotland by Jacobs to assess the risk due to debris flow landslide hazards along the A83 Trunk Road in Glen Kinglas and identify areas where future work could be focussed. This was an update to a report prepared in 2014 to assess the impact associated with changes to the hillside during the intervening period including remedial measures implemented and deforestation.
- STPR2: Initial Appraisal: Case for Change – Argyll and Bute Region Report, Feb 2021.
- STPR2: Update and Phase 1 recommendations Report, Feb 2021.
- Access to Argyll and Bute (A83) – DMRB Stage 1 Assessment Report, Apr 2021.

In conducting these studies, Transport Scotland and its consultants engaged in significant early consultation with key stakeholders and the wider public. A preliminary assessment was undertaken on the eleven route corridor options identified as part of STPR2 as well as four additional route corridor options proposed by members of the public during the consultation held in September and October 2020.

1.4. Stakeholders

The DMRB assessment process involves a rolling programme of continuous engagement with local communities and stakeholders. This engagement is aimed at ensuring local businesses, communities and interested parties are kept informed of developments and their feedback is considered as the project develops.

The project Stakeholder Engagement Plan sets out the strategy for external consultation and engagement activities with stakeholders including regulatory and statutory stakeholders, landowners, communities, businesses and wider stakeholders including members of the public in relation to the medium and long-term solutions for the Access to Argyll and Bute (A83) project.

Several key stakeholder groups, including the A83 Taskforce and Environmental Steering Group (ESG) have been set up to represent communities and businesses to ensure they are kept up to date with the development of the project and to provide an opportunity to gather feedback. The DMRB Stage 2 engagement on the project has included:

- Preferred Route Corridor Consultation – 18th March 2021. The purpose of this consultation was threefold. Firstly, to gain feedback on the selection of Route Corridor 1 as the preferred route corridor. Secondly, to seek feedback on the five initial route options presented as part of a Pre DMRB Stage 2 works. Thirdly, to invite feedback specifically on any other route options which members of the public felt should be considered within Glen Croe. This information helped inform the full DMRB Stage 2 assessment.
- Updates to the A83 website in December 2022
- Ongoing updates to the A83 Story Map. The A83 Story Map includes an accessible library of information on the project and is updated accordingly and at key intervals. It also provides contact details where feedback can be provided at any time.
- Meetings with A83 Taskforce to provide updates on the project and to seek their feedback. The minutes of the meetings are made available to download from the Transport Scotland project website.
- Meetings with the Environmental Steering Group to provide them with updates on the project and to seek their feedback.
- Meetings with landowners in the preferred corridor.
- Meeting with Statutory Consultees.

Our specialist lands team acts as a key point of contact with the stakeholders, supported by engineering and environmental specialists, where appropriate.

The main stakeholder groups are as follows:

Statutory Consultees

- Argyll & Bute Council
- Loch Lomond & Trossachs National Park Authority
- Nature Scot (Scotland's Nature Agency, formerly Scottish Natural Heritage)
- Historic Environment Scotland
- Scottish Environment Protection Agency (SEPA)
- Scottish Forestry

Communication with the statutory consultees is via the Environmental Steering Group, A83 Taskforce and specific meetings/correspondence as required.

Specialist Groups

These groups were established to support the delivery of a solution to the A83 and continue to be involved in the delivery of the project:

- A83 Environmental Steering Group (ESG)
  - Argyll & Bute Council
  - Loch Lomond and the Trossachs National Park Authority
  - Nature Scot
  - Historic Environment Scotland
  - Scottish Environment Protection Agency (SEPA)
  - Scottish Forestry
- A83 Taskforce

The A83 Taskforce is presided over by the Minister for Transport and was set up in August 2012 in response to the issues faced in Glen Croe. The A83 Taskforce is made up of and represents a variety of stakeholders, including the local authority, national park authority, community councils, local business, hauliers and numerous other interested parties.

Meetings are now held with the A83 Taskforce three times a year noting to date there has been 23 meetings regarding the project.

Other Stakeholders

Furthermore, there is ongoing consultation with potentially impacted landowners, nearby community councils, trusts, businesses and active and sustainable travel groups in addition, to utility and emergency services providers.

1.5. DMRB Stage 2 Scheme Assessment Report

This DMRB Stage 2 Scheme Assessment Report for the Access to Argyll and Bute (A83) has been prepared in accordance with the guidance for ‘Preparation of the Stage 2 Report’ contained in the DMRB, Volume 5, Section 1, Part 2, TD 37/93 ‘Scheme Assessment Reporting’.

The report describes the existing conditions within the preferred corridor of the A83 and presents a series of refined Scheme Options from the previously developed five route options to increase the resilience of the A83 from landsides associated with the Beinn Luibhean slope and to ensure safer and more resilient traffic operations.

At DMRB Stage 2, the refined Scheme Options have been appropriately developed to enable an assessment of their comparative impact and performance and to enable the appraisal of costs, engineering, traffic and environmental impacts of each. The Scheme Options are presented in Chapter 3.

Alignments for each Scheme Option have been modelled in three-dimensions, and preliminary layout drawings have been prepared for structures. These are presented in Volume 2 of this Stage 2 Scheme Assessment Report.

1.6. Report Structure

This report has been prepared according to the principles set out in the guidance on the preparation of Stage 2 Report given under DMRB TD 37/93's 'Scheme Assessment Reporting' as per Annex B.

To accommodate the extent of information being presented, the report is divided into three volumes, as follows:

- Volume 1 – Main Report and associated Appendices
- Volume 2 – Engineering Drawings
- Volume 3 – Environmental Drawings.

Volume 1 (Main Report and associated Appendices) is further sub-divided into six parts as outlined below:

- Part 1 – Project Background, the existing conditions along the preferred corridor and the options developed for assessment.
- Part 2 – Engineering Assessment – Presents the Scheme Options being developed in more detail and outlines the engineering factors under consideration in the development and assessment of these options.

- Part 3 – Environmental Assessment Report – Considers the environmental baseline conditions and assesses the Scheme Options against environmental criteria in accordance with the requirements of the DMRB.
- Part 4 – Traffic and Economic Assessment – Outlines the traffic and economic modelling and forecasting work undertaken and assesses the effects and impacts of the Scheme Options under consideration.
- Part 5 – Summary and Recommendations – summarises the various aspects of the assessment to enable a recommendation to be made on a Preferred Route.
- Part 6 – Appendices – Various supporting tables and collated information relevant to the assessments undertaken.

2. Existing Conditions

2.1. Introduction

This chapter describes the existing engineering conditions of, and adjacent to, the A83 within the preferred corridor. The conditions relating to the scheme location, including topography, climate, land use, geology and hydrology are described. The conditions of the existing A83, B828 and the OMR have been considered in detail, with engineering factors including:

- Accident data
- Geometric design standards (speed limits, alignment, cross-section)
- Traffic conditions
- Diversions routes
- Pavement
- Junctions and accesses
- Structures (including culverts and retaining walls)
- Hydrology, drainage and the water environment
- Roadside features
- Active travel facilities
- Utilities
- Public transport provision

2.2. Location and Context of the Scheme

2.2.1. Location

The preferred corridor consists of the existing Glen Croe valley starting from a point approximately 460m south-east of the intersection of the A83 and the OMR and ending at a point on the existing A83 at the south-east end of Glen Kinglas near Butterbridge. Figure 2-1, below, identifies the scheme location and extents of the Glen Croe corridor shown in red dash line. The existing conditions have been assessed along the A83 considering potential impacts and relevance to the Scheme Options.

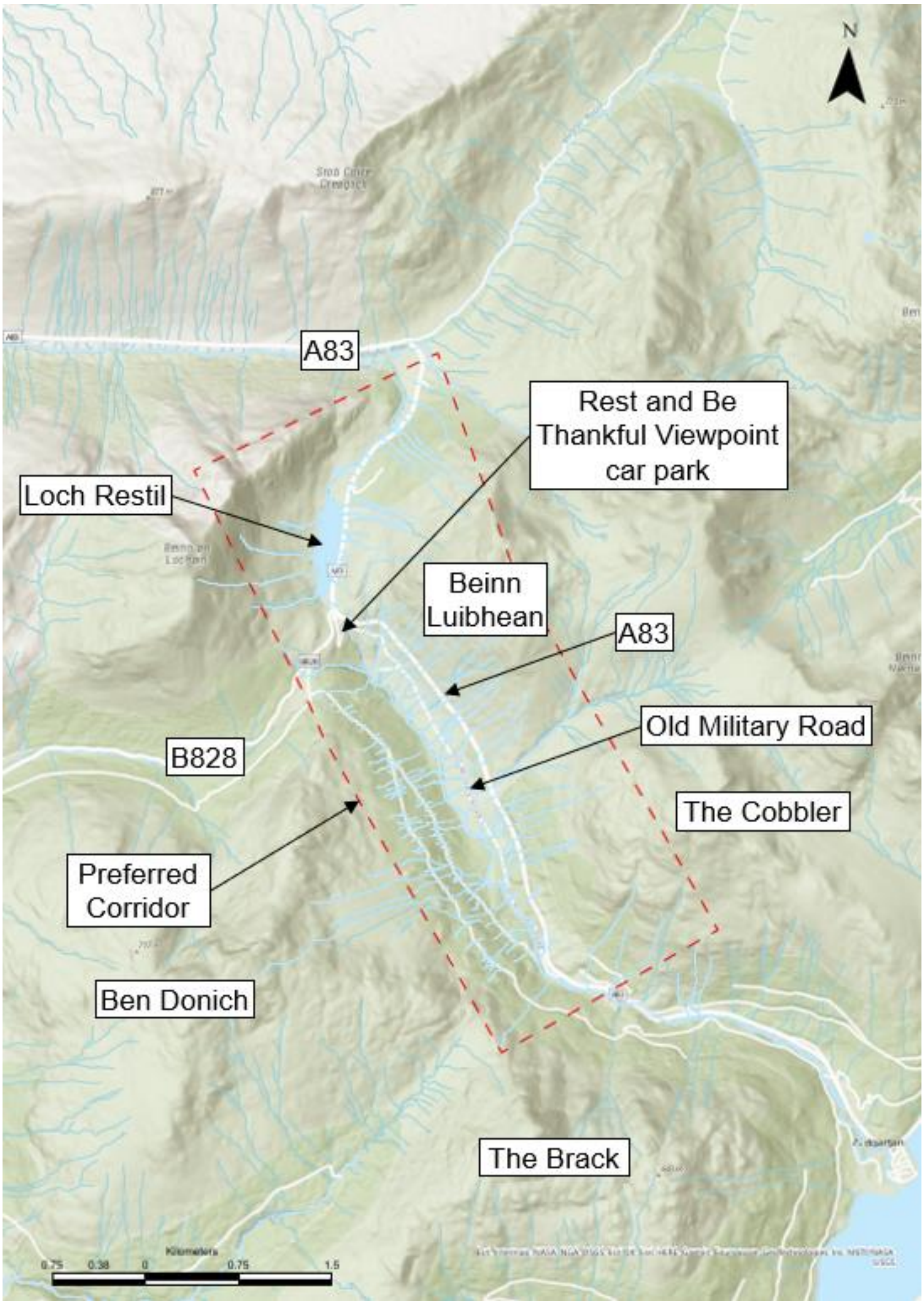

Figure 2-1 - Glen Croe corridor extents

Drawing series A83AAB-AWJ-GEN-LTS_GEN-DR-CX-000001 to A83AAB-AWJ-GEN-LTS_GEN-DR-CX-000004 contained in Volume 2 illustrates the existing conditions and includes chainages along the existing A83 which have been used in this chapter for reference.

2.2.2. Topography

Within the preferred corridor, the A83 traverses through Glen Croe, which is flanked on both sides by various mountains namely The Cobbler, Cruach Fhiarach, The Brack, Ben Donich, Beinn Luibhean, and Beinn an Lochain. The existing ground levels along the preferred corridor rise from circa 85m above ordnance datum at the south-east extents of the corridor to a height of circa 265m above ordnance datum at the north-eastern extents of the corridor adjacent to the Rest and Be Thankful viewpoint car park. Ground levels on the eastern side of Glen Croe rise steeply to the summits of The Cobbler, at approximately 884 metres above ordnance datum and Beinn Luibhean, at approximately 858 metres above ordnance datum. On the western side of Glen Croe ground levels again rise steeply to the summit of Ben Donich, at approximately 847 metres above ordnance datum.

The existing conditions drawings A83AAB-AWJ-GEN-LTS_GEN-DR-CX-000001 to A83AAB-AWJ-GEN-LTS_GEN-DR-CX-000004 contained in Volume 2 exhibit existing contours at 5 metres intervals.

2.2.3. Climate

The preferred corridor has been noted for its cold and wet climate. Met Office (2021) reported an annual average maximum temperature of 11.65°C in the West of Scotland for the period between 1991 and 2020. The Centre for Ecology and Hydrology (2021) reported an annual average rainfall of roughly 3145mm in Glen Falloch (located around 11km north-east of the preferred corridor). Met Office 2021 data for the period between 1991 and 2020 indicates that Scotland receives an average annual rainfall of 1573.32mm.

The current road network may be impacted by climate change in a number of ways. SEPA guidance (SEPA, 2019) includes allowances for peak rainfall, peak river flows and sea levels. Between now and 2100, it is expected that peak river flow allowances will rise by 56% in the Argyll River Basin Region and by 44% in the Clyde River Basin Region, both of which the A83 traverses.

2.2.4. Land Use

Residential and Commercial Property

There are six properties within the preferred corridor, including two residential properties, one located to the south adjacent to the A83, south of the Croe Water bridge and the other at the northern end of the corridor on the valley floor below the Rest and Be Thankful viewpoint car park. Along the valley floor, adjacent to the OMR, there are four outbuildings/livestock sheds.

Agriculture

Within the preferred corridor, the land use is mostly agricultural and commercial forestry in the form of coniferous plantation woodland on the adjacent slopes, including portions of The Brack and Ben Donich on the south-western side, and The Cobbler on the north-eastern side.

Forestry

Ardgartan forest can be found to the west of the existing A83 within the preferred Corridor.

Development Land

A desk study indicates that there are no relevant planning applications within the preferred corridor.

2.2.5. Geology, Geomorphology and Ground Conditions

General

Information for the geotechnical assessments has been gathered from available desk study information (Access to Argyll and Bute (A83) Preliminary Sources Study Report), supplemented by field walkovers and information from the Preliminary Ground Investigation for the Proposed Scheme. An overview of the consulted information is included in Table 2-1 while an overview of the consulted published reports is presented in

Table 2-2.

A full discussion of the anticipated geotechnical conditions is presented in the Access to Argyll and Bute (A83) Preliminary Sources Study Report (A83AAB-JAC-HGT-COR_01-RP-GI-0028) prepared by Jacobs/Aecom JV. A summary of the anticipated geotechnical conditions is presented below and in Table 2-3. Reference should also be made to the following drawings as contained in Volume 2:

- Superficial Geology (Drawing ref A83AAB-AWJ-EGT-LTS_GEN-DR-VT-000125)
- Solid Geology (Drawing ref. A83AAB-AWJ-EGT-LTS_GEN-DR-VT-000124)
- Geotechnical Constraints and Hazards (Drawing ref A83AAB-AWJ-EGT-LTS_GEN-DR-VT-000123)
- Green Option - Exploratory hole plan and profile (Drawing ref. A83AAB-AWJ-HGT-LTS_LA0-DR-GE-000001 to A83AAB-AWJ-HGT-LTS_LA0-DR-GE-000003)
- Yellow Option - Exploratory hole plan and profile (Drawing ref. A83AAB-AWJ-HGT-LTS_LB3-DR-GE-000001 and A83AAB-AWJ-HGT-LTS_LB3-DR-GE-000002)
- Brown Option - Exploratory hole plan and profile (Drawing ref. A83AAB-AWJ-HGT-LTS_LC3-DR-GE-000001 and A83AAB-AWJ-HGT-LTS_LC3-DR-GE-000002)
- Purple Option - Exploratory hole plan and profile (Drawing ref. A83AAB-AWJ-HGT-LTS_LD1-DR-GE-000001 to A83AAB-AWJ-HGT-LTS_LD1-DR-GE-000003)
- Pink Option - Exploratory hole plan and profile (Drawing ref. A83AAB-AWJ-HGT-LTS_LEA-DR-GE-000001 to A83AAB-AWJ-HGT-LTS_LEA-DR-GE-000003)

Sources of Information

Table 2-1 - Information consulted

Information Type	Title / Source
Topography	Ordnance Survey mapping Google Earth Pro aerial photography, 2003 - 2021 Geo-Rope, Drone Survey Imagery, 2019 - 2020 Fugro, Aerial Imagery, 2021
Geological information	British Geological Survey (BGS) Geological Datasets: 1:50 000 scale

Information Type	Title / Source
	Solid Superficial Linear Mass Movement Artificial 1:10 000 scale Superficial Linear Mass Movement Artificial BGS Geosure Dataset v8. 1:50 000 scale Debris Flow Landslide Compressible Ground Collapsible Deposits Soluble Rocks Running Sand Shrink Swell BGS Civils Dataset 1:50 000 scale Bulking volume Corrosivity (ferrous) Discontinuities Engineered fill Excavatability Foundation conditions Strength Sulfate/sulfide British Geological Survey (BGS) GeoIndex Onshore

Information Type	Title / Source
	BGS, Lexicon of Named Rock Units BGS, Geological Survey of Scotland, 1:50,000 Geological Map Series, Solid, Sheet 37E, Lochgoilhead, 1990 BGS, Geological Survey of Scotland, 1:50,000 Geological Map Series, Solid, Sheet 38W, Ben Lomond, 1987 BGS, Geological Survey of Scotland, 1:63,360 Geological Map Series, Solid, Sheet 38, Loch Lomond, 1901; BGS, Memoirs of the Geological Survey of Great Britain (Scotland), The Geology of Mid-Argyll (Explanation of Sheet 37) BGS, 1:10,000 Superficial Geology Mapping dataset, currently undergoing review within the BGS Finlayson, Glacial conditioning and paraglacial sediment reworking in Glen Croe (the Rest and Be Thankful), western Scotland, 2020. Scottish National Heritage - Carbon and peatland 2016 map
Hydrology and hydrogeology	SEPA, Water Environment Hub (WEH) interactive map SEPA, Flood Risk Management Maps SEPA, Flood Maps datasets BGS, Groundwater Flooding Susceptibility dataset BGS, 1:625,000 Hydrogeological Map Series, Sheet 18, 1988 BGS, GeoIndex Onshore BGS, User Guide: Aquifer Productivity (Scotland) GIS datasets BGS, User Guide: Groundwater Vulnerability (Scotland) GIS dataset
Ground Investigation	H.T.S Associates - A83 Rest and be Thankful Rockhead Location Investigation (February 1997) Land-Drill Geotechnics Ltd. - Rest and be Thankful Replacement Culvert and Road Embankment (June 2009) Geo-Rope - A83 Rest and be Thankful, Factual Ground Investigation Summary Report (September 2017)

Information Type	Title / Source
	Geo-Rope – Probe holes and core holes report, Phase 8 (June 2018) Geo-Rope – Probe holes report, Phase 1 (May 2019) DAM Geotechnical Services Ltd – Factual Report on Ground Investigation at A83 Rest and Be Thankful (July 2019) Geo-Rope – Bore Hole Report, Phase 6 (August 2019) Geo-Rope – Rotary Core Report, Phase 6 (August 2019) Geo-Rope – Test pit report, Phase 6 (September 2019) DAM Geotechnical Services Ltd – Geophysical Survey Report Upslope of A83 Trunk Road Phase 5 & 6 Proposed Catch Pits near the Rest and Be Thankful Argyll and Bute (December 2019) DAM Geotechnical Services Ltd – Geophysical Survey Report downslope between A83 Trunk Road and OMR near the Rest and Be Thankful Argyll and Bute (January 2020) Geo-Rope – Probe Hole Report, Phase 6 (March 2020) DAM Geotechnical Services Ltd – Geophysical Survey Report Upslope of A83 Trunk Road Phase 3b Proposed Catch Pit Near the Rest and Be Thankful Argyll and Bute (October 2020) Jacobs – A83 RaBT Form: OMR Trial Pits (November 2020) Raeburn Drilling and Geotechnical Ltd – Access to Argyll and Bute (A83) Report on Preliminary Ground Investigation (September 2022 – Draft Report)
Historical Information	Canmore. (n.d.). Dumbarton - Tarbet - Inveraray - Tyndrum Military Road. Retrieved April 2023, from https://canmore.org.uk/site/126746/dumbarton-tarbet-inveraray-tyndrum-military-road National Library of Scotland. (n.d.). Argyllshire, Sheet CXXXIV. Retrieved April 17, 2023, from https://maps.nls.uk/view/228776134

Information Type	Title / Source
	National Library of Scotland. (n.d.). Sheet 61 - Oban & Loch Awe - Popular Edition. Retrieved April 2023, from https://maps.nls.uk/view/193108743 National Library of Scotland. (n.d.). Sheet 61 - Oban & Loch Awe - War Revision, 1940 [Popular edition marginalia]. Retrieved April 2023, from https://maps.nls.uk/view/193108740

Table 2-2 - Reports consulted

Report Name	Date
British Geological Survey, Rest and Be Thankful Pass, A83, Argyll and Bute (2012), Landslide Case Study, [Online]. Available: https://www.bgs.ac.uk/case-studies/rest-and-be-thankful-pass-a83-argyll-and-bute-2012-landslide-case-study/.	2012
AECOM, July 2016 - A83 Rest & be Thankful/review of existing mitigation measures – phases 1 to 12	July 2016
Transport Research Laboratory, Monitoring and Modelling of Landslides in Scotland, Characterisation of Slope Geomorphological Activity and the Debris Flow Geohazard (Report Reference: PPR852, Issue 1)	March 2018
Transport Research Laboratory, "The Quantitative Assessment of Debris Flow Risk to Road Users on the Scottish Trunk Road Network, A83 Rest and be Thankful (Report Reference: PPR798, Issue 1)	October 2018
Jacobs, A Proposed Methodology to Characterise the Hazard Posed by Boulders: A Case Study from Glen Croe (Document Number: B2359902/TGE/REP/01|2, Revision 2, Final)	August 2020
BEAR Scotland RaBT Monitoring Reports: 4G Annual Monitoring Report, Rest and Be Thankful 2019/2020 4G Annual Monitoring Report, Rest and Be Thankful 2018/2019 4G Annual Monitoring Report, Rest and Be Thankful 2017/2018 4G Annual Monitoring Report, Rest and Be Thankful 2016/2017 4G Annual Monitoring Report, Rest and Be Thankful 2015/2016 4G Annual Monitoring Report, Rest and Be Thankful 2014/2015 4G Annual Monitoring Report, Rest and Be Thankful 2013/2014	2013-2020
Jacobs, Access to Argyll and Bute (A83) Preliminary Sources Study Report Corridor 1, A83AAB-JAC-HGT-COR_01-RP-GI-0028 | C03, April 2022	April 2022

Information Excluded from the Assessment

At the time of writing, the reporting for the Preliminary Ground Investigation is ongoing. However, the assessment has considered the draft factual report on the Preliminary Ground Investigation, which is dated September 2022, therefore this has not adversely impacted the assessment.

In addition, a selection of assessments in connection with scheme development are ongoing and will be considered further as part of the Stage 3 assessment. These include;

- Inspection and assessment of existing earthwork/rock cut assets
- Assessment of impact and risk posed by hazards within and beyond the proposed construction footprint including but not limited to:
  - Debris flow
  - Slope instabilities - Landslides
  - Rockfall

Geomorphology and Natural Terrain Hazards

The geomorphology of the land within the study area can be broadly summarised as attributable to processes during the last glacial period. The southern and central sections of the study area are characterised by the glacial u-shaped valley of Glen Croe. The glen is flanked by the slopes of Beinn Luibhean (858m), the Cobbler (Ben Arthur – 884m), The Brack (787m), Ben Donich (847m), and Beinn an Lochain (901m). Loch Restil is situated immediately north of the main valley of Glen Croe. Coire Croe is a hanging valley situated between Beinn Luibhean and the Cobbler adjacent to Glen Croe.

A significant proportion of the slopes of Glen Croe have been highlighted in the GeoSure Debris Flow dataset as having high susceptibility to debris flow. The GeoSure landslide dataset also records large areas on both valley sides as having a high probability of active landslide activity or for these to have occurred in the past.

Multiple historical landslides are recorded on the National Landslide Database provided in the BGS GeoIndex within the study area, on the west facing slopes of Beinn Luibhean and locally on the west facing slopes of The Cobbler. Historical landslides and mass movement deposits have been recorded on the east facing slopes of Ben Donich. Significant proportions of the slopes, particularly on The Cobbler and Ben Donich, have dense forestry cover which may obscure evidence of previous landslides.

The west facing slopes of Beinn Luibhean are recorded as having significant issues with debris flows impacting the existing A83 route. Events have also been recorded elsewhere in the study area including the north-west facing slope of Beinn Luibhean, and the south-west and west facing slopes of the Cobbler. Scarps from past debris flows are visible throughout the route areas on the available LiDAR and aerial imagery.

Rockfall events from the slopes above the A83 have been recorded impacting the existing A83 route. A significant number of large (>3m length) boulders can be observed on the slopes above the existing A83 on the available aerial imagery, with some boulders being observed further downslope and within forested areas during walkovers. Rock exposures are present within the study area above the proposed route alignments with recorded intersecting joint sets that may result in rockfall.

Debris flow barriers and rockfall catch fences have been installed across the Beinn Luibhean slopes above the A83. In addition, catchpits have been excavated adjacent to the A83 to retain landslide debris and prevent it from impacting the road. There are currently two existing catchpits, which have areas of soil nailing and rock bolts to stabilise the walls of the pits. Adjacent to the OMR, a 6.6m high, 175m long, temporary HESCO barrier has been constructed to reduce the likelihood of debris flow material from impacting the OMR.

Other ground improvement and remediation works have been undertaken at various locations throughout the site. These including the installation of retaining walls, soil nails, slope drainage and erosion control measures.

Existing Ground Conditions

Made ground is present locally across the study area associated with the existing A83, OMR, forestry tracks and Rest and Be Thankful viewpoint car park. There is also made ground associated with existing ground stabilisation and landslide mitigation measures. Made ground encountered during ground investigations includes tarmac layers, engineered and non-engineered fill.

The natural superficial deposits underlying the site are reported to comprise:

- Peat: Surface deposits and buried peat have been identified across the study area with recorded thicknesses ranging from 0.2m to 1.5m. The peat is generally described as soft to firm dark brown slightly sandy slightly silty fibrous peat. Plastic pseudo-fibrous peat and plastic amorphous peat have also been recorded.
- Alluvium and River Terrace Deposits: Based on the published geology, alluvium, alluvial fan deposits and river terrace deposits are anticipated to be present within the Glen Croe valley floor, locally underlying the OMR, and surrounding Loch Restil. Descriptions of the deposits vary from loose orangish brown slightly gravelly silty fine to coarse sand to very loose to medium dense greyish brown very sandy silty fine to coarse subangular and subrounded gravel. Laminations of sandy clay and silt and lenses of peat are expected to occur locally within these deposits.
- Colluvium: Colluvial deposits are expected throughout the study area with thicknesses and extents highly dependent on the locations, types, and volumes of historical failure events. Available data indicates that colluvial deposits may be encountered overlying or interbedded with topsoil, peat, alluvial and glacial deposits. Typical descriptions of these deposits include loose to medium dense silty or clayey sands and gravels with varying proportions of subrounded to angular cobbles and boulders of schist. For the purposes of this assessment, debris flow deposits have been considered within the overall category of colluvium.
- Glacial deposits: Published geological maps indicate both hummocky (moundy) glacial deposits and glacial till within the study area. Typical descriptions of the glacial deposits identify granular material comprising dense to very dense light brown to brown slightly silty or clayey fine to coarse sand and angular to subangular fine to coarse gravel with occasional angular to subangular cobbles and boulders of schist.
- Weathered bedrock: A layer of weathered bedrock overlying the competent bedrock has been interpreted in various exploratory holes. Descriptions of the material interpreted as weathered bedrock typically comprise drillers' descriptions of soft rock denoting weathered or degraded bedrock, fractured rock with fine silt and/or voids, broken schist and fractured schist.

Available data and site reconnaissance indicates that bedrock is at or near the surface at across the higher ground and at the northern extent of Glen Croe. Within the lower parts of Glen Croe and around Loch Restil the depth to bedrock increases, with recorded thickness of superficial deposits up to approximately 18m.

The bedrock geology beneath the site is reported to comprise metamorphic strata of the Beinn Bheula Schist Formation and igneous intrusions of the South of Scotland Granitic Suite and North Britain Siluro-Devonian Calc-Alkaline Dyke Suite. The bedrock is recorded as consisting of:

- Psammite: described as “strong and very strong very narrowly and narrowly banded schistose grey psammite with very closely spaced very narrow and narrow white quartzite, dark grey semi-pelite and dark grey pelite bands”.
- Pelites and semi-pelite: described as “strong and very strong very narrowly and narrowly banded schistose dark greenish grey pelite with extremely closely and very closely spaced very narrow to thin dark grey semi-pelite bands”.
- Dolerite/Diorite: Igneous strata encountered during the intrusive investigations have generally been identified as dolerite. The dolerite is typically described as “very strong dark grey dolerite with very narrow (0.5mm-2mm thick) closely spaced grey quartz veins; Slightly weathered evident as slight loss of strength and green staining on fracture surfaces”. Diorite has also been recorded banded with layers of finer grained dolerite.

A number of generally north-east/south-west trending faults are mapped within the north and west of the study area, intersecting all of the proposed route alignments. The type and displacement of these faults are not recorded, however there is a visible discontinuity within the bedrock outcrops at these locations aligned with the proposed fault location, as these discontinuities follow generally straight lines across the topography, they are likely close to vertical and steeply dipping.

Fault breccia has been recorded in five boreholes undertaken for the Preliminary Ground Investigation. Four boreholes (AAB-BH1002, AAB-BH1027A, AAB3-BH1032 and AAB-BH1037i) are located close to the valley floor, with one borehole (AAB-BH1044) located on the upper forestry track on the western slopes of Glen Croe. At borehole AAB3-BH1032, artesian groundwater conditions have been recorded associated with the fault zone.

Scheme Option Summaries

A summary of the ground conditions and potential geotechnical hazards affecting the five Scheme Options are presented in Table 2-3, below.

Table 2-3 - Scheme Option Summaries

Option	Summary
Green Option	Geological Conditions Made ground deposits are mapped in the BGS 1:10k dataset and recorded within boreholes undertaken for the Preliminary Ground Investigation. The made ground is associated with the existing A83 and OMR, and existing forestry tracks. Alluvium is mapped between approximately Ch0 and Ch200 and Ch600 to Ch750 with alluvial fan deposits identified between Ch200 and Ch400. From approximate Ch400 to Ch600, Ch750 to Ch 900, Ch1700 to Ch1800 and at the northern tie-in Ch4150 to Ch4221, hummocky glacial deposits are mapped. Glacial till is mapped between Ch1800 and Ch3500. In addition, colluvium and mass movement deposits are recorded on the slopes of Ben Donich above the proposed route alignment. Very loose and loose sands and gravels have been recorded at various exploratory holes in the vicinity of the Green Option, to a maximum depth of 12.1m bgl. Peat is mapped adjacent to Loch Restil at Ch4050 to 4150. Small pockets and thin bands of peat/peaty soil are also recorded within deposits of alluvium and colluvium, as identified at trial pit AAB-TP1001, located adjacent Ch300. There are no recorded superficial deposits between Ch900 and Ch1700 or Ch3500 and Ch4050, which indicates that bedrock is shallow. This is confirmed by the visibility of bedrock outcrops on aerial imagery. Within borehole logs, thin deposits of non-intact weathered bedrock are recorded across the study area. This is described as broken and weathered Schist (drillers log). The predominant underlying bedrock for the Green Option alignment is the Beinn Bheula Schist Formation, consisting of

Option	Summary
	foliated pelite, semi-pelite, psammite, and quartzite. Igneous intrusions of the North Britain Siluro-Devonian Calc-Alkaline dyke suite are recorded between Ch3500 and Ch4050 consisting of lamprophyre. **Groundwater Conditions** Ground water strikes have been recorded at nine exploratory holes along the Green Option, at depths ranging between 0.8m bgl and 5.5m bgl. Groundwater levels have been monitored at 13 boreholes from the Preliminary Ground Investigation. The groundwater levels vary from 0.42m bgl to 11.1m bgl, with typical depths less than 3.5m bgl. **Potential Geotechnical Hazards** The geological conditions indicate the following potential hazards: Peat/organic soils Soft clays and silts (alluvium) Very loose and loose granular deposits Presence of boulders and obstructions in superficial deposits Bedrock stability Bedrock excavatability High groundwater table In addition, natural hazards are also present: Debris flows - Incised channels and potential slope failures scarps can be observed within the aerial/LiDAR imagery available adjacent to the route. Rockfall/Boulder fall - Large boulders are visible on the slopes of Ben Donich above the proposed Green Option alignment, with the potential for these to roll and impact the road. Flooding – At its southern extent, the proposed Green Option alignment passes through areas mapped as having a high likelihood for river and surface water flooding.

Option	Summary
Yellow Option	Geological Conditions Made ground has been identified associated with the northern and southern tie-ins to the existing A83 and along the OMR. Along the Yellow Option, hummocky glacial deposits are mapped from Ch0 to Ch200, Ch750 to Ch800 and Ch2350 to Ch2522 at the northern tie-in. Debris flow deposits are mapped from Ch200 to Ch350, Ch900 to Ch1000 and Ch1350 to Ch1750. These debris flow deposits are likely underlain by glacial till. Alluvial fan deposits are mapped from Ch350 to Ch750, Ch800 to Ch900 and Ch900 to Ch1350. Alluvium is mapped surrounding Croe Water in the base of the glen, with the potential for soft, compressible sediments to be present. In addition, very loose and loose sands and gravels have been recorded at various exploratory holes in the vicinity of the Yellow Option, to a maximum depth of 8.0m bgl. Peat is mapped adjacent to Loch Restil at Ch2250 to Ch2350. Small pockets and thin bands of peat/peaty soil are recorded are known to occur in other lithological units including debris flow deposits and colluvium. Buried peat up to 1.5m thick has been recorded in exploratory holes upslope of Ch500 to Ch1200. Within borehole logs, up to 5.1m of non-intact weathered bedrock has been recorded. This is described as very gravelly fine to coarse sand. There are no recorded superficial deposits between Ch1750 to Ch2250 indicating shallow bedrock. This is confirmed by the visibility of bedrock outcrops on aerial imagery and boreholes within this section have encountered bedrock at shallow depths. Bedrock is generally identified as the Beinn Bheula Schist formation comprising of foliated pelite, semi-pelite, psammite and quartzite. Igneous intrusions of the North Britain Siluro-Devonian

Option	Summary
	Calc-Alkaline dyke suite are recorded between Ch2100 to Ch2250 consisting of lamprophyre. Groundwater Conditions Groundwater strikes have been recorded at eight exploratory holes along the Yellow Option at depths ranging between 0.2m bgl and 6.7m bgl. At borehole AAB-BH1032, which is located at approximate Ch1580, artesian groundwater conditions were noted following intersection of faulted zones at 20.02m bgl and 24.0m bgl. Groundwater levels have been monitored in 12 boreholes from the Preliminary Ground Investigation and 5 boreholes undertaken in 2009 as part of an investigation for culvert replacements. The groundwater levels vary from ground level to 12.55m bgl, with typical depths less than 4m bgl. Potential Geotechnical Hazards The geological conditions indicate the following potential hazards: Peat Deposits/Peaty soils Very loose and loose granular deposits Presence of boulders and obstructions in superficial deposits Soft clays and silts (alluvium) High groundwater table In addition, natural hazards are also present: Debris flow - Debris flows have regularly been recorded on the western slopes of Beinn Luibhean, above the proposed alignment at Ch400 to Ch1850. A significant number of scarps, material deposited by debris flows, and steeply incised, scoured channels are visible on this slope. There are also a smaller number of debris flows recorded associated with the west facing slopes of the Cobbler above Ch0 to Ch200. There are visible incised channels and scarps on this slope.

Option	Summary
	Rockfall/Boulder fall - Large boulders are visible on the slopes of Beinn Luibhean and the Cobbler above the proposed route alignment with the potential for these to roll and hit the road. Large boulders have also been observed within forested areas during site walkovers. Rock outcrops of the Beinn Bheula Schist are present above the route alignment with recorded intersecting discontinuity sets that allow for potential rockfall issues, such as wedge and topple failure. Flooding – Where the Yellow Option crosses the Croe Water there are areas of low through to high likelihood of river flooding.
Brown Option	Geological Conditions Made ground can be expected to be encountered along the length of the existing A83 alignment. The made ground includes tarmac layers, engineered and non-engineered fill. Given the age of the original construction of the A83, the tarmac layers may be contaminated with tar or tar-bitumen binders Along the route of the Brown Option hummocky glacial deposits are mapped from Ch0 to Ch150, Ch300 to Ch450, and Ch2350 to Ch2396 at the northern tie-in. Debris flow deposits are mapped from approximate Ch150 to Ch300, Ch450 to Ch1650 on the lower slopes of Beinn Luibhean and the Cobbler. These debris flow deposits are likely underlain by glacial till. Glacial Till is recorded from Ch1650 to Ch1850. Very loose and loose sands and gravels have been recorded at various exploratory holes in the vicinity of the Brown Option, to a maximum depth of 11.7m bgl. Peat is mapped from Ch2300 to Ch2350 associated with the low topography next to the existing A83 road adjacent to Loch Restil. Small pockets and thin bands of peat/peaty soil are recorded within other lithological units including debris flow deposits and colluvium.

Option	Summary
	Thin peaty topsoil (≤0.4m depth) have been recorded at exploratory holes in the vicinity of the Brown Option. Within borehole logs, thin layers of non-intact weathered bedrock have been recorded overlying competent bedrock. This is described as a broken weathered schist, and psammite (drillers logs). There are no recorded superficial deposits between Ch1850 and Ch2300 indicating shallow bedrock and/or thin superficial deposits. This is confirmed by the visibility of bedrock outcrops on aerial imagery and bedrock being encountered at shallow depths within boreholes in the vicinity of this section of the alignment. The predominant underlying bedrock for the Brown Option alignment is the Beinn Bheula Schist, consisting of foliated pelite, semi-pelite, psammite, and quartzite. An intrusion of the South of Scotland Granitic Suite is present between Ch150 and Ch750. This appears to have been exploited at the disused quarry upslope of Ch700, where exposures of dolerite/diorite have been mapped. Igneous intrusions of the North Britain Siluro-Devonian Calc-Alkaline dyke suite are mapped between Ch2100 and Ch2300 consisting of lamprophyre. Rock outcrops above the route alignment have intersecting discontinuity sets that allow for potential rockfall issues, such as wedge and topple failure. Faulting is also visible in some existing catchpits that may lead to rock slope stability issues. Groundwater Conditions Groundwater strikes have been recorded at 18 exploratory holes along the Brown Option alignment, with depths varying from 0.25m bgl to 7.7m bgl. Groundwater levels have been monitored in seven boreholes from the Preliminary Ground Investigation and seven boreholes undertaken in 2009 as part of an investigation for culvert replacements. The groundwater levels vary from 0.15m bgl to 7.48m bgl, with typical depths less than 4m bgl.

Option	Summary
	Potential Geotechnical Hazards The geological conditions indicate the following potential hazards: Made ground – potential contaminants within tarmac layers Peat/organic soils Very loose and loose granular deposits Presence of boulders and obstructions in superficial deposits Bedrock stability Bedrock excavatability High groundwater table In addition, natural hazards are also present: Debris flow - Debris flows have regularly been recorded on the western slopes of Beinn Luibhean, above the proposed alignment at Ch400 to Ch1850. A significant number of scarps, material deposited by debris flows, and steeply incised, scoured channels are visible on this slope. There are also a smaller number of debris flows recorded associated with the west facing slopes of the Cobbler above Ch0 to Ch200. There are visible incised channels and scarps on this slope. Rockfall/Boulder fall - Large boulders are visible on the slopes of Beinn Luibhean and the Cobbler above the proposed route alignment with the potential for these to roll and hit the road. Large boulders have also been observed within forested areas beneath Ben Arthur during site walkovers. Flooding – The potential for river flooding has been identified associated with the crossing of the Croe Water at the southern extent of the Brown Option.
Purple Option	Geological Conditions Made ground has been identified associated with the northern and southern tie-ins to the existing A83 and along the OMR.

Option	Summary
	Along the Purple Option, hummocky glacial deposits are mapped between Ch0 and Ch300, Ch500 and Ch550, Ch800 and Ch850, and Ch3250 to Ch3500. Debris flow deposits are mapped between Ch300 and Ch400, and Ch1600 to Ch1850. These debris flow deposits are likely underlain by glacial till. Alluvial fan deposits are mapped from Ch400 to Ch500, Ch550 to Ch800, and Ch850 to Ch600. Alluvium is mapped surrounding Croe Water in the base of the glen, with the potential for soft, compressible sediments to be present. Colluvium is mapped from Ch3100 to Ch3250. This colluvium is likely underlain by glacial deposits. Very loose and loose sands and gravels have been recorded at various exploratory holes in the vicinity of the Purple Option, to a maximum depth of 8.8m bgl. Peat is recorded north of Loch Restil underlying the proposed junction alignment at the northern end of the Purple Option. Small pockets and thin bands of peat/peaty soil are known to occur within other lithological units including debris flow deposits and colluvium. Buried peat up to 1.5m thick has been recorded in exploratory holes upslope of Ch600 to Ch1300. Within borehole logs, up to 5.1m of non-intact weathered bedrock is recorded overlying competent bedrock. This is described as very gravelly fine to coarse sand. The majority of the route alignment cuts through the Beinn Bheula Schist Formation, consisting of foliated pelite, semi-pelite, psammite, and quartzite. Igneous intrusions of the North Britain Siluro-Devonian Calc-Alkaline dyke suite are recorded at Ch2000 to Ch2400. Two north-south trending faults are shown on the BGS 1:50 000 linear dataset at Ch1950 and Ch2250. The nature and

Option	Summary
	displacement of these faults is not recoded. There are visible discontinuities within the bedrock outcrops at these locations, which suggest the faults are close to vertical/steeply dipping. Faulting may cause groundwater and rock stability issues during tunnel construction. Groundwater Conditions Groundwater strikes have been recorded at nine exploratory holes along the Purple Option alignment, with depths varying from 0.2m bgl to 6.7m bgl. At borehole AAB-BH1032, which is located adjacent approximate Ch1650, artesian groundwater conditions were noted following intersection of faulted zones at 20.02m bgl and 24.0m bgl. Groundwater levels have been monitored in thirteen boreholes from the Preliminary Ground Investigation and five boreholes undertaken in 2009 as part of an investigation for culvert replacements. The groundwater levels vary from ground level to 12.55m bgl, with typical depths less than 4m bgl. Potential Geotechnical Hazards The geological conditions indicate the following potential hazards: Peat/organic soils Soft clays and silts (alluvium) Very loose and loose granular deposits Presence of boulders and obstructions in superficial deposits Bedrock faulting Bedrock stability Bedrock excavatability High groundwater table In addition, natural hazards are also present: Debris flow - Debris flows have regularly been recorded on the western slopes of Beinn Luibhean, above the proposed alignment

Option	Summary
	at Ch400 to Ch1850. A significant number of scarps, material deposited by debris flows, and steeply incised, scoured channels are visible on these slopes. There are also a smaller number of debris flows recorded associated with the west facing slopes of the Cobbler above Ch0 to Ch200. There are visible incised channels and scarps on this slope. Rockfall/Boulder fall - Large boulders are visible on the slopes of Beinn Luibhean and the Cobbler above the proposed route alignment with the potential for these to roll and hit the road. Large boulders have also been observed within forested areas during site walkovers. Rock outcrops of the Beinn Bheula Schist are present along the route alignment with recorded intersecting discontinuity sets that allow for potential rockfall issues, such as wedge and topple failure. Flooding – Where the Purple Option crosses the Croe Water there are areas of low through to high likelihood of river flooding.
Pink Option	Geological Conditions Made ground has been identified associated with the northern and southern tie-ins to the existing A83 and along the OMR. Along the southern tie-in to the existing A83, the proposed Pink Option has glacial till mapped between Ch0 to Ch150. Debris flow deposits are mapped between Ch150 to Ch450, which includes the southern cut and cover section of the tunnel. These debris flow deposits are likely underlain by glacial till. Peat is recorded north of Loch Restil associated with the proposed junction alignment joining the northern end of the pink route option to the existing A83. Small pockets and thin bands of peat/peaty soil are known to occur within other lithological units including debris flow deposits and colluvium. Thin peaty topsoil and buried peat have been recorded at exploratory holes in the vicinity of the northern tie-in.

Option	Summary
	Colluvium is mapped between Ch3350 to Ch3500, and Ch3750 to Ch3941. This material is likely underlain by glacial deposits. Hummocky glacial deposits are mapped between Ch3500 and Ch3750. Thin layers of weathered bedrock have been identified above the competent bedrock. The proposed Pink Option tunnel alignment is primarily within strata of the Beinn Bheula Schist Formation, consisting of foliated pelite, semipelite, psammite, and quartzite. An intrusion of the South of Scotland Granitic Suite is mapped between Ch50 and Ch1200, which has been found to comprise diorite and dolerite. Two north-south trending faults are shown on the BGS 1:50 000 linear dataset at Ch2250 and Ch2750. The nature and displacement of these faults is not recoded. There are visible discontinuities within the bedrock outcrops at these locations, which suggest the faults are close to vertical/steeply dipping. Faulting may cause groundwater and rock stability issues during tunnel construction. Groundwater Conditions Groundwater strikes have been recorded at eighteen exploratory holes along the Pink Option alignment, with depths varying from 0.25m bgl to 7.7m bgl. Groundwater levels have been monitored in six boreholes from the Preliminary Ground Investigation and seven boreholes undertaken in 2009 as part of an investigation for culvert replacements. The groundwater levels vary from 0.15m bgl to 7.48m bgl, with typical depths less than 4m bgl. Potential Geotechnical Hazards The geological conditions indicate the following potential hazards: Peat/organic soils Presence of boulders and obstructions in superficial deposits

Option	Summary
	Bedrock faulting Bedrock stability Bedrock excavatability High groundwater table In addition, natural hazards are also present: Debris flow - Debris flows have been recorded on the western slopes of Beinn Luibhean and Ben Arthur, above the proposed tunnel portals. A number of scarps, material deposited by debris flows, and steeply incised, scoured channels are visible on these slopes. Rockfall/Boulder fall - Large boulders are visible on the slopes of Beinn Luibhean and the Cobbler above the proposed route alignment with the potential for these to roll and hit the road. Large boulders have also been observed within forested areas during site walkovers. Rock outcrops are present along the route alignment with recorded intersecting discontinuity sets that allow for potential rockfall issues, such as wedge and topple failure.

2.2.6. Traffic Conditions

Existing Traffic Patterns

Information on traffic volumes has been provided by Transport Scotland from the National Traffic Data System (NTDS) for the period between 2015 and 2019. Details of the sources of this data and how it was used is contained in Part 4 Chapter 3.

Based on Average Annual Daily Traffic (AADT) for the most recent year available, traffic levels between Tarbet and Lochgilphead were between 3,100 and 5,300 vehicles. Along the A83 at the Rest and Be Thankful, the AADT value from the latest available year (2019) was observed to be 4,400 vehicles.

Accident data

An analysis of personal injury accident data has been undertaken. This has enabled an assessment of current road safety conditions by establishing the number and severity of accidents and the accident rate in relation to traffic flow, allowing comparison with national trends. Personal injury accidents are classified as fatal, serious or slight dependent on the most severely injured casualty while the accident rate is expressed as the number of personal injury accidents per million vehicle kilometres travelled.

The location and severity of the personal injury accidents recorded between 2015 and 2019 are shown in Figure 2-2. Fatal accidents (red) are recorded where the level of injuries sustained caused death within 30 days of the accident. Serious accidents (yellow) are recorded where a casualty is detained in hospital or sustains fractures, concussion, severe cuts or where death occurs 30 or more days after the accident. Slight accidents (green) are recorded when a casualty sustains a sprain, bruise or slight cut.

The study along the preferred corridor reveals that the accident severity ranges from slight to serious accident severity.

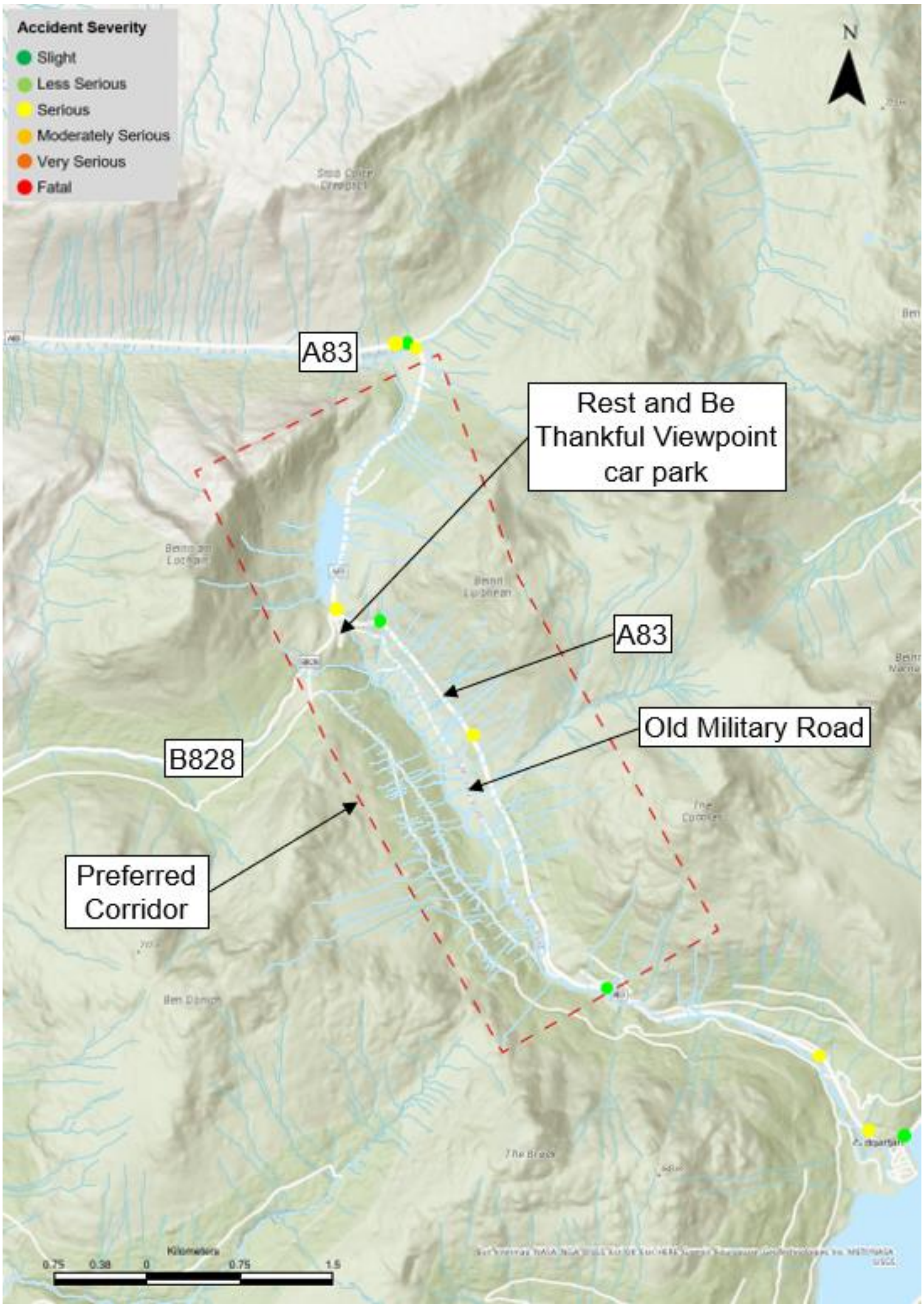

Figure 2-2 - Accidents by Severity

In total, seven accidents were recorded between Ardgartan and the Rest and Be Thankful viewpoint car park, with four being serious and the remainder slight. Furthermore, there were three accidents recorded on the tight left-hand bend at Butterbridge as the A83 drops towards Glen Kinglas, to the north of the preferred corridor, with two being serious and one slight.

2.2.7. Geometric design standards

Speed Limits

As a rural trunk road, the national speed limit for single carriageway roads applies to the length of the A83 throughout the preferred corridor.

Alignment

In the 1930s, the A83 replaced the OMR at the base of the valley between the lower and upper parts of the glen.

A study of the existing A83 alignment within the Preferred Corridor has been completed during the DMRB Stage 2 process. The horizontal alignment along the existing A83 within the preferred corridor is presented within Table 2-4, below.

Table 2-4 - Existing A83 horizontal alignment summary within the preferred corridor

Horizontal Radii	No. of Bends	Approximate Length of Road
Up to 255m	7	730m
255m – 360m	7	519m
360m – 510m	6	774m
510m – 720m	3	268m
720m – 1020m	3	265m
Greater than 1020m	5	557m

The study also identified that the steepest gradient of A83 carriageway present within the area was 5.69%, with the average gradient of 4.13%. As such, the vertical gradient is generally in compliance with Cl 5.1 of DMRB CD 109 ‘Highway Link Design’. The vertical curvature of the A83 various throughout the preferred corridor. The lowest sag curve is approximately K = 26 with the remainder generally exceeding K = 50. The lowest crest curves consist of approximately a K =12 and two curves of K = >45, with the remainder exceed K =100.

As a result, of existing rock cuts, tight bend radii and minimal verge provision driver visibility will be impacted over short distances. It is noted that a more appropriate design speed may be 85kph when considering a bendiness assessment of the existing A83 over this length.

Cross-section

The cross section of the A83 though Glen Croe is mostly that of a rural, un-kerbed single carriageway road with no hard strip provision and constantly varying verge widths, with no or notionally no verge at some locations. Only junction bell mouths and limited lay-bys have kerbed sections. The existing A83 within the preferred corridor has an average cross-sectional width of carriageway of approximately 6.5m. This value is above the minimum specified cross-sectional width of a single carriageway, as per Table 2.3 of DMRB CD 109 ‘Highway Link Design’.

Due to the historic nature of the A83 and the variance from standard, the cross-section is generally non-compliant with current design standards for a rural single all-purpose carriageway.

2.2.8. Junctions and Accesses

A total of 8 junctions and accesses connecting directly to the A83 were recorded. These are shown on the Existing Conditions drawings A83AAB-AWJ-GEN-LTS_GEN-DR-CX-000001 to A83AAB-AWJ-GEN-LTS_GEN-DR-CX-000004 contained in Volume 2 and are summarised below:

- B-road junction: 1
- OMR access: 1
- Residential access: 1
- Access Tracks / Field Access: 6

The junction between the A83 and B828 is an at-grade simple priority junction.

2.2.9. Lay-bys

There are eight lay-bys within the preferred corridor, with 6 in the northbound direction and 2 in the southbound direction. The use of lay-by signs is inconsistent and varies depending on the type of lay-by provided. The types of lay-bys provided are summarised below:

- 1 lay-by which exhibits a small, kerbed segregation island
- 5 lay-bys similar in layout to a Type B arrangement but with variations
- 2 informal lay-bys

The existing lay-by locations are identified on the Existing Conditions drawings A83AAB-AWJ-GEN-LTS_GEN-DR-CX-000001 to A83AAB-AWJ-GEN-LTS_GEN-DR-CX-000004 contained in Volume 2.

Existing lay-bys do not conform with current design standards.

It is noted that there is also evidence of vehicles parking within existing accesses such as the access to Local Path 3, south of the Croe Water.

2.2.10. Diversion Routes

The OMR is used as a predominately convoy controlled single lane diversion route when the A83 is closed within Glen Croe. In instances when the OMR cannot be used, a longer diversion route via the A819 local road, A85 Trunk Road and A82 Trunk Road is required. A diversion distance and journey time has been estimated from the junction between the A83 and A815 local road to Tarbet, this is outlined in Table 2-5 and Figure 2-3, below.

Table 2-5 – Diversion route when the OMR cannot be used

Closure of A83 Between	Diversion Route	Diversion Distance	Diversion Journey Time	Journey Time Difference
Rest and Be Thankful viewpoint car park and Ardgartan	From the A83 Trunk Road/A815 local road junction, head west on A83 Trunk Road to Inveraray, then north on the A819 local road to Dalmally. Turn east on to A85 Trunk Road to Tyndrum, and then follow the A82 Trunk Road south to Tarbet.	59.5 miles	Up to 80 mins	+59 mins

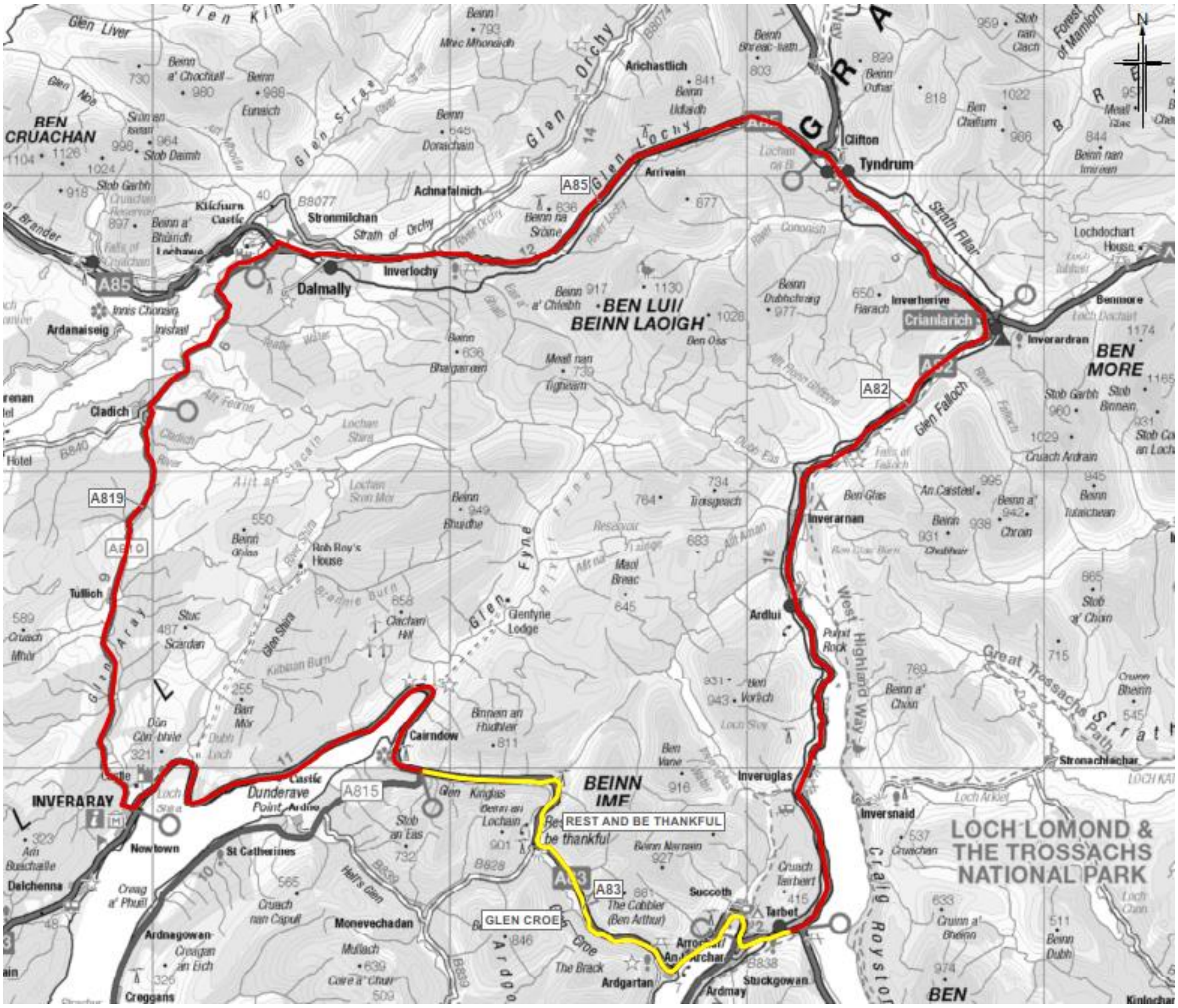

Figure 2-3 - Diversion route when the OMR cannot be used

Without a diversion, the travel distance between these two points is approximately 12.5 miles, therefore in this particular instance, the additional journey length created by the diversion is approximately 47 miles.

Depending on journey origin and destination, the longest diversion length experienced by travellers would be over 60 miles.

2.2.11. Road Pavement

As far as could be assessed, the A83 appears to be of flexible construction with a bituminous/asphaltic surface course. Recent improvement schemes will have applied TS 2010 surface course in line with other Scottish trunk roads.

Horizontal curves towards the northern end of the corridor have worn high friction surfacing.

No further assessment of the pavement condition has been carried out during the DMRB Stage 2 assessment.

2.2.12. Structures

The information relating to existing structures within the preferred corridor has been extracted from Transport Scotland's Integrated Road Information System (IRIS) within the Structures Management System (SMS). These are identified on the existing conditions drawings A83AAB-AWJ-GEN-LTS_GEN-DR-CX-000001 to A83AAB-AWJ-GEN-LTS_GEN-DR-CX-000004 contained in Volume 2.

A83 Bridge Structures

The Cobbler Bridge, shown in Figure 2-4 below, is the only Trunk Road bridge present within the preferred corridor. The structure is a three-span reinforced concrete bridge with a reinforced concrete slab and masonry clad parapets. It is supported on masonry clad columns and a reinforced concrete foundation.

Figure 2-4 - The Cobbler Bridge

The structure carries the A83 over the Croe Water. Table 2-6 contains summary information for the Cobbler Bridge.

Table 2-6 - Existing bridge structures

Chainage (m)	Watercourse Crossed	Structure No.	Deck Width (m)	Bridge Span (m)	Structure Type
11+400	Croe Water	A83 60	7.5	14.6	Composite beam and slab

Culverts

Within the scheme extents there are a total of 60 watercourse crossings of the A83 that have been identified, 18 of which have been confirmed by topographic survey, undertaken by Jacobs (2020). Of the 18 confirmed crossings, 13 of these are pipe culverts with diameters ranging from 375mm to 900mm and five are box culverts. The remaining 42 crossings of the A83 have been identified through interrogation of Ordnance Survey (OS) mapping, satellite imagery and Google Street View and will require verification by a topographical survey. Table 2-7 contains summary information for the existing culverts within the preferred corridor.

Table 2-7 - Existing culverts

Chainage (m)	Year of Completion	Culvert No.	Width / Diameter (m)	Span (m)	Structure Type
9+495	1938	A83 50 C18	0.9	14	Pipe
10+420	1937	A83 50 C60	1.8	15	Box
10+720	1938	A83 50 C73	0.9	10	Box
11+025	1938	A83 50 C87	0.9	18	Box
11+120	1938	A83 50 C91	0.9	17	Box
11+580	Unknown	A83 C16*	0.6	32	Pipe
11+670	1938	A83 60 C8	0.9	15	Box
11+830	Unknown	A83 C18*	0.6	27	Pipe
11+965	Unknown	A83 C19*	0.45	21	Pipe
12+040	Unknown	A83 C21*	0.6	17	Pipe
12+200	Unknown	A83 C23*	0.45	20	Pipe

Chainage (m)	Year of Completion	Culvert No.	Width / Diameter (m)	Span (m)	Structure Type
12+310	1938	A83 60 C23	1.2	26	Box
12+465	1938	A83 60 C26	0.9	24	Pipe
12+525	Unknown	A83 C26*	1.4	10	Box
12+655	Unknown	A83 C27*	0.6	9	Pipe
12+790	2003	A83 60 C30	1.8	14	Box
12+995	1939	A83 60 C38	1.2	12	Solid Slab
13+085	1938	A83 60 C40	0.9	12	Pipe

* Culvert numbers relate to AWJV reference system opposed to IRIS.

Retaining Walls

There are 6 retaining wall structures present along the preferred corridor. Table 2-8 contains summary information for the existing retaining walls along the preferred corridor.

Table 2-8 - Existing Retaining Walls

Chainage (m)	Year of Completion	Retaining Wall No.	Length (m)	Max/Min Height (m)	Structure Type
10+425	1938	A83 50 W61	35	2.1 / 1.1	Masonry
12+210	2020	A83 60 W17	No Information		

Chainage (m)	Year of Completion	Retaining Wall No.	Length (m)	Max/Min Height (m)	Structure Type
12+250	1938	A83 60 W22	160	6.0 / 0.6	Masonry
14+690	1940	A83 60 W76	18	2.5 / 0.9	Masonry
14+955	1800	A83 60 W79	38	5.5 / 1.0	Insitu Reinforced Concrete
15+000	1940	A83 60 W83	17	2.6 / 1.0	Mass Concrete

The retaining walls comprise:

- 3 masonry stone walls
- 1 in-situ reinforced concrete wall
- 1 mass concrete wall
- 1 unknown (no information available)

The walls vary in height up to approximately six metres and are of lengths up to 82 metres.

2.2.13. Hydrology, Drainage and Water Environment

The Croe Water, Kinglas Water and Loch Restil are all present within the preferred corridor. Croe Water is one of the main tributaries of Loch Long within the A83 corridor and has a catchment of approximately 18km^2 and is approximately 7.7km in length. The catchment is rural and includes several minor watercourses. Kinglas Water is one of the main tributaries of Loch Fyne and has a catchment of approximately 30km^2. Loch Restil is a freshwater water body covering an area of approximately 0.1km^2. The water body is unclassified by SEPA and lies within the Kinglas Water catchment.

The Existing Condition drawings A83AAB-AWJ-GEN-LTS_GEN-DR-CX-000001 to A83AAB-AWJ-GEN-LTS_GEN-DR-CX-000004 contained in Volume 2 indicate the extents of the flood plains around these bodies of water.

The current A83 and temporary diversion via the OMR has no installed measures designed to attenuate peak flow, contain accidental spillages nor treat routine runoff water quality.

There are a series of slope management works and channel modifications undertaken by BEAR Scotland with pre-approval by SEPA via CAR registrations and simple licences adjacent to the A83 within the preferred corridor. These include channel diversions, straightening, reprofiling, scour protection and catchpits. The catchpit features have been installed upslope of the A83, with a total length of approximately 200m, to intercept and collect incoming surface flows and landslide material, diverting runoff through chambers to pipes below the carriageway. These may provide limited flow attenuation and require ongoing removal of collected sediment.

There are no visible SuDS provisions along the preferred corridor which is unsurprising considering that the A83 was built before the introduction of modern SuDS techniques and given the challenging topography along the preferred corridor.

SEPA’s river flood maps for 10, 200 and 1000-year return periods show that sections of the A83 and the OMR lie within the functional floodplain. Additionally, SEPA's surface water flood mapping indicates some relatively small, localised pockets of flooding in the valley of Glen Croe, with medium likelihood of surface flooding.

The existing conditions drawings A83AAB-AWJ-GEN-LTS_GEN-DR-CX-000001 to A83AAB-AWJ-GEN-LTS_GEN-DR-CX-000004 contained in Volume 2 exhibit the SEPA flood mapping extents for the 200-year return period.

2.2.14. Roadside Features

Road Restraint Systems

Road Restraint Systems, often known as safety barriers, are widely deployed along the A83 within the preferred corridor. These barriers are often made of tension corrugated beam (TCB) to the south of the Rest and Be Thankful viewpoint car park and open box beam (OBB) to the north.

Certain stretches of barrier employ ramp-style terminals, which are typically of performance class P2. There are currently a total of 15 terminals with ramp access and one location with no terminal included. These do not conform to the required specifications for a two-way single carriageway road, which state that the road must have a performance class of P4 and be energy absorbing (that is, not ramped). There are five P4 terminals deployed on the A83 within the preferred corridor.

The parapets of the bridges are generally constructed out of masonry.

These are identified on the existing conditions drawings A83AAB-AWJ-GEN-LTS_GEN-DR-CX-000001 to A83AAB-AWJ-GEN-LTS_GEN-DR-CX-000004 contained in Volume 2.

Signage

Signing on the A83 within the preferred corridor includes warning, advance directional, directional, route confirmation, tourist and information signs. Signs are positioned in expected peripheral locations and do not obstruct footpaths. Generally, signs are mounted at appropriate heights with observations as below:

- Directional signage includes Gaelic and English.
- No regulatory signs are present.
- No traffic signals or road lighting are present.

Snow Poles

BEAR Snow pole provision between the Rest and Be Thankful and Glen Kinglas adjacent to the A83 carriageway is included in Scotland's Winter Service Plan for the Northwest Unit (2018-2019), as is a precautionary salting and plough route between Campbeltown and the Rest and Be Thankful. This indicates that there is snow build-up or surface frost and ice in this area, which may influence route resilience during snowstorms.

2.2.15. Active Travel

Within the extents of the preferred corridor, existing active travel provision is limited, consisting principally of one Core Path and three local paths. The assessment suggests that all existing facilities within the corridor are predominantly used for recreation and leisure purposes, opposed to commuting or active travel, based on their location, i.e. proximity to trip generators etc and type i.e. gradient, alignment and amenity.

The four principal paths are shown in Figure 2-5 and on the existing conditions drawings A83AAB-AWJ-GEN-LTS_GEN-DR-CX-000001 to A83AAB-AWJ-GEN-LTS_GEN-DR-CX-000004 contained in Volume 2. The information on the existing core path and three local paths which have been identified within the preferred corridor are outlined below.

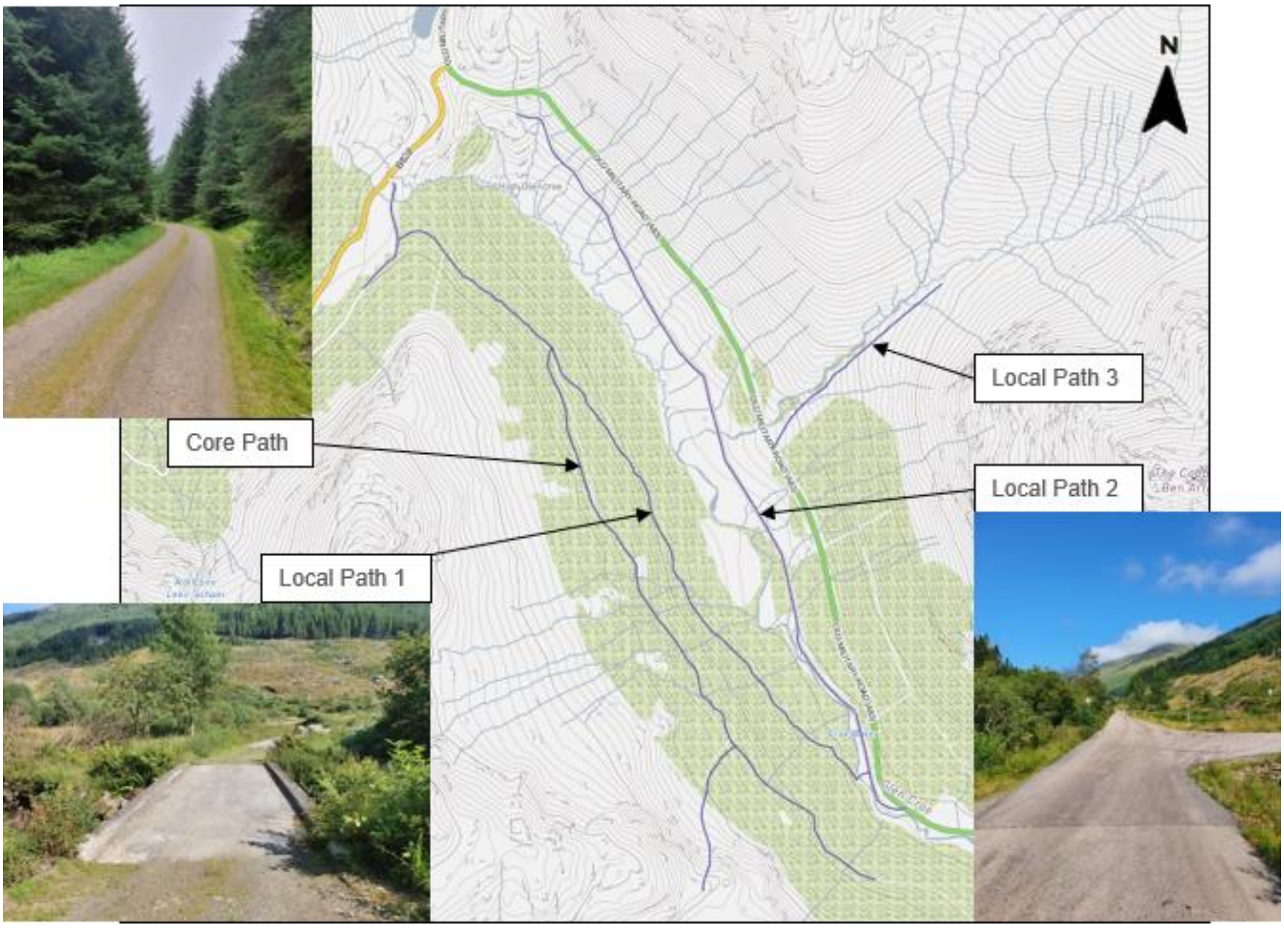

Figure 2-5 - Existing Walking, Wheeling and Cycling provision within the Preferred Corridor

The existing A83 generally consists of a 6m wide carriageway with grassed verges varying between 0.5m and 2m within the preferred corridor. Beyond the immediate corridor there are isolated extents of the existing A83 which do contain footways with the nearest identified lengths being east of the Ardgartan Holiday Park connecting to Arrochar and two short, isolated sections at Cairndow and the top of Loch Shira which are approximately 3km, 6.8km and 19km from the extents of the preferred corridor, respectively.

From AWJV's ongoing site inspection and consultation, there is evidence of the A83 being used by road cyclists through the corridor, mostly for recreation and leisure activities which is supported by Strava and other equivalent open data sources in the area. Due to the cross section, there is no evidence to suggest this is used by pedestrians.

2.2.15.1. Core Path

Core Paths facilitate, promote, and manage access rights under the Land Reform (Scotland) Act 2003, providing the public access throughout the local area. The Core Path network is a key part of outdoor access provision and is intended to cater for a range of public users, including walkers, cyclists, horse riders and disabled people. Every local authority and National Park therefore have a responsibility to prepare a Core Path Plan. This Core Path is included in the Core Paths Plan for the Loch Lomond & The Trossachs National Park by the National Park Authority which was adopted on 23 June 2010.

Located on the western side of Glen Croe, it runs north from Ardgartan along a forestry track to a point adjacent to the Glen Mohr car park and approximately 430m south-west of the Rest and Be Thankful viewpoint car park, where it then turns south-west towards Gleann Mòr and Lochgoilhead.

The Core Path uses a Forestry and Land Scotland (FLS) access track known as the Upper Forestry Access Track. It has an unbound granular surface with gradients varying significantly along its length within the scheme extents. The average gradient is approximately 5 to 5.5% but increases in points to over 8%. The width also varies with an average of 3.1m and a minimum of 2.5m in points. The route is used as a forestry maintenance access and a forestry extraction route where access to walking, wheeling and cycling is temporarily restricted.

A typical image of the Core Path is shown in Figure 2-5, above.

Additionally, the Ardgartan Peninsula Loop, a 33km forest recreation mountain bike route, utilises the Core Path/Upper Forestry Access Track.

2.2.15.2. Local Paths

Local paths are routes which have been identified through consultation or where there is anecdotal evidence of use but do not have a formal status.

Local Path 1

Local Path 1 is an undesignated path located on the western slopes of Glen Croe, positioned generally downslope of the Core Path described above. It loops between the A83 and OMR junction via a bridge to the Core Path towards High Glen Croe.

Like the Core Path, it runs along a FLS access track known as the Lower Forestry Access Track. As such, it also has an unbound granular surface. Average gradients are around 6% but increase in points to over 10%. The width varies with an average of 3.1m and a minimum of 2.5m in points.

To cross Croe Water, users must pass over a concrete bridge which has a width of around 3m. However, no edge protection in the form of a parapet or guardrail is provided and only minor upstands are present, see Figure 2-5, above. The route is used as a forestry maintenance access and a forestry extraction route where access to walkers, wheelers and equestrians is temporarily restricted.

Local Path 2

Local Path 2 is an undesignated path which follows the OMR. It runs from the A83 /OMR junction along the floor of Glen Croe to High Glencroe at which point it climbs sharply with hairpin bends where it connects into the Rest and Be Thankful viewpoint car park.

Despite a notable length of the OMR being privately owned, it can be used by walkers, wheelers and cyclists due to the Right to Roam law in Scotland although there are gates that need to be negotiated which act as a barrier to some. However, Transport Scotland has agreement with the current landowners and when the A83 is closed as a result of landslides, the OMR is used as a temporary diversion route for the displaced traffic. During its operation as a diversion, the OMR effectively becomes unusable for walkers, wheelers or equestrians, although cyclists can and do continue to use the route.

The OMR has a bound paved surface and a typical width of 4.3m. It is wider at the southern end which can facilitate two-way traffic and narrows further north where it is still suitably wide to accommodate motorised traffic. Along the valley floor, the route undulates significantly with localised steep sections, but has an average gradient of 1.8% over 2km. However, north of High Glencroe gradients increase to over 14.7% for a length of 140m. Figure 2-5, above, shows the OMR.

Local Path 3

Local Path 3 is an undesignated path located to the east of the A83. It is accessed from an existing informal access immediately south of Croe Water, generally running parallel to the watercourse as it heads uphill providing access to the adjacent hills, particularly Beinn Luibhean and The Cobbler. Furthermore, it is known through consultation that SSE use this path as a means of foot access to their infrastructure within the area.

It is understood that the path is fairly informal and has formed over time through continual use. As a result, it is a mixture of natural surface and sub-surface ground material and is uneven underfoot.

2.2.15.3. Additional Informal Paths

In addition to the four paths noted above, two informal mountain biking trails and a hill walking route are present on the western slopes of Glen Croe. These were identified through local knowledge of the area and are shown on Figure 2-6, below.

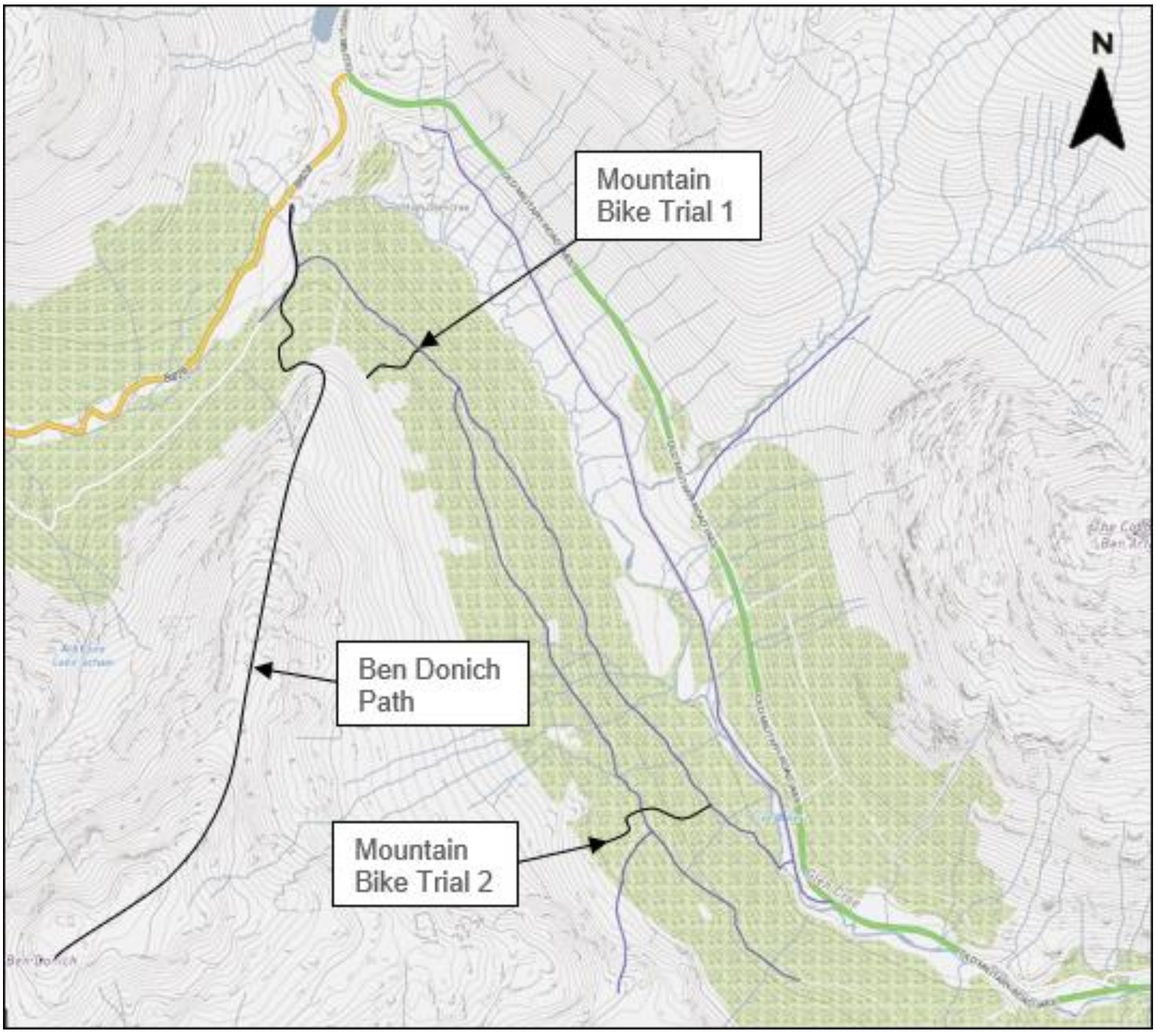

Figure 2-6 - Additional informal paths within the Preferred Corridor

Mountain Bike Trail 1 is towards the northern end of Glen Croe. It is accessed, and also ends, from the Core Path where users traverse through the trees on the lower slopes of Ben Donich.

Mountain Bike Trail 2 is at the southern end of Glen Croe. Again, it is accessed from the Core Path and traverses through the trees on the lower slopes of Ben Donich passing over the Upper Forestry Access Track and ends on the Lower Forestry Access Track / Local Path 1.

A hillwalking route to Ben Donich starts at the Glen Mohr FLS car park, crossing the Core Path and continuing up the ridge of the hill. The route up and down follows the same path.

2.2.16. Public Transport Provision

Within the preferred corridor, the A83 forms part of the route of three bus services, two services providing links to strategic and regional destinations, and one a regional service. The bus stop is currently located immediately north of the Rest and be Thankful viewpoint car park within a bus turning area off the B828.

Figure 2-7 - Photograph of the bus stop adjacent to the Rest and Be Thankful Viewpoint car park looking north to Loch Restil

Bus operators in the preferred corridor are West Coast Motors (on behalf of Scottish Citylink) and Garelochhead Coaches. Frequencies for key regional and strategic routes are included in Table 2-9, below.

Table 2-9 - A83 Key Bus Routes and Frequencies

Service	Origin	Destination	Typical Frequency (Mon – Fri)	Typical Frequency (Sat – Sun)
302	Helensburgh	Carrick Castle	4x daily per direction	3x daily per direction
926	Glasgow	Campbeltown	5x daily per direction	6x daily per direction
976	Glasgow	Oban	2x daily per direction	2x daily per direction

2.2.17. Utilities

A C2 notification was issued to Statutory Undertakers in line with the New Roads and Street Works Act (NRSWA) 1991. Responses were received from all Statutory Undertakers contacted, with only two confirming they had apparatus within the preferred corridor. Within the scheme extents BT Openreach currently have existing apparatus in the form of:

- underground cables and chambers running parallel to both the A83 and the OMR, along the respective lower slope verges for the extents of the preferred corridor; and
- an overhead line running parallel to the B828 between Lochgoilhead and the Rest and Be Thankful viewpoint car park, where the overhead is then routed underground.

Mobile Broadband Network Limited (MBNL) also have apparatus within the scheme extents in the form of:

- a mast which is located adjacent to the southbound verge of the B828, approximately 200m south-west of the Rest and Be Thankful viewpoint car park.

Utilities mentioned above are identified on the existing conditions drawings A83AAB-AWJ-GEN-LTS_GEN-DR-CX-000001 to A83AAB-AWJ-GEN-LTS_GEN-DR-CX-000004 contained in Volume 2.

This page is blank.

3. Description of Scheme Options

3.1. Description of Options

This chapter introduces the Scheme Options assessed as part of the DMRB Stage 2 assessment. Section 5.2 contains a summary of how these options were developed through the assessment process and Section 5.3 contains a full engineering description of the Scheme Options. Plan and profiles of each of the Scheme Options are contained in Volume 2.

The 5 Scheme Options considered are illustrated in Figure 3-1 below, and consist of the following:

- Yellow – Viaduct Option (A83AAB-AWJ-HML-LTS_LB3-DR-CH-000001)
- Brown – Debris Flow Shelter Option (A83AAB-AWJ-HML-LTS_LC3-DR-CH-000001)
- Green – Forestry Track Option (Debris Flow Shelter) (A83AAB-AWJ-HML-LTS_LA0-DR-CH-000001)
- Purple – Tunnel and Viaduct Option (A83AAB-AWJ-HML-LTS_LD1-DR-CH-000001)
- Pink – Tunnel Option (A83AAB-AWJ-HML-LTS_LEA-DR-CH-000001)

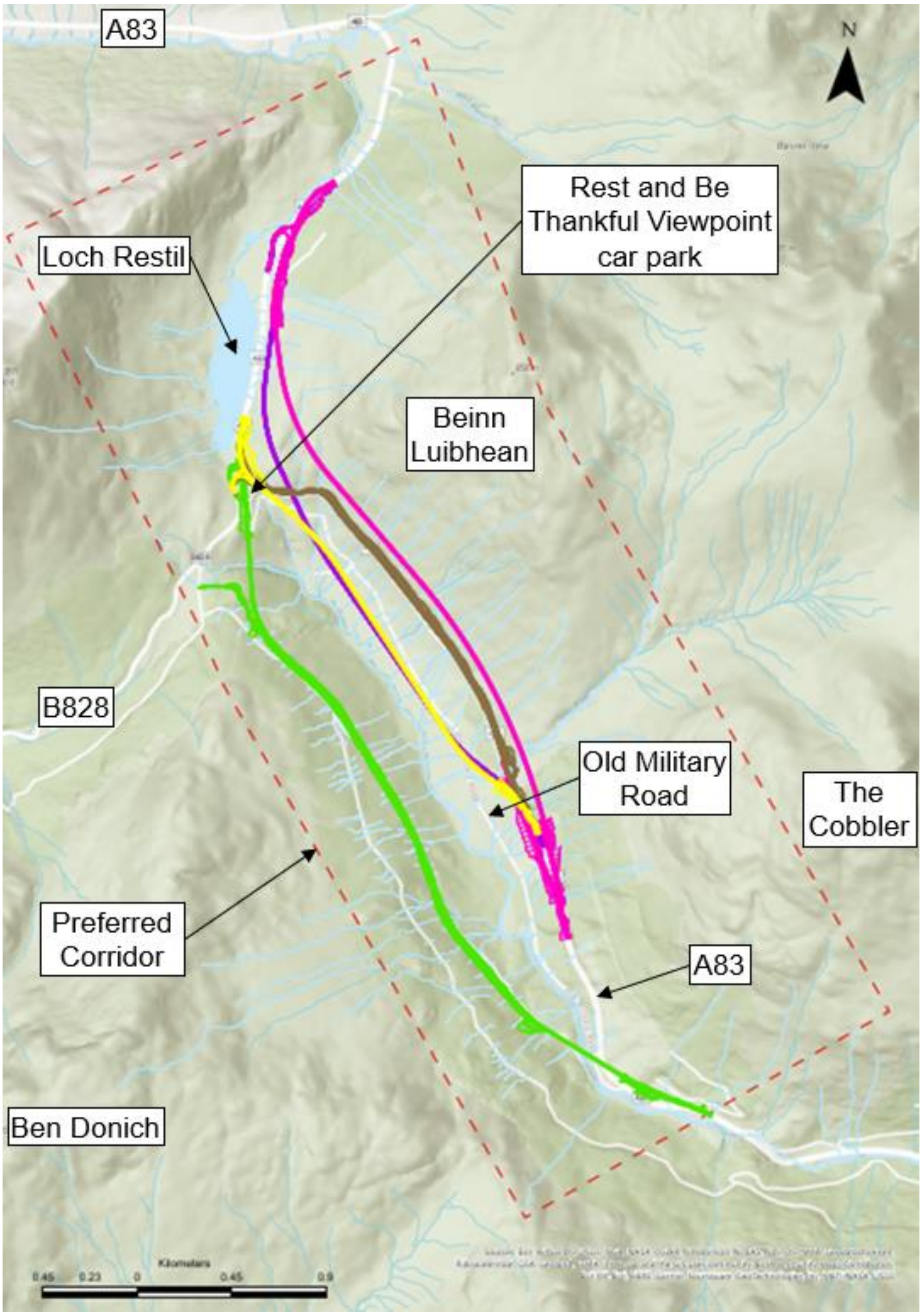

Figure 3-1 - Scheme Options within the Preferred Corridor

3.1.1. Yellow Option

The Yellow Option features a predominantly offline alignment located in the Glen Croe Valley on the lower slopes of Beinn Luibhean, below both the existing A83 and the OMR. The Yellow Option is 2.5km in length, of which 1.8km of the route is on a viaduct up to 90m above the ground.

Figure 3-2 - Visualisation of the Yellow Option

The Yellow Option ties-in to the existing A83 south of the existing bridge over the Croe Water. From there, it progresses in a north-to-north-westerly direction along a raised embankment before it transitions to viaduct for most of its length.

The route exits the viaduct adjacent to the Rest and Be Thankful viewpoint car park where it follows the line of the existing A83 to its northern tie-in north of the existing junction providing access to the B828.

Consequently, it may be necessary to reconfigure the existing junction with the B828. The Yellow Option also requires significant verge widening of the southbound verge, on the inside of the bend directly opposite the B828 junction, to improve visibility of the road ahead for drivers.

Reconfiguration of the existing bus stop and turning area and a new access to the Rest and Be Thankful viewpoint car park may also be necessary.

Figure 3-3 - Visualisation of the B828 junction and associated southbound verge widening for the Yellow Option

3.1.2. Brown Option

The Brown Option is a predominantly online route and is therefore on or very close to the route of the existing A83. The Brown Option is 2.4km long with debris flow and landslide protection achieved through the inclusion of a debris flow shelter combined with a catchpit for 1.37km with the catchpit and a protection wall extending a further 180m to the north.

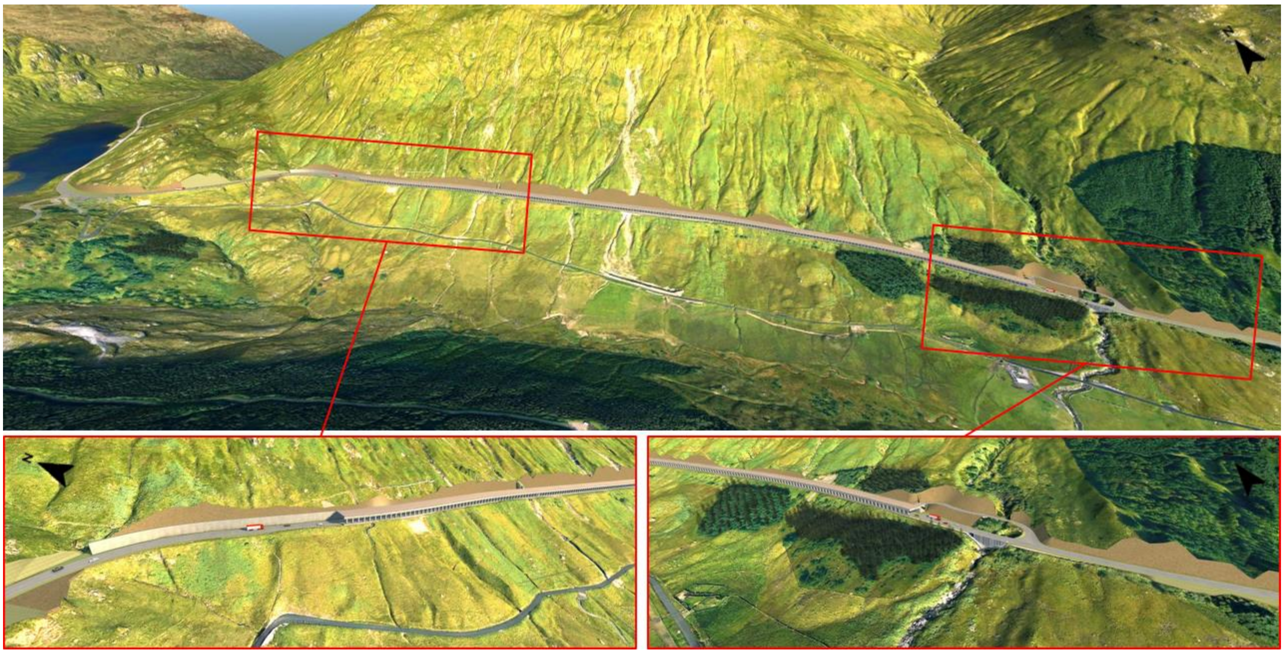

Figure 3-4 - Visualisation of the Brown Option

The Brown Option ties-in to the existing A83 south of the existing bridge over the Croe Water with the debris flow shelter starting north of the Croe Water. The Brown Option, protected by the debris flow shelter, continues in a northerly direction on the line of the existing A83 towards the Rest and Be Thankful viewpoint car park.

The debris flow shelter stops 100m in advance of the existing sharp left-hand bend that takes the existing A83 towards the B828 and Rest and Be Thankful viewpoint car park to ensure driver visibility is not impeded across the corner.

Protection is then achieved by the protection wall and catchpit in the southbound verge. The Brown Option then continues on the line of the existing A83 and terminates at an existing straight section of road north of the existing B828 junction.

As the Brown Option ties-in north of the existing B828 junction it may be necessary to alter the junction and as a consequence may involve notable verge widening of the southbound verge, directly opposite the junction, to improve visibility of the road ahead for drivers.

Figure 3-5 - Visualisation of the B828 junction and associated southbound verge widening for the Brown Option

3.1.3. Green Option

The Green Option features a predominantly offline alignment located on the lower slopes of Ben Donich on the western side of Glen Croe loosely following the line of an existing forestry track in Ardgartan Forest. The Green Option is 4.35km long and includes two viaduct structures, one at the southern end and one at the northern end, and a length of debris flow shelter. A visualisation highlighting the full extents of the Green Option is shown in Figure 3-6, below.

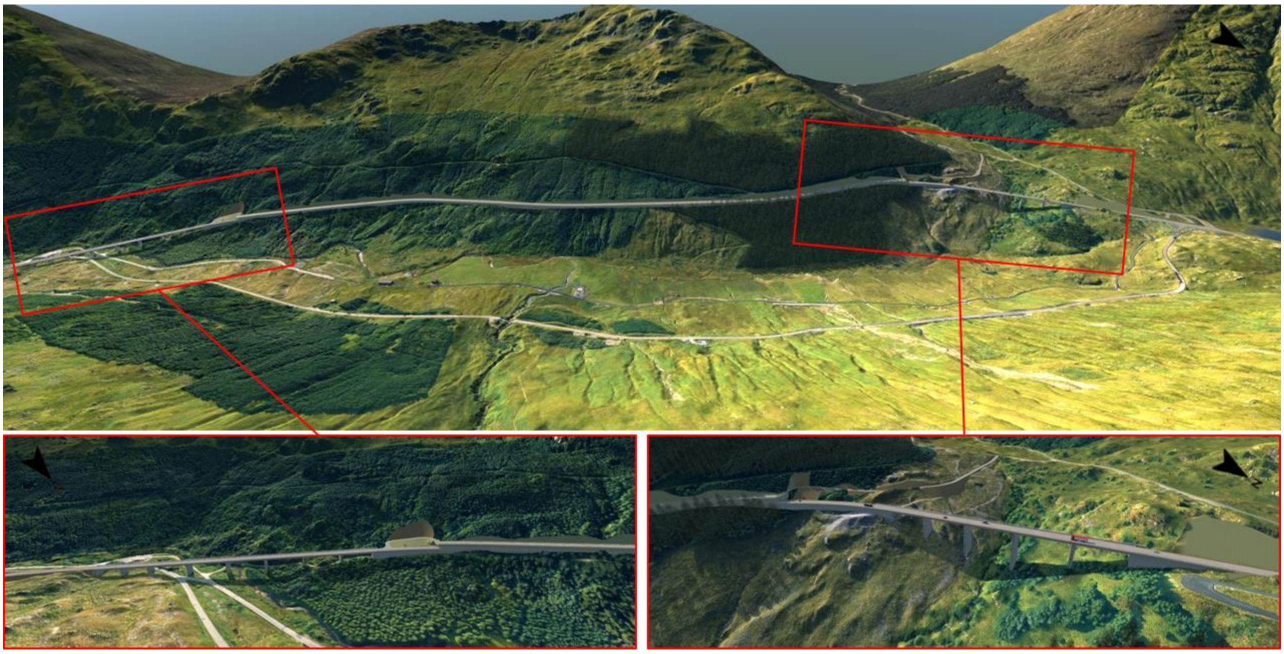

Figure 3-6 - Visualisation of the Green Option

The Green Option ties-in to the existing A83 at the southern end of Glen Croe, south-east of the existing junction that provides access to the OMR. The route heads in a westerly direction to the north of the existing A83, before crossing the existing A83, OMR and Croe Water on the first viaduct which has a length of 435m.

To retain access to the OMR, forestry tracks, adjacent land parcels and residential properties two new junctions, one on either side of the road, are required with the Green Option, as shown in Figure 3-7, below.

Figure 3-7 - Visualisation of the Green Option and proposed junctions at the southern end of Glen Croe

Beyond the viaduct, the Green Option continues in a generally north-westerly direction as it meets the lower slopes of Ben Donich. At this point the debris flow shelter, which is 2.3km long, commences to protect the road from potential landslides and debris flow events.

Beyond the debris flow shelter the Green Option continues in a northerly direction as it approaches the head of Glen Croe where the second viaduct, with a length of 275m, carries the Green Option over a steep gulley.

Once across the viaduct, the Green Option continues north, parallel with the northernmost section of the OMR and adjacent to the Rest and Be Thankful viewpoint car park. The Green Option then passes in close proximity to the existing junction between the A83 and B828.

Consequently, a new junction is required between the Green Option and the B828 on the northbound side of the road and the Rest and Be Thankful viewpoint car park on the southbound side of the ride.

Figure 3-8 - Visualisation of the Green Option and proposed junctions with the B828 Glen Mhor local road and Rest and Be Thankful Viewpoint car park

Reconfiguration of the existing bus stop and turning area would also be necessary.

The Green Option ties-in to the existing A83 at a point approximately 190m north of the existing junction between the A83 and B828.

3.1.4. Purple Option

The Purple Option features a predominantly offline alignment located in the Glen Croe valley on the lower slopes of Beinn Luibhean, below both the OMR and the existing A83. The Purple Option is 3.7km in length, with 1.5km of the route on a viaduct up to 52m above the ground and 1.2km of the route in a tunnel, beneath the OMR, existing A83 and western slopes of Beinn Luibhean.

Figure 3-9 - Visualisation of the Purple Option on Viaduct

The Purple Option shares a similar alignment to that of the Yellow Option where it traverses through the Glen Croe valley on viaduct until approximately 150m south of the tunnel entrance. However, the vertical profile is set lower to the ground over its full length.

The Purple Option ties-in to the existing A83 south of the existing bridge that carries the A83 over the Croe Water. From there, it progresses in a north-to-north-westerly direction initially on embankment before transitioning to a viaduct.

The viaduct carries the Purple Option through the base of Glen Croe valley to the head of Glen Croe, southeast of the Rest and Be Thankful viewpoint car park to the southern tunnel portal. The Purple Option then continues in a tunnel in a northerly direction below the OMR, existing A83 and western slopes of Beinn Luibhean emerging approximately 150m north-east of Loch Restil to the east of the existing A83. From there, the Purple Option continues in a northerly direction as an open section of road for approximately 580m before it ties-in with the existing A83 as it descends towards Glen Kinglas.

As a result of the tunnel, the Purple Option bypasses the existing B828 junction and the Rest and Be Thankful viewpoint car park. Therefore, a new junction is required to maintain access. This requires a section of the existing A83, approximately 930m in length, to take vehicles south to the B828. A new junction would be created approximately 330m north-east of Loch Restil connecting the Purple Option to the existing A83.

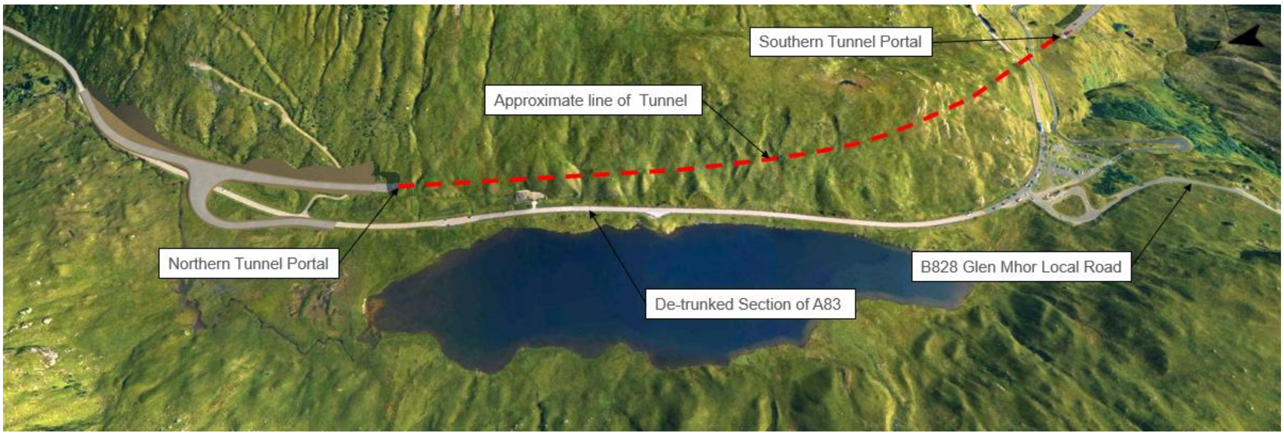

Figure 3-10 - Visualisation of the Purple Option and the new B828 Glen Mhor local road junction north-east of Loch Restil

The change to the junction location will require the re-location of the current bus stop and turning area at the Rest and Be Thankful viewpoint car park.

3.1.5. Pink Option

The Pink Option is a predominantly offline alignment featuring a 3km long tunnel situated beneath the western slopes of Beinn Luibhean. The Pink Option is 3.94km in length and ties-in to the existing A83 approximately 750m north of the junction that allows access to the OMR when the local diversion is in operation.

From there, it diverts to the east of the existing A83 and continues into the hillside with the southern entrance to the tunnel located approximately 350m south of the Croe Water and continues in a northerly direction below the western slopes of Beinn Luibhean offset from the existing A83. To help facilitate the construction of the southern tunnel portal and the mining works a temporary diversion of the A83 is required to minimise impact on trunk road traffic.

Figure 3-11 - Visualisation of the southern entrance to the Pink Option tunnel and the temporary diversion of the A83.

Similar to the Purple Option, the Pink Option emerges from the tunnel approximately 150m north-east of Loch Restil on the eastern side of the existing A83. The Pink Option then continues north as an open section of road for approximately 580m before it ties-in to the existing A83 as it begins to descend towards Glen Kinglas.

As a result of the tunnel, the Pink Option bypasses the existing B828 junction and the Rest and Be Thankful viewpoint car park. Therefore, a new junction is required to maintain access. This would require using a section of the existing A83, approximately 930m in length, to take vehicles south to the B828. A new junction would be created approximately 330m north-east of Loch Restil connecting the Pink Option to the existing A83.

Figure 3-12 - Visualisation of the Pink Option and the new B828 Glen Mhor local road junction north-east of Loch Restil

The change to the junction location will require the re-location of the current bus stop and turning area at the Rest and Be Thankful viewpoint car park.

3.2. Cost Estimates

Cost estimates have been prepared for each of the five Scheme Options. To establish the cost estimates, the Scheme Options were broken down into key components including structures and complex structures, earthworks and geotechnical measures, pavement and other considerations. For each component a bill of quantities was produced.

The rates utilised in the bill of quantities were developed based on latest cost information available via tenders, open book projects, latest material price information from the markets, historical information and consultation with relevant construction sector. In addition, AWJV consulted its internal market cost intelligence service to consider the cost impact over the immediate future and longer-term expectation (inflation) together with BCIS five-year civil engineering forecast dated February 2023 and the Building Cost Information Service All-In Tender Price Index (BCIS TPI) and Projected Formula VOP Index.

The rates and costs are presented at Q1 2023 prices for comparative assessment purposes.

The estimates include a number of significant determined costs, as listed below:

- Design and preparation costs.
- Land acquisition, legal fees and compensation
- Site Supervision
- Preliminaries
- Public Utility diversion costs
- VAT
- Project Risk and Opportunity and
- Optimism Bias.

Due to the nature of the Scheme Options, a comparative assessment of operation and maintenance costs was also undertaken and is reported separately.

Transport Scotland has developed a quantified risk assessment process to consider risk and opportunity to be applied across its projects. This approach has been applied to consider the risks and opportunities that may affect the Scheme Options.

The methodology considers the potential cost/benefit of the Proposed Scheme from each of the risk and opportunities, how likely they are to occur and how these can be mitigated or actioned.

In recognition that each of the five Scheme Options are substantially different, risk and opportunity registers were created for each Scheme Option in addition to a Proposed Scheme risk and opportunity register which contains risks and opportunities that are applicable to all options.

The figures presented within Table 3-1, below, are estimates based upon preliminary designs and comprise the direct cost of construction and preparation adjusted for risk/opportunity, optimism bias, and Value Added Tax (VAT).

The estimates below present the Plausible Best Case, Most Likely (mid-range) and Plausible Worse Case Cost based on quantified risk and opportunity outcomes. The definition of each is described below;

- Plausible Worse Case = Maximum Estimated Value of Risk – Minimum Estimated Value of Opportunity
- Most Likely = Most Likely Estimated Value of Risk – Most Likely Estimated Value of Opportunity
- Plausible Best Case = Minimum Estimated Value of Risk – Maximum Estimated Value of Opportunity

The VAT allowance has been based upon an assessment of the value of the works associated with each Scheme Option which are to be constructed beyond of the existing highway boundary. VAT has been included for works within the highway boundary where guidance from HMRC suggests this is required, i.e, within the context of bridges.

The direct cost of construction includes for scheme preparation costs and physical construction of the works, which were determined from cost rates applied to determined quantities. This includes an assessment of the temporary works required to facilitate said construction in such an environment.

Optimism Bias is the recognised way of adjusting cost estimates to account for a tendency towards underestimation. Scottish Transport Appraisal Guidance (STAG) advises that “Adjustments for Optimism Bias may be reduced over time as more reliable costs are developed and project specific risk work is undertaken” (reference STAG Technical Database paragraph 13.3.2).

At DMRB Stage 2, Transport Scotland suggests an Optimism Bias of 44% is used for fixed links (tunnels and bridges) and 25% is used for roads.

Table 3-1 – DMRB Stage 2 Cost Comparison of Scheme Options (2023 prices)

	Yellow Option	Brown Option	Green Option	Purple Option	Pink Option
Plausible Most Likely Cost	**£554,280k**	**£432,749k**	**£877,111k**	**£1,048,449k**	**£1,337,882k**
Option Comparison – Most Likely	**128%**	**100%**	**203%**	**242%**	**309%**
Plausible Worst-Case Cost	£595,545k	£465,373k	£932,498k	£1,128,561k	£1,377,982k
Plausible Best-Case Cost	£514,566k	£404,229k	£821,695k	£968,304k	£1,300,645k
Variation: Plausible Worst-Case - Plausible Best-Case	£80,979k	£61,144k	£110,803k	£160,257k	£77,337k

Note: For the option comparison the lowest cost is given a value of 100% with the other options presented as a percentage increase above this figure.

Table 3-2 notes the cost comparison with respect to the operational and maintenance costs associated with each Scheme Option.

Table 3-2 - Operation and Maintenance Cost Comparison of Scheme Options

Scheme Option	**Yellow Option**	**Brown Option**	**Green Option**	**Purple Option**	**Pink Option**
Option Comparison	144%	100%	256%	564%	477%

Note: For the option comparison the lowest operational and maintenance cost is given a value of 100% with the other options presented as a percentage increase above this figure.

Part 2: Engineering Assessment

4. Engineering Overview

4.1. Introduction

This chapter outlines the design considerations and approach with respect to the development, refinement and assessment of Scheme Options to deliver the Proposed Scheme.

This is followed by the engineering assessment which is contained within Chapter 5 of this report.

4.2. Design Approach

Given the nature of the glen and scheme objectives of providing a long-term, resilient and sustainable solution to address the issue of landslides closing the A83, significant engineering interventions are required.

The type of interventions will protect the road and its users from landslide and rock fall, with options considered generally comprising tunnels, viaducts and debris flow shelters. The alignment of the Scheme Options is therefore intrinsically linked with the form of protection considered, ie a tunnel can only be achieved by an alignment that enters the hillside.

Given the nature of the interventions, a key part of the development and assessment during DMRB Stage 2 was to consider the constructability, operation and maintenance of the engineering interventions, including consideration of the potential temporary works footprint.

The assessment of constructability, operation and maintenance has driven a number of design developments to ensure the comparative assessment was robust. A summary of the main design developments is contained in Chapter 5.

The following physical features have been considered through the design development and refinement process:

- Topography

- Geology, geomorphology and ground conditions, specifically the vulnerability of the existing hillsides to movement (debris and rockfall)
- Hydrology and hydrogeology
- Existing roads and accesses
- Other adjacent infrastructure
- Utilities
- Sustainable travel infrastructure
- Environmental constraints, including designated sites.

These are further detailed in Chapter 5 and illustrated on the Engineering Drawings in Volume 2 and the Environmental Drawings in Volume 3.

The Scheme Options have been developed using a detailed Digital Terrain Model (DTM) provided by Transport Scotland.

4.3. Engineering Standards and Design Approach

A number of Scheme Options have been developed for assessment in accordance with the DMRB design standards. The design principles outlined below have been applied to their development and comparative assessment.

4.3.1. Road Design

The Scheme Options have been developed in accordance with the DMRB. In particular, the following technical design standards:

- CD109 Highway Link Design
- CD 123 Geometric Design of At-grade Priority and Signal-controlled Junctions
- CD 127 Cross-sections and Headrooms
- CD 169 The Design of Lay-bys, Maintenance Hardstandings, Rest Areas, Service Areas and Observation Platforms
- CD 352 Design of Road Tunnels
- CD 377 Requirements for Road Restraint Systems; and
- CG 501 Design of Highways Drainage Systems

4.3.2. Mainline

For the purpose of comparative assessment, the Scheme Options have been developed based on a 100kph design speed. However, significant lengths of the existing A83 in the vicinity of the Proposed Scheme have been assessed to have an 85kph design speed. The design speed will be further assessed and agreed during DMRB Stage 3.

4.3.3. Cross-section

A Category S2 rural all-purpose road has been adopted for assessment purposes although it is noted that significant lengths of the existing A83 in the vicinity of the Proposed Scheme do not meet this standard.

In line with DMRB design standard CD 127 – ‘Cross-sections and Headrooms’, a S2 rural all-purpose road features a 7.3m wide carriageway, with 1m hard strips and minimally 2.5m verges on both sides; representing an improvement in the cross-section of the existing A83 through Glen Croe.

The requirements, in terms of access and junction treatments, for a S2 road are outlined in Table 4-1 of DMRB CD109 ‘Highway Link Design’ (and reproduced in Table 4-1, below).

Table 4-1 - Category S2 access and junction requirements

Road Type	Edge Treatment	Access Treatment	Major/Minor Road Treatment
Single Carriageway	1m hard strips	Limited access except isolated existing access with left turns only. Clearway.	At-grade

The cross-section within the tunnelled sections is consistent with DMRB CD 352 ‘Design of Road Tunnels’ and comprise of 2.0m escape passage separated by a fire rated wall, 1.2m footway, 7.3m carriageway and 2.0m footway.

Drawings A83AAB-AWJ-HGN-LTS_GEN-DR-CH-000001, A83AAB-AWJ-STU-LTS_GEN-DR-CT-000004 and A83AAB-AWJ-STU-LTS_GEN-DR-CT-000005 in Volume 2 include typical mainline cross sections.

The mainline sections and their individual options have been developed, where possible, to incorporate fully compliant horizontal and vertical curvature. Where necessary, verge widening for forward visibility has been applied to meet desirable minimum standards set out in DMRB CD109 ‘Highway Link Design’ based on a design speed of 100(A)kph noting this may be reviewed at DMRB Stage 3.

Note - Verge dimensions are minimum values that may need to be increased to suit particular circumstances e.g., forward visibility.

Headroom will also be in accordance with DMRB CD 127 ‘Cross-sections and Headrooms’, noting the route is not a high load route.

Further geometry and constraints pertaining to various Scheme Options are outlined below. It is noted that due to the nature of the glen and existing A83 alignment, some departures from standard are required. These are outlined in Chapter 5.

4.3.4. Junctions

Within the preferred corridor there is only 1 public road junction to the A83 for the B828, located north of the Rest and be Thankful viewpoint car park. The existing arrangement is loosely based on an at-grade simple priority junction to DMRB CD 123 ‘Geometric Design of At-Grade Priority and Signal-Controlled Junctions’ but incorporates a layby to the merge radius.

All works to the junction of the B828 and the A83 shall be designed in accordance with the DMRB CD 123 ‘Geometric Design of At-Grade Priority and Signal-Controlled Junctions’. For the purposes of DMRB Stage 2 assessment, a priority junction with ghost island on the major road has been considered.

It is noted that the traffic flows associated with the major and minor roads are appropriate to the upper limit of a simple priority junction therefore further consultation shall be undertaken at DMRB Stage 3 to confirm if a simple priority junction equivalent to the existing situation is more appropriate.

In addition to the DMRB design standards, local authority (Argyll and Bute Council) guidance has also been used to develop the minor road approach.

4.3.5. Local Roads and Private Accesses

As noted in Chapter 2 there are a number of direct accesses to the A83 serving residential, forestry and agricultural processes. Direct accesses will continue to be permitted to the A83 with the Proposed Scheme in place and any works to the existing or alternative direct accesses provided will be designed to the DMRB CD 123 ‘Geometric Design of At-Grade Priority and Signal-Controlled Junctions’.

Any accesses to the B828 will be designed to local authority standards.

4.3.6. Geotechnical and Earthworks

Information for the geotechnical assessments has been gathered from available desk study information (Access to Argyll and Bute (A83) Preliminary Sources Study Report), supplemented by field walkovers and information from the Preliminary Ground Investigation for the scheme.

A full discussion of the anticipated geotechnical conditions is presented in the Access to Argyll and Bute (A83) Preliminary Sources Study Report (A83AAB-JAC-HGT-COR_01-RP-GI-0028) prepared by Jacobs/Aecom.

4.3.7. Structures

All structures unless agreed otherwise will be designed to DMRB Standards to have a 120-year design life. Where there is potential for an existing structure to be retained as part of a Scheme Option, it shall be assessed, and its use agreed with the overseeing organisation. This may include consideration of Departures from Standard during DMRB Stage 3 due to the evolution of design standards.

Due to the specialist nature of tunnels, a number of additional design standards and specifications shall be considered specifically in the context of these options:

- British Tunnelling Society (BTS), 2010. Specification for tunnelling (3rd Edition).
- British Tunnelling Society (BTS), 2004. Tunnel lining design guide.
- EN 1990 (2002) Eurocode: Basis of structural design.
- EN 1991-1-1 (2002) Eurocode 1: Actions on structures.
- EN 1992-1-1 (2004) Eurocode 2: Design of concrete structures.
- EN 1997-1 (2004) Eurocode 7: Geotechnical design.

- FHWA, 2009 Federal Highway Administration of U.S. – Department of Transportation, FHWA: Technical Manual for Design and Construction of Road tunnels, Civil elements (FHWA-NHI-10.034)
- Muir Wood, A. 2000. Tunnelling management by design.
- Tied, H, 1990. A literature study of the arching effect.
- Vesic, A.B., 1961. Beams on elastic subgrade and the Winkler's hypothesis. In Proceedings of the 5thInternational Conference on Soil Mechanics and Foundation Engineering, Paris, 1, pp. 845-851.

4.3.8. Hydrology and Drainage

Hydrology

A preliminary hydrological assessment of the catchment areas for each watercourse crossing has been carried out to determine indicative sizes and types of watercourse crossing (pipe, arch or bridge structure).

New culverts at watercourse crossings have been sized to pass the 1 in 200-year flood return period flow and will include appropriate freeboard (minimum 300mm) to account for silt deposition and to facilitate passage of floating debris.

The design of proposed watercourse diversions will also be carried out during DMRB Stage 3, along with hydraulic and fluvial geomorphology assessments of the affected watercourses. The design approach will seek to replicate where practicable the existing flow regime and fluvial geomorphology, thus avoiding potential for increased flood risk, channel erosion and siltation.

Drainage

The road drainage has been developed in accordance with the design principles set out in DMRB and current best practice in Sustainable Drainage Systems (SuDS), in line with Scottish Planning Policy.

The drainage design for the five Scheme Options will consist of new gravity drainage networks, which will convey flows to suitable outfall points via sustainable drainage systems (SuDS). No existing formal highway drainage systems have been identified up to this stage, so it is assumed there is no or limited opportunity to re-use existing drainage infrastructure.

4.3.9. Pavement

Pavement areas and initial construction depths have been developed to inform the cost estimates.

Initial construction depths have been developed in accordance with the following DMRB standards:

- DMRB CD 224 'Traffic Assessment'
- DMRB CD 226 'Design of new pavement construction'

4.3.10. Road Restraint Systems

Initial road restraint system (RRS) layouts have been developed to inform the cost estimates. At this stage the RRS design is limited to two dimensional models which estimate the following RRS requirements for each of the options considered:

- Length of need
- Containment level
- Type of terminals (P1 or P4)

Layouts have been developed based on guidance within DMRB CD 377 'Requirements for Road Restraint Systems', noting a full assessment using the Road Restraint Risk Assessment Process (RRRAP) will be undertaken during DRMB Stage 3.

4.3.11. Utilities and Associated Infrastructure

Existing utilities within the study area have been identified through review of information provided by the utility providers. The key utilities identified include:

- BT Openreach underground cables and chambers which run parallel and in close proximity to both the A83 and the OMR.
- Mobile Broadband Network Limited (MBNL) mast, which is located on the B828, approximately 200m south-west of the Rest and Be Thankful Viewpoint car park.

Further work will be undertaken during DMRB Stage 3 to confirm the presence or otherwise of private water supplies.

4.3.12. Walkers, Wheelers, Cyclists and Horse-Riders

The design of walking, wheeling, cycling and horse riding will be in accordance with the DMRB, specifically CD 143 ‘Designing for Walking, Cycling and Horse-riding’.

An assessment and review is also being undertaken in accordance with DMRB GG 142 ‘Walking, Cycling and Horse Riding Assessment and Review. The assessment seeks to identify opportunities to improve walking, cycling and horse-riding facilities in the area and includes consultation with other statutory and non-statutory bodies.

5. Engineering Assessment

5.1. Introduction

This chapter of the report summarises the conclusion of the engineering assessment of DMRB Stage 2.

The engineering assessment includes a summary of the option development and description of the engineering features associated with the relevant Scheme Options as assessed. It also discusses the potential impacts of each Scheme Option.

Each Scheme Option has been developed to an appropriate level of detail to enable the comparative assessment of options. It is important to remember, that these options remain preliminary designs. The Preferred Route at the conclusion of DMRB Stage 2 will be developed further during DMRB Stage 3 as part of an iterative design process taking into account emerging findings from further targeted ground investigation and survey work across all technical and environmental disciplines.

5.2. Scheme Option Development

Each Scheme Option went through a rigorous development and refinement process to support the comparative assessment of Scheme Options. The development and refinement process considered a broad range of engineering, environmental and economic criteria, to ensure a balanced approach to development and assessment.

Given the nature of the interventions considered, a key part of the engineering development and assessment during DMRB Stage 2 was to consider the constructability, operation, and maintenance of the structures. Including consideration of the potential temporary works footprint and future maintenance requirements. The assessment of constructability, operation and maintenance has driven a number of design developments to ensure the comparative assessment was robust.

The below is a summary of the option development of each Scheme Option.

5.2.1. Yellow Option

The intent of the Yellow Option is to protect the road users from landslides and rock fall by raising the road above the areas of vulnerability associated with the Beinn Luibhean Slope, allowing any failures to pass under the structure.

The engineering description of the Yellow Option is contained in sub-section 5.3.1.

As the existing A83 is on a fairly constant 5% uphill gradient from south of the Croe Water to the Rest and Be Thankful viewpoint carpark. The Yellow Option would follow a similar vertical profile on a horizontal alignment offset from the existing A83.

As the level of the road is generally set by the gradient, the height of the viaduct structure above ground level is dependent on the horizontal alignment and its location on the slope.

The main focus of the design development was to refine the alignment to provide the best balance of impacts, specifically with respect to temporary works footprint and pier height.

Initially, an alignment was considered above the OMR which sought to minimise the height of the structure. However, this would mean constructing the substructure and piers which support the structures deck on steeply sloping, side long ground. In this scenario, the structure would be up to 55m above ground level.

Given the height of the structure, a 40m wide (perpendicular to the road) and 30m long (parallel to the road) notionally flat working platform is considered appropriate. The size of the working platform is required to construct the substructure which includes a piled solution and to support a slip form rig and tower/mobile cranes to construct the piers and deck. Each working platform should be accessible by vehicle during both construction and maintenance of the structure.

Applying the above working platform dimensions to an alignment located above the OMR results in significant excavation into the hillside immediately below the existing A83. This introduces considerable engineering challenge and risk, when considering the vulnerability of the hillside in this area. Figure 5-1, below, represents a typical cross section through one of the working platforms in the northern half of the viaduct.

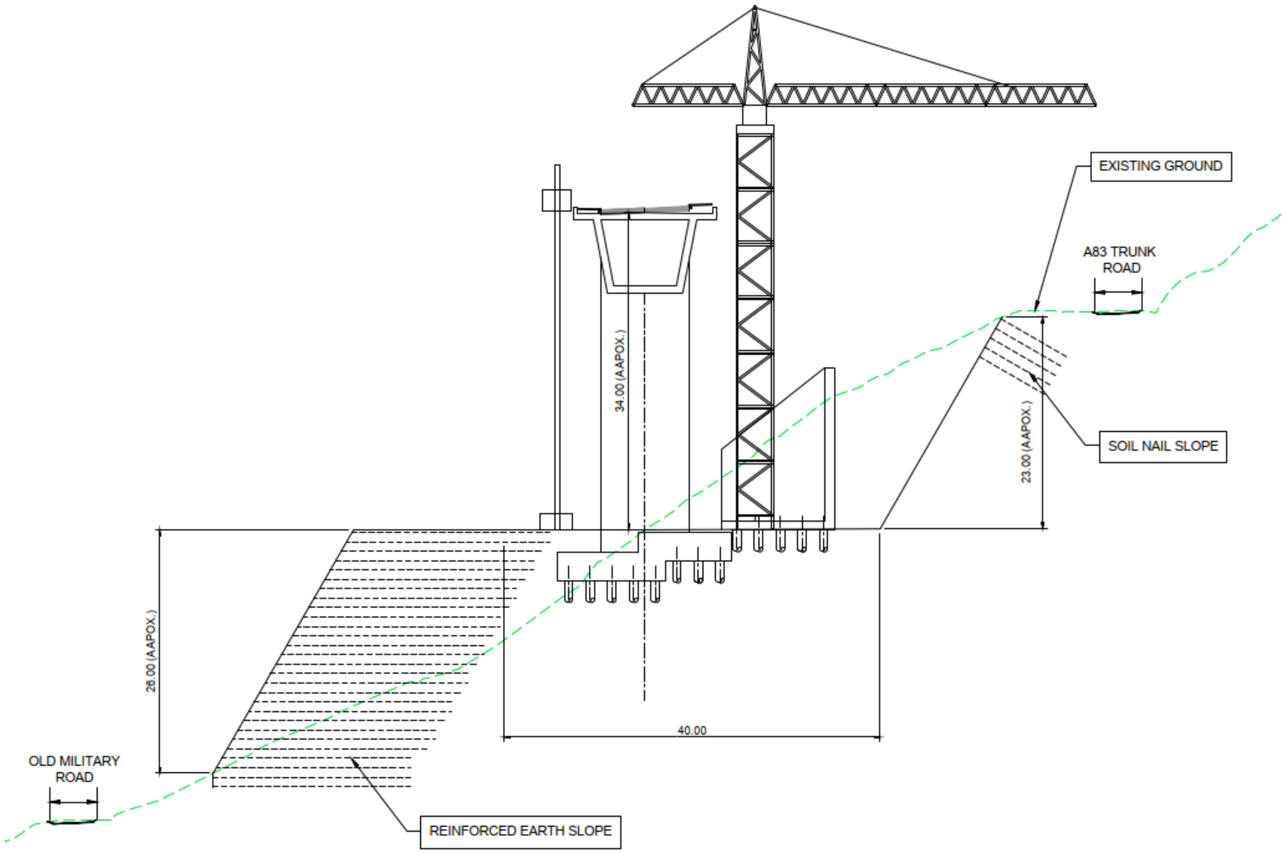

Figure 5-1 - Typical Temporary Works Footprint for Alignment Above OMR

In this case, an over 20m high 70 degree cut slope is required on the uphill side immediately below the A83. On the down slope side an over 25m high 1 in 1 slope is required to tie back into existing ground at the OMR. Due to the steep slope on the downhill side, a reinforced earth solution is required, and the temporary works footprint has been widened to accommodate the reinforcement such that it wouldn't compromise the substructure.

It is noted that this cross section is not achievable between the A83 and OMR, in the northern section approaching the Rest and Be Thankful viewpoint and a permanent diversion to the OMR of more than 250m would be required to facilitate the construction of the viaduct.

Furthermore, due to the level of the working platform above the OMR, access directly from the OMR to each working platform cannot be practically achieved, therefore a parallel access track would be required to each platform and would be located on the widened section of the platform as noted above.

Due to the impacts, the alignment was moved below the OMR using an equivalent approach. As the ground is flatter, the resultant footprint and impact are much smaller, with a cross section at the equivalent location shown in Figure 5-2, below.

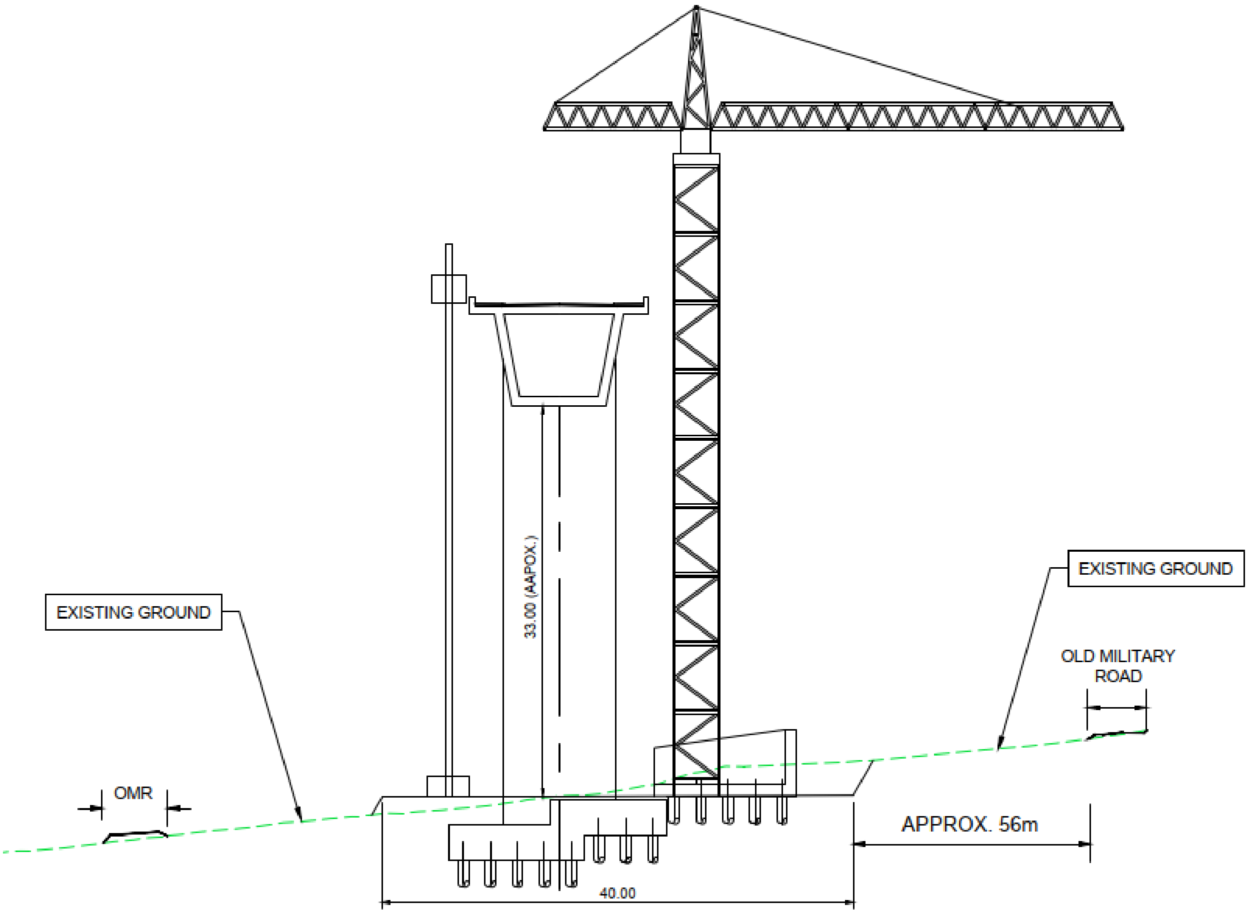

Figure 5-2 - Typical Temporary Works Footprint for Alignment Below OMR

Whilst this does increase the height of the structure to a maximum of 90m above ground level, the solution significantly reduces the overall footprint of the option and the amount of excavation into the vulnerable hillside, which is considered fundamental to mitigating the risk during construction.

It also moves the piers into a significantly less vulnerable location, meaning they are less susceptible to landslide during operation. This reduces the maintenance requirements of the structure and will result in a more resilient solution overall.

5.2.2. Brown Option

The intent of the Brown Option is to protect the road users from landslides and rock fall by forming a protective structure around the road which would be located broadly online of the existing A83.

The principal areas of development focussed on:

- the form of structure, and the mechanism for clearing debris
- the constructability of the viaduct
- disruption during construction (see constructability section)

The engineering description of the Brown Option is contained in sub-section 5.3.2.

5.2.2.1. Form of Structure

The initial proposal for the debris flow shelter had a reinforced concrete roof slab, which was sloped at a sufficient angle to allow the discharge of material and water over the roof and down the valley without affecting the road as shown in Figure 5-3, below. To protect the super structure from rock fall, the roof would be protected by a compressible and sacrificial material to cushion the impact of a boulder strike.

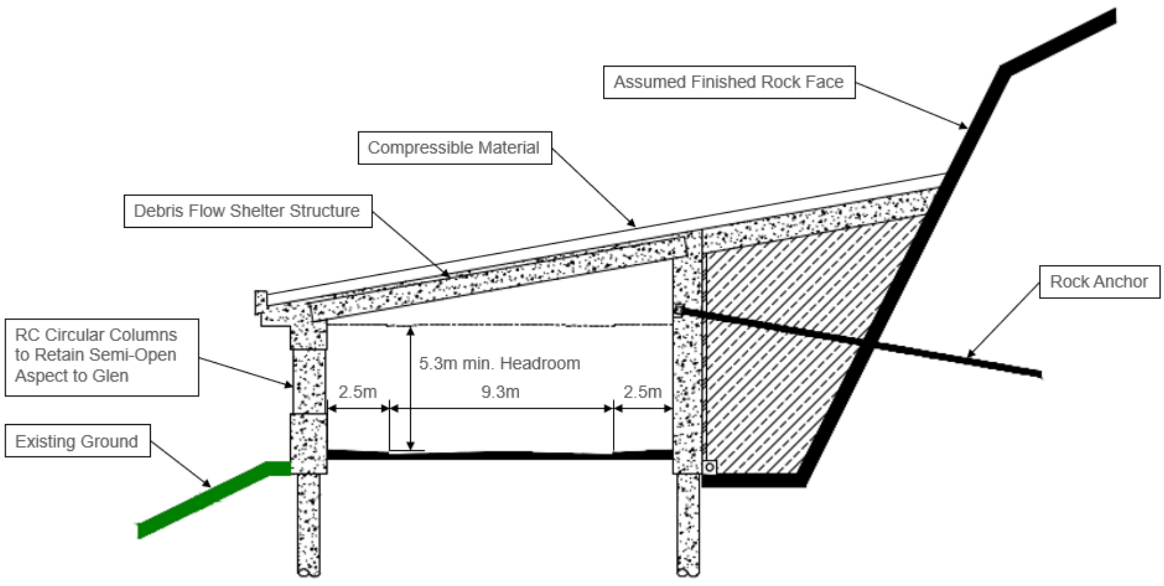

Figure 5-3 - Conceptual sketch of Debris Flow Shelter with concrete roof slab sloped towards valley floor

Whilst the roof would protect the road user, further consideration of how material and water moved across the roof did pose significant challenge, particularly with respect to the impact this may have on the resilience of the structure, downstream slope stability and water environment. This included ensuring the compressible material would remain intact to protect the structure and, the potential for undermining the structure caused by secondary incident on the downhill slope.

Furthermore, due to the irregularity of the bedrock below the superficial deposits, the roof slab may have to extend large distances before encountering suitable rock to tie into; noting it is possible that in some locations there may not be a suitable location to terminate the slab.

In response to the challenges, the design was refined to better control the movement of material and water and to improve access to the structure for maintenance and inspection purposes with a view to making the structure more resilient.

To achieve this a catchpit was introduced to the uphill side as shown in Figure 5-4, below.

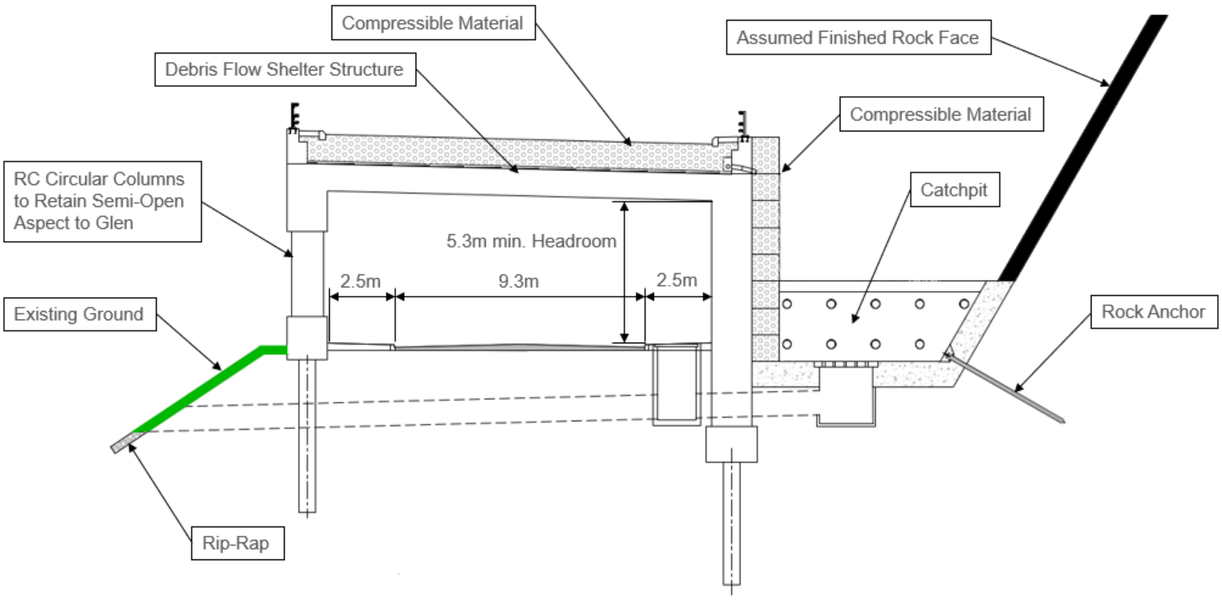

Figure 5-4 - Conceptual sketch of Debris Flow Shelter and catchpit on the uphill side

The purpose of the catchpit is to channel the flow of superficial deposits and rock fall, allowing them to be dealt with safely and efficiently, without adversely impacting the road user or downstream slope.

The catchpit solution also allows the catchment, including its numerous watercourses to be channelled beneath the structure retaining the characteristics of the water environment as closely as possible, whilst mitigating the risk of downstream scour through controlled discharge.

The debris flow shelter structure, i.e., the roof over the road, is there to provide an extra level of protection to road users in the event of a major landslide that could overtop the roof and to protect the road from rock fall.

The roof will also provide access to the structure and catchpit for maintenance, including maintenance of the compressible material to protect from boulder strike. The bespoke access arrangement will minimise the risk of disturbance in the form of traffic management to the road user providing a more resilient solution.

5.2.2.2. Viaduct Constructability

The Brown Option initially contained a viaduct above the OMR to cross the existing ravine, south of the Rest and Be Thankful viewpoint carpark. The initial assessment raised equivalent concerns to that raised through the Yellow Option with respect to constructability of this viaduct. In particular, the impact of the working platforms noting these would require permanent diversion of the OMR and pose a health and safety risk during construction.

As the form of structure for the flow shelter had now evolved, it was considered that an equivalent level of resilience could be achieved by extending the catchpit and protection wall up to the ravine that the viaduct sought to bypass. This marked the end of the Beinn Luibhean slope and the main area of vulnerability.

As it is only the catchpit and protection wall that is required, opposed to the full debris flow shelter, this does not restrict the forward stopping sight distance, which will be improved from the existing situation through the removal of an existing rock plug on the inside of the bend.

5.2.3. Green Option

The Green Option is located on the western side of Glen Croe on the lower slopes of Ben Donich, on the opposite side of the glen from the existing A83. The engineering description of the Green Option is contained in sub-section 5.3.3.

To reach the western slope, viaducts are required at the southern and northern extent. For development purposes the Green Option has been split into 3 sections, noting the central section has a bearing on the outer sections and is therefore presented first.

5.2.3.1. Central Section

Further assessment of the hillside has highlighted a number of potential landslip zones on the lower and upper Ben Donich slopes. As such, landslide protection measures are considered appropriate along the majority of its length. Two options were considered to provide such protection. These options are;

- a viaduct located at a similar elevation to the forestry track but offset such that the road would be supported on structure allowing landslide material to pass under similar to the Yellow Option; and,
- a debris flow shelter broadly online of the existing forestry track with structure similar to that of the Brown Option.

As noted with respect to the Yellow Option above, constructing a viaduct on steep ground which is vulnerable to landslide requires a significant amount of temporary works to ensure the works can be undertaken safely.

Unlike the Yellow Option, the slopes of the western side of the valley remain fairly uniform to the Croe Water. Therefore, moving the structure to flatter, less vulnerable ground is not practicable on the west side of the valley. This means there is little ways of practically mitigating the temporary works requirements.

As such a debris flow shelter similar to that of the Brown Option is considered the most practical and least impactful way of providing the required protection. For details of the developments associated with a debris flow shelter see sub-section 5.2.2.1, above.

As the roof of the structure is designed specifically to make the maintenance and operation of the structure more efficient, ramps to the roof were carefully designed to facilitate access to both ends of the structure.

5.2.3.2. Southern Viaduct

A viaduct is required to cross the OMR and Croe Water. The elevation of the viaduct is such to tie into the lower forestry track therefore the focus has been on pier and abutment spacing to make sure the existing forestry track remains accessible as this would form a key construction route for the debris flow shelter which forms the critical path item to the Green Option programme.

5.2.3.3. Northern Viaduct

The pier locations were refined to consider how access will be achieved in the permanent case both to the piers and the adjacent debris flow shelter.

5.2.4. Purple Option

The intent of the Purple Option is to protect the road users from landslide and rock fall from the Beinn Luibhean slope by raising the road above the hazard (viaduct) similar to that of the Yellow Option. However, the Purple Option also considers a length of tunnel to reduce the height of the viaduct required. The engineering description of the Purple Option is contained in section 5.3.4.

5.2.4.1. Viaduct Section

The proposed line of the viaduct is equivalent to that of the Yellow Option, meaning the principal design developments with respect to the construction of piers is the same.

As the viaduct enters a tunnel, immediately south of the Rest and Be Thankful viewpoint car park, additional focus has been given to the viaduct / tunnel interface. Particularly with respect to the construction of the northern abutment and southern portal.

This has included how this area will be accessed during construction and refining the options such that we are confident that there is minimal impact to the OMR which will likely be the temporary diversion during construction. Figure 5-5, below, shows the area.

Figure 5-5 - Construction access from the OMR to the northern abutment / southern portal of the Purple Option

5.2.4.2. Tunnel

The principal focus areas with respect to the tunnel are as follows:

- Tunnel cross section including evacuation procedures, fire protection and heating, ventilation and air conditioning (HVAC)
- Mining methodology
- Portal location including extent of cut and cover

Tunnel Cross section

As noted in Chapter 4 and Section 5.3, the tunnel cross section is generally governed by DMRB CD352 ‘Design of Road Tunnels’, however key to the consideration of cross section is the strategy with respect to HVAC, fire and evacuation.

Due to the length of tunnel, various options were considered, particularly with respect to evacuation, which included consideration of intermediate escape/exhaust shafts.

Given the location, it was felt that the safest and most robust approach was to include for a segregated and fire protected evacuation route along the full extent of the tunnel. Whilst this would increase the size of the cross section it would also provide a place to locate certain mechanical, electrical and plumbing components meaning they could be accessed without traffic management in the tunnel.

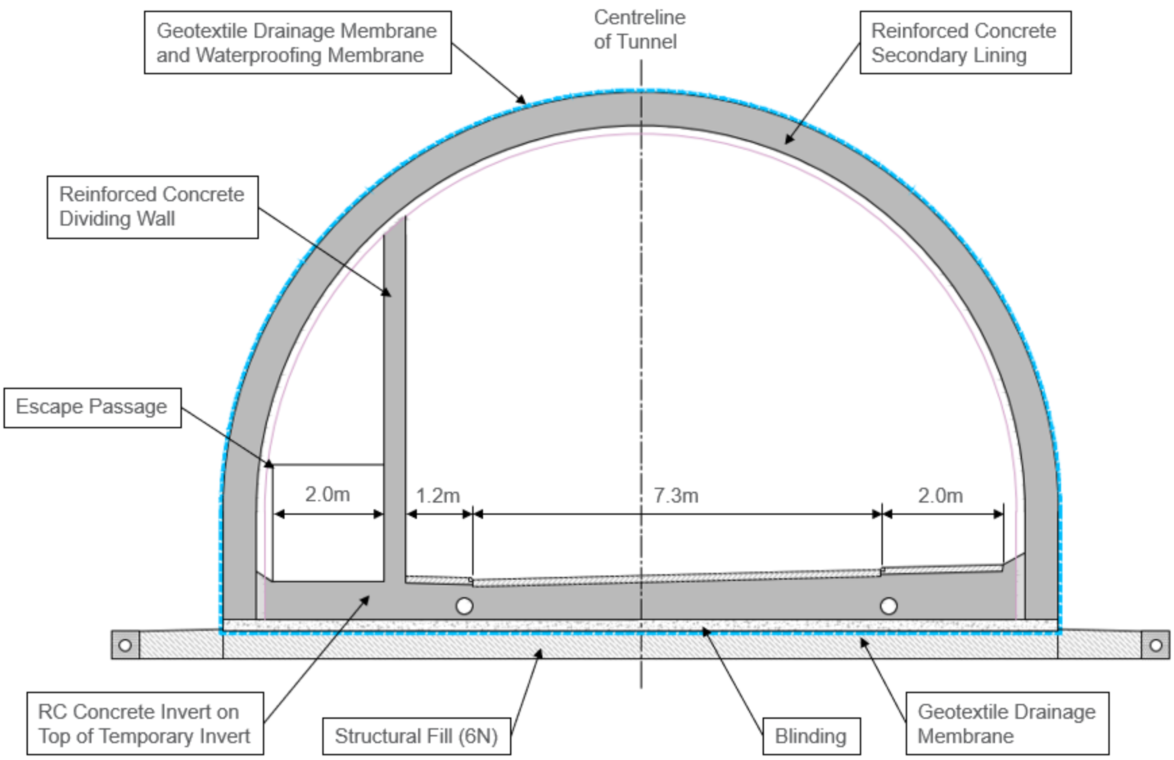

Figure 5-6 - Tunnel Typical Cross Section

Localised amendments to the cross section would also be required for electrical supplies and plant rooms.

Mining Methodology

Once the cross section of the tunnel was clarified, an assessment of the most appropriate mining techniques was undertaken considering a broad range of engineering, environmental and economic factors.

The principal techniques considered were:

- Drill and Blast;
- Road Header; and,
- Tunnel Boring.

Each technique had a range of advantages and disadvantages associated with it, and would influence the construction sequence, programme and cost.

The initial assessment confirmed that based on the ground conditions, a drill and blast solution was the most appropriate, and this also had the benefit of having the least lead in time as it did not require significant or potentially bespoke plant. It also required the smallest temporary footprint and laydown area which reduced the amount of additional excavation and impact local to the portals.

Portal location including extent of cut and cover

As a drill and blast operation requires less laydown areas, the design for the portals was developed and refined. For both portals several refinements were considered to optimise the extent of the mined operation compared to the cut and cover tunnel.

For the southern portal this was important to ensure the OMR could remain accessible and for the northern portal this is because the tunnel enters the ground at a heavy skew meaning a relatively long length of cut and cover is required before sufficient depth of rock is achieved to start the mining operation.

5.2.5. Pink Option

The intent of the Pink Option is to protect the road users from landslide and rock fall from the Beinn Luibhean slope through moving the road underground well below the risk area by means of a tunnel. The engineering description of the Pink Option is contained in sub-section 5.3.5.

As with the Purple Option the focus areas were as follows:

- Tunnel cross section including evacuation procedures, fire protection and HVAC
- Mining methodology
- Portal location including extent of cut and cover

The design development with respect to cross section and mining methodology is equivalent to both the Purple and Pink Options. Therefore, please refer to the previous section for details.

The main difference is with respect to the length of the tunnel and the southern portal. For the southern portal, the design development focussed on understanding the potential disruption to the A83 caused by undertaking extensive excavation and mining in its vicinity and options to mitigate this disruption where possible.

The initial assessment confirmed that due to the side long ground and rock profile, there would likely be considerable disruption and even extensive closures of the A83 during construction of the tunnel. To obtain the separation required a temporary diversion to the A83 was developed. The impact of the temporary diversion was assessed against the impact of the disruption, and it was concluded that a temporary diversion of the A83 is appropriate to facilitate the construction of the southern portal as illustrated in Figure 5-7, below.

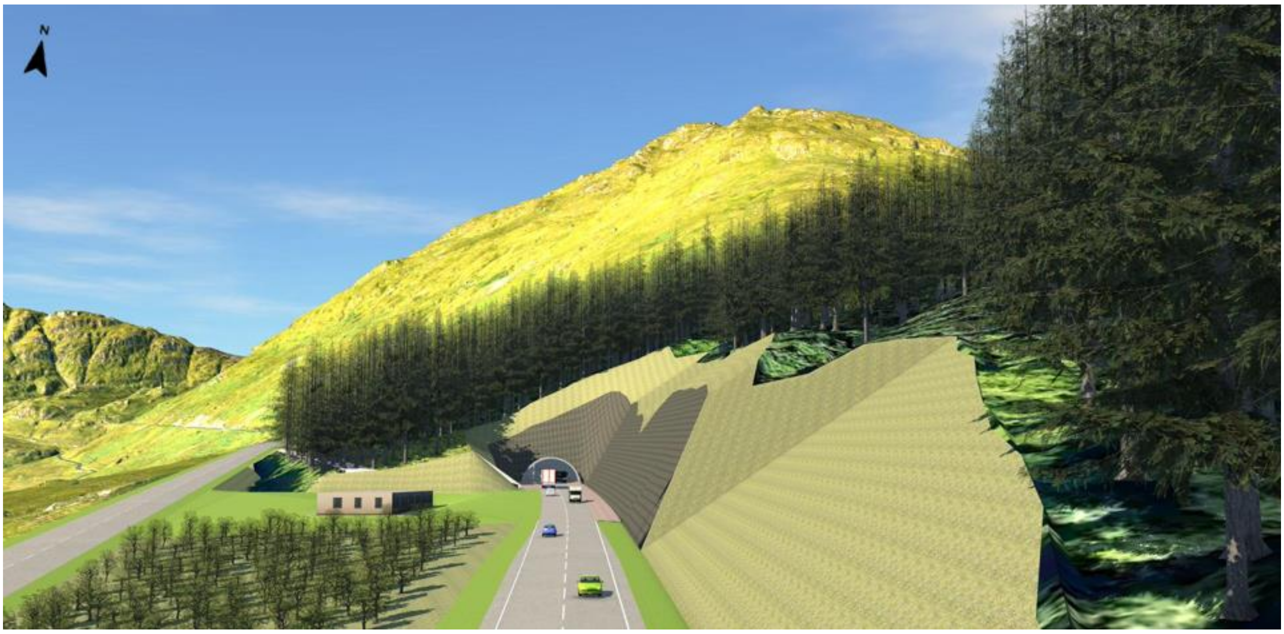

Figure 5-7 - Pink Option southern portal and temporary diversion of the A83

5.3. Engineering Description of Route Options

The following represents an engineering description of the Scheme Options as assessed. The details are still preliminary, and the Preferred Route will be subject to design refinements through DMRB Stage 3. Plan and profiles of each of the Scheme Options are contained in Volume 2.

5.3.1. General Option Summary – Yellow

5.3.1.1. Mainline

The horizontal and vertical alignment geometry information associated with the Yellow Option mainline is presented on drawings A83AAB-AWJ-HML-LTS_LB3-DR-CH-000002 to A83AAB-AWJ-HML-LTS_LB3-DR-CH-000003 included in Volume 2 of this report. The mainline alignment of the Yellow Option can be split into three sections; the southern tie-in to the existing A83, the viaduct and the northern tie-in to the existing A83.

Southern Tie-in (Ch. 0 to Ch. 320)

Figure 5-8 - Visualisation of the Yellow Option Southern Tie-in

The Yellow Option ties-in to the A83 on an existing straight section approximately 350m southeast of the existing bridge over the Croe Water. From here it diverges in a generally north-to-north-westerly direction towards the OMR and the Glen Croe valley floor. The horizontal alignment associated with the southern tie-in is fully compliant with Table 2.10 of DMRB CD 109 'Highway Link Design' for a 100kph design speed. The minimum radius specified is a 510m radius curve.

The vertical alignment within the southern tie-in section of the Yellow Option is fully compliant with DMRB CD 109 'Highway Link Design' with a maximum gradient of 5.7% which is less than the 6% maximum allowable prescribed in Table 5.1 of DMRB CD 109 'Highway Link Design' for an all-purpose single carriageway and a single sag curve which is equal to the desirable minimum K value of 26 prescribed in Table 2.10 in DMRB CD 109 'Highway Link Design' for a 100kph design speed.

Viaduct (Ch. 320 to Ch. 2,110)

Figure 5-9 - Visualisation of the Yellow Option Viaduct looking north up Glen Croe from Crow Water

The viaduct for the Yellow Option, described further in sub-section 5.3.1.2**,** commences at Ch. 320, approximately 50m south-east of the Croe Water. Over its 1.8km length the horizontal alignment includes a right-hand curve at the southern end to allow a skewed crossing of the OMR followed by a long straight that runs parallel with the OMR and a left-hand curve at the northern end taking the alignment back towards the Rest and Be Thankful viewpoint car park. The horizontal alignment associated with the viaduct is fully compliant with Table 2.10 of DMRB CD 109 'Highway Link Design' for a 100kph design speed. The minimum radius specified is a 720m radius curve.

The vertical alignment on the viaduct for the Yellow Option is fully compliant with DMRB CD 109 'Highway Link Design' with a maximum gradient of 5.7% which is less than the 6% maximum allowable prescribed in Table 5.1 of DMRB CD 109 'Highway Link Design' and a single crest curve with K value of 55 which is one step below the desirable minimum K value prescribed in Table 2.10 in DMRB CD 109 'Highway Link Design'.

Northern Tie-in (Ch. 2,110 to Ch. 2,520)

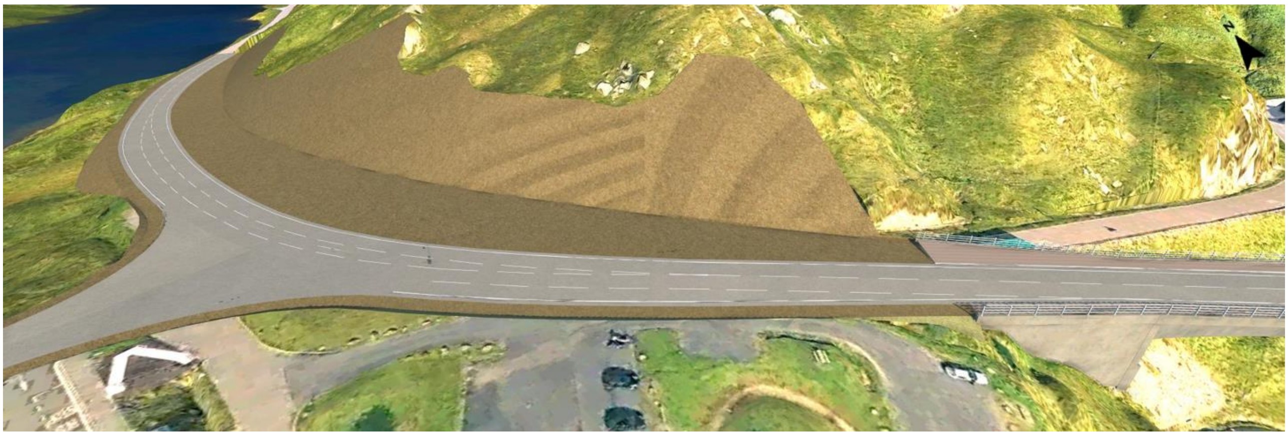

Figure 5-10 - Visualisation of the Yellow Option Northern Tie-in looking north-east to Loch Restil

The northern abutment of the Yellow Option viaduct is approximately 35m south-east of the Rest and Be Thankful viewpoint car park between the OMR and the existing A83. From this point the alignment looks to follow the horizontal alignment of the existing A83. As such, there are a number of horizontal curves with the minimum radius set at 127m which is greater than two steps below the desirable minimum 360m radius prescribed in Table 2.10 in DMRB CD 109 ‘Highway Link Design’.

The vertical alignment associated with the northern tie-in is fully compliant with DMRB CD 109 ‘Highway Link Design’ with a maximum gradient of 1% which is less than the 6% maximum allowable prescribed in Table 5.1 of DMRB CD 109 ‘Highway Link Design’, a single crest curve with K value of 55 which is one step below the desirable minimum K value prescribed in Table 2.10 in DMRB CD 109 ‘Highway Link Design’ and a single sag curve with K value of 26, the desirable minimum prescribed in Table 2.10 of DMRB CD 109 ‘Highway Link Design’.

5.3.1.2. Structures

This section provides an overview of the anticipated structure requirements for the Yellow Option. Further development of structural options will be undertaken during DMRB Stage 3.

The location of structures required for the Yellow Option are indicated on the drawings listed in Table 5-1, below and presented in Volume 2 of this report.

The DMRB Stage 2 assessment process has considered both a post tensioned concrete balanced cantilever and steel-concrete composite deck solution for the viaduct. The initial assessment has concluded that they both have the potential to meet the functional requirements of the structure and the overall footprint, and construction programme would be similar. For illustrative purposes, throughout the report, the images reflect the balanced cantilever solution, but the following section provides a summary of both forms of construction.

Table 5-1 - Yellow Option Structures Drawings

Option Evaluated	Drawing Number	Title
Yellow Option (Post Tensioned Concrete Balanced Cantilever Viaduct Deck)	A83AAB-AWJ-SBR-LTS_LB3-DR-CB-000001	General Arrangement – Overview
	A83AAB-AWJ-SBR-LTS_LB3-DR-CB-000002	General Arrangement – Typical Details
	A83AAB-AWJ-SBR-LTS_LB3-DR-CB-000003	General Arrangement – South Abutment to Pier P02
	A83AAB-AWJ-SBR-LTS_LB3-DR-CB-000004	General Arrangement – Pier P02 to Pier P04
	A83AAB-AWJ-SBR-LTS_LB3-DR-CB-000005	General Arrangement – Pier P04 to Pier P07
	A83AAB-AWJ-SBR-LTS_LB3-DR-CB-000006	General Arrangement – Pier P07 to Pier P10
	A83AAB-AWJ-SBR-LTS_LB3-DR-CB-000007	General Arrangement – Pier P10 to Pier P13

Option Evaluated	Drawing Number	Title
	A83AAB-AWJ-SBR-LTS_LB3-DR-CB-000008	General Arrangement - Pier P13 to Pier P16
	A83AAB-AWJ-SBR-LTS_LB3-DR-CB-000009	General Arrangement - Pier P16 to North Abutment
Yellow Option (Steel-Concrete Composite Viaduct Deck)	A83AAB-AWJ-SBR-LTS_LB3-DR-CB-000101	General Arrangement – Overview
	A83AAB-AWJ-SBR-LTS_LB3-DR-CB-000102	General Arrangement – Typical Details
	A83AAB-AWJ-SBR-LTS_LB3-DR-CB-000103	General Arrangement – South Abutment to Pier P02
	A83AAB-AWJ-SBR-LTS_LB3-DR-CB-000104	General Arrangement – Pier P02 to Pier P04
	A83AAB-AWJ-SBR-LTS_LB3-DR-CB-000105	General Arrangement – Pier P04 to Pier P07
	A83AAB-AWJ-SBR-LTS_LB3-DR-CB-000106	General Arrangement – Pier P07 to Pier P10
	A83AAB-AWJ-SBR-LTS_LB3-DR-CB-000107	General Arrangement – Pier P10 to Pier P13

Option Evaluated	Drawing Number	Title
	A83AAB-AWJ-SBR-LTS_LB3-DR-CB-000108	General Arrangement – Pier P13 to Pier P16
	A83AAB-AWJ-SBR-LTS_LB3-DR-CB-000109	General Arrangement – Pier P16 to North Abutment

The proposed A83 viaduct illustrated in Figure 5-11 would be a 19-span road bridge located in the Glen Croe valley on the lower slopes of Beinn Luibhean. The viaduct would cross the OMR, and various watercourses, notably the Croe Water. The carriageway has a single lane in each direction with verges on either side. For comparison purposes the parapets are 1.5m high N2.

Figure 5-11 - Visualisation of the Yellow Option Viaduct looking north up Glen Croe from Croe Water

The viaduct would be 1.8km long with three distinct geometric elements – a constant radius curve 350m in length at the southern end, a straight section 980m in length and a constant radius curve 480m in length at the northern end. The following summarises the two possible forms of construction.

Post Tensioned Concrete Balanced Cantilever

Using the balanced cantilever method, the viaduct would consist of north and south abutments, 18 rectangular hollow piers and 19 box girder spans, ranging from 50m to 110m in length. The piers will be founded on pile foundations ranging in depth dependant on the ground conditions encountered at the individual pier locations.

The piers may be constructed using slip form construction and the superstructure is built using cantilever form travellers which allows construction of the deck structure in a series of segments. When constructing the deck, segments are constructed evenly starting at the pierhead and cantilevering outwards towards the next pier. Each segment constructed in one direction has an equivalent balancing segment constructed in the opposite direction. This is to ensure the structure is balanced at all times during construction. Cantilevered spans are then stitched together with concrete to form one continuous span. A schematic of the process is shown in Figure 5-12-12, below.

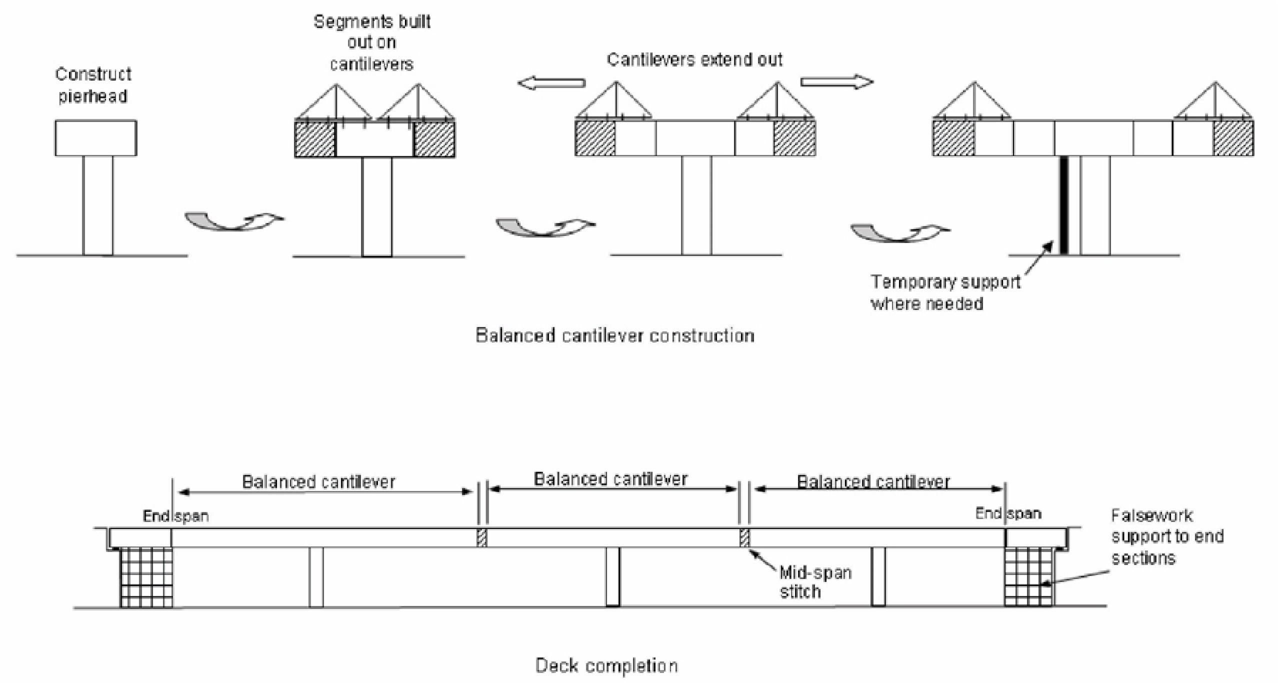

Figure 5-12 - Balanced cantilever construction process

Debris flow deflection structures will be constructed at an early stage of the pier construction sequence to provide a suitable base for the construction tower crane and to deflect any potential debris flow and landslide events away from the piers during construction.

Steel-Concrete Composite

The substructure and piers will be equivalent to the balanced cantilever solution.

The composite superstructure comprises of two steel trapezoidal box beams composite with a reinforced concrete slab with reinforced concrete copes. The superstructure may be articulated on hollow reinforced concrete piers and solid abutments with bored reinforced concrete piles.

5.3.1.3. Junctions

As the Yellow Option mainline alignment passes in close proximity to the existing B828 junction it may be necessary to provide a new junction. This may take the form of a priority junction with a ghost island in accordance with the guidance set out in DMRB CD 123 'Geometric Design of At-Grade Priority and Signal-Controlled Junctions'. The layout incorporates the following design parameters:

- 105m long diverge taper
- 40m exit radius
- Min 15m entry radius followed by 1:6 taper.
- 3.5m wide ghost island

5.3.1.4. Local Roads and Accesses

As a result of the upgraded B828 junction, it may be necessary to provide amended access to the Rest and Be Thankful viewpoint car park. This would take the form of a simple priority junction in accordance with the guidance set out in DMRB CD 123 'Geometric Design of At-Grade Priority and Signal-Controlled Junctions'.

It may also be necessary to provide an amended bus stop and turning area, reconfigured to work with the B828 junction and the revised junction to the Rest and Be Thankful viewpoint car park.

5.3.1.5. Earthworks

Approximate bulk earthworks volumes for the permanent and temporary works associated with the Yellow Option are included below. Further breakdown of these figures is included in Section 5.4.

- Cut Volume: 227,719m^3

- Fill Volume: 100,196m^3

5.3.2. General Option Summary – Brown

5.3.2.1. Mainline

The horizontal and vertical alignment geometry information associated with the Brown Option mainline is presented on drawings A83AAB-AWJ-HML-LTS_LC3-DR-CH-000002 to A83AAB-AWJ-HML-LTS_LC3-DR-CH-000003 included in Volume 2 of this report. The mainline alignment of the Brown Option can be split into four sections; the southern tie-in to the existing A83, the debris flow shelter, the debris flow protection wall and the northern tie-in to the existing A83.

Southern Tie-in (Ch. 0 to Ch. 320)

Figure 5-13 - Visualisation of the Brown Option southern tie-in looking north up Glen Croe

The Brown Option ties-in to the A83 on an existing straight section approximately 230m south-east of the existing bridge over the Croe Water. From here it progresses north generally online of the existing road. The horizontal alignment associated with the southern tie-in is fully compliant with Table 2.10 of DMRB CD 109 ‘Highway Link Design’ for a 100kph design speed. The minimum radius specified is an 850m radius curve.

The vertical alignment within the southern tie-in section is also fully compliant with DMRB CD 109 ‘Highway Link Design’ with a maximum gradient of 5% which is less than the 6% maximum allowable prescribed in Table 5.1 of DMRB CD 109 ‘Highway Link Design’ for an all-purpose single carriageway.

Debris Flow Shelter (Ch. 320 to Ch. 1,690)

Figure 5-14 - Visualisation of the Brown Option Debris Flow Shelter looking north up Glen Croe from Croe Water

The debris flow shelter, and associated catchpit described further in sub-section 5.3.2.2**,** commences approximately 90m north-to-northwest of the bridge over the Croe Water. From here the alignment progresses generally north on the line of the existing A83, with some minor deviations to improve geometry. The horizontal alignment associated with the debris flow shelter is fully compliant with Table 2.10 of DMRB CD 109 'Highway Link Design' for a 100kph design speed. The minimum radius specified is a 720m radius curve.

The vertical alignment within the debris flow shelter is fully compliant with DMRB CD 109 'Highway Link Design' with a maximum gradient of 5.1% which is less than the 6% maximum allowable prescribed in Table 5.1 of DMRB CD 109 'Highway Link Design' for an all-purpose single carriageway and a crest curve with K value of 250 and a sag curve with a K value of 200 which are both greater than the desirable minimum K values for a 100kph design speed of 100 and 26, respectively, prescribed in Table 2.10 in DMRB CD 109 'Highway Link Design'.

The alignment of the Brown Option has been designed such that it removes the need for earthworks embankments on the downhill side of the road to minimise construction on potentially unstable existing debris flow deposits that are a prominent feature on the lower slopes of Beinn Luibhean. As such along the full extents of the debris flow shelter the cross section predominantly features earthworks cuttings on the uphill side of the debris flow shelter and catchpit.

Debris Flow Protection Wall (Ch. 1,690 to Ch. 1,870)

Figure 5-15 - Visualisation of the Brown Option Debris Flow Protection Wall looking north up Glen Croe

Beyond the debris flow shelter at Ch. 1,870 the Brown Option includes a debris flow protection wall, described further in sub-section 5.3.2.2**,** to provide the necessary resilience to the A83. The Brown Option transitions from the debris flow shelter to the debris flow protection wall at this point as the horizontal alignment to the north, which matches the existing A83 horizontal alignment, is below the standards set out in CD DMRB CD 109 'Highway Link Design' for a 100kph design speed. As such, the removal of the open column wall on the valley floor side of the debris flow shelter affords greater forward visibility of the road ahead for drivers. The horizontal alignment of the Brown Option along the extents of the debris flow protection wall has a horizontal curve with a radius of 105m which is greater than two steps below the desirable minimum 360m radius prescribed for a 100kph design speed in Table 2.10 in DMRB CD 109 'Highway Link Design'.

The vertical alignment of the Brown Option adjacent to the debris flow protection wall is fully compliant with DMRB CD 109 'Highway Link Design' with a maximum gradient of 5.1% which is less than the 6% maximum allowable prescribed in Table 5.1 of DMRB CD 109 'Highway Link Design' for an all-purpose single carriageway.

Northern Tie-in (Ch. 1,870 to Ch. 2,400)

Figure 5-16 - Visualisation of the Brown Option Northern Tie-in looking north-west to Loch Restil

Like the Yellow Option, at the northern tie-in the proposed alignment of the Brown Option looks to follow the horizontal alignment of the existing A83. As such, there are a number of horizontal curves with the minimum radius set at 150m which is greater than two steps below the desirable minimum 360m radius prescribed for a 100kph design speed in Table 2.10 in DMRB CD 109 ‘Highway Link Design’.

To allow suitable forward visibility of the road ahead for drivers significant verge widening has been included in the southbound verge of the proposed alignment at the northern tie-in, opposite the junction with the B828.

The vertical alignment associated with the northern tie-in is fully compliant with DMRB CD 109 ‘Highway Link Design’ with a maximum gradient of 5.1% which is less than the 6% maximum allowable prescribed in Table 5.1 of DMRB CD 109 ‘Highway Link Design’ for an all-purpose single carriageway and a single crest curve with K value of 55 which is one step below the desirable minimum K value prescribed for a 100kph design speed in Table 2.10 in DMRB CD 109 ‘Highway Link Design’.

5.3.2.2. Structures

This section provides an overview of the anticipated structure requirements for the Brown Option. Further development of structural options will be undertaken during DMRB Stage 3.

The location of structures required for the Brown Option are indicated on the drawings listed in Table 5-2, below and presented in Volume 2 of this report.

Table 5-2 - Brown Option Structures Drawings

Option Evaluated	Drawing Number	Title
Brown Option (Debris Flow Shelter with Catchpit)	A83AAB-AWJ-SBR-LTS_LC3-DR-CB-000001	General Arrangement – Overview
	A83AAB-AWJ-SBR-LTS_LC3-DR-CB-000002	General Arrangement – Debris Flow Shelter – Typical Cross Section Details (Sheet 1 of 2)
	A83AAB-AWJ-SBR-LTS_LC3-DR-CB-000003	General Arrangement – Debris Flow Shelter – Typical Cross Section Details (Sheet 2 of 2)
	A83AAB-AWJ-SBR-LTS_LC3-DR-CB-000004	General Arrangement – Typical Details – Retaining Wall
	A83AAB-AWJ-SBR-LTS_LC3-DR-CB-000005	General Arrangement – Longitudinal Elevation Chainage 300 – 680 (Sheet 1 of 5)
	A83AAB-AWJ-SBR-LTS_LC3-DR-CB-000006	General Arrangement - Longitudinal Elevation Chainage 680 -1020 (Sheet 2 of 5)
	A83AAB-AWJ-SBR-LTS_LC3-DR-CB-000007	General Arrangement - Longitudinal Elevation Chainage 1020 -1360 (Sheet 3 of 5)

Option Evaluated	Drawing Number	Title
	A83AAB-AWJ-SBR-LTS_LC3-DR-CB-000008	General Arrangement - Longitudinal Elevation Chainage 1360 -1680 (Sheet 4 of 5)
	A83AAB-AWJ-SBR-LTS_LC3-DR-CB-000009	General Arrangement - Longitudinal Elevation Chainage 1680 -1860 (Sheet 5 of 5)
	A83AAB-AWJ-SBR-LTS_LC3-DR-CB-000010	General Arrangement - Access Ramp - Bridge Over Croe Water
	A83AAB-AWJ-SBR-LTS_LC3-DR-CB-000011	General Arrangement – Bridge Over Croe Water

Debris Flow Shelter

The debris flow shelter would be 1.37km in length and would commence at Ch. 320, approximately 90m north of the existing bridge over the Croe Water. It would be a single span portal frame structure which the proposed A83 will pass through. It is proposed that the structure would comprise of a solid reinforced concrete back wall and roof slab, with an open column wall facing the floor of the valley. A reinforced concrete catchpit is proposed on the uphill side of the structure, which would be connected to the solid wall of the debris flow shelter.

Cushioning material, in the form of gabion baskets or equivalent, would be provided over adjacent to the protection wall. The structure may be piled on the downhill and uphill side of the structure, however, some sections may be supported on spread foundations, depending on ground conditions. The roof would include a layer of cushioning material above and would also facilitate access for maintenance and inspection. The parapets would be 1.5m high.

Figure 5-17 - Visualisation of the southern entrance to the Brown Option Debris Flow Shelter, looking north up Glen Croe

Debris Flow Protection Wall

At the northern end of Glen Croe approximately 590m south-east of the existing B828 junction the debris flow shelter stops and protection of the A83 is proposed via the inclusion of a protection wall and catchpit on the uphill side of the road for a further 180m. This provides the necessary protection to the road whilst allowing forward visibility of the road ahead for drivers that would otherwise be obstructed by the open column wall facing the floor of the valley. The protection wall will take the form of a solid reinforced concrete wall. Cushioning material, in the form of gabion baskets or similar, would also be provided adjacent to the protection wall. The protection wall will likely be supported on spread foundations, depending on ground conditions.

Figure 5-18 - Visualisation of the Brown Option Debris Flow Protection Wall and the northern entrance to the Debris Flow Shelter, looking south-east down Glen Croe

5.3.2.3. Junctions

Like the Yellow Option, the Brown Option passes in close proximity to the existing B828 junction, and it may be necessary to provide a new junction. This may take the form of a priority junction with a ghost island in accordance with the guidance set out in DMRB CD 123 ‘Geometric Design of At-Grade Priority and Signal-Controlled Junctions’ although it is noted the traffic flows are marginal and may suggest a simple priority junction is more appropriate. The layout as currently assessed incorporates the following key design parameters:

- 105m long diverge taper
- 40m exit radius
- Min 15m entry radius followed by 1:6 taper
- 3.5m wide ghost island

5.3.2.4. Local Roads and Accesses

To allow cyclic maintenance of the catchpit at the rear of the debris flow shelter access is required to the debris flow shelter roof. This has been provided at the southern end of the debris flow shelter utilising an existing informal access approximately 35m south of the Croe Water crossing of the A83.

Figure 5-19 - Visualisation of the maintenance access to the roof of the Debris Flow Shelter for the Brown Option

Like the Yellow Option, the Brown Option may also require an amended access to the Rest and Be Thankful viewpoint car park as a result of the upgraded B828 junction. This will take the form of a simple priority junction in accordance with the guidance set out in DMRB CD 123 'Geometric Design of At-Grade Priority and Signal-Controlled Junctions'.

It would also be necessary to provide an amended bus stop and turning area, reconfigured to work with the B828 junction and the revised junction to the Rest and Be Thankful viewpoint car park.

5.3.2.5. Earthworks

Approximate bulk earthworks volumes for the permanent and temporary works associated with the Brown Option are included below. Further breakdown of these figures is included in Section 5.4.

- Cut Volume: 311,168m^3
- Fill Volume: 3,274m^3

5.3.3. General Option Summary - Green

5.3.3.1. Mainline

The horizontal and vertical alignment geometry information associated with the Green Option mainline is presented on drawings A83AAB-AWJ-HML-LTS_LA0-DR-CH-000002 to A83AAB-AWJ-HML-LTS_LA0-DR-CH-000004 included in Volume 2 of this report. The mainline alignment of the Green Option can be split into five sections; the southern tie-in to the existing A83, a southern viaduct, the debris flow shelter, a northern viaduct and the northern tie-in to the existing A83.

Southern Tie-in (Ch. 0 to Ch. 460)

Figure 5-20 - Visualisation of the Green Option southern tie-in looking west towards Ben Donich

The Green Option ties-in to the existing A83 on a straight section approximately 450m east of the existing junction with the OMR. The alignment is then located to the north of the existing A83 in land between the existing A83 and an existing forestry access track heading in a generally westerly direction towards the lower slopes of Ben Donich. The horizontal alignment within this section is compliant with the standards provided in Table 2.10 of DMRB CD 109 'Highway Link Design' for a 100kph design speed with the minimum radius used set at 510m.

The vertical alignment within this initial stretch of alignment is fully compliant with Table 2.10 and Table 5.1 of DMRB CD 109 'Highway Link Design'. It contains two gradients, both of which are less than the 6% maximum allowable in Table 5.1 of DMRB CD 109 'Highway Link Design' for an all-purpose single carriageway and a single sag curve with a K value of 26, the desirable minimum prescribed in Table 2.10 of DMRB CD 109 'Highway Link Design' for a 100kph design speed.

Southern Viaduct (Ch. 460 to Ch. 900)

Figure 5-21 - Visualisation of the Green Option Southern Viaduct looking north up Glen Croe

The southern viaduct, described further in sub-section 5.3.3.2, commences at Ch. 460, approximately 140m south-east of the existing junction that allows access from the A83 to the OMR, used when the local diversion is in operation. The Green Option then continues in a westerly direction towards the lower slopes of Ben Donich crossing the existing A83, OMR, Croe Water and the Glen Croe lower forestry track. The horizontal alignment associated with the southern viaduct is generally straight. However, at both ends the alignment is on transition out of and into curves which are both compliant with the standards presented Table 2.10 of DMRB CD 109 ‘Highway Link Design’ for a 100kph design speed.

The vertical alignment over the southern viaduct is fully compliant with Table 2.10 and Table 5.1 of DMRB CD 109 ‘Highway Link Design’. It contains two grades, both of which are less than the 6% maximum allowable in Table 5.1 of DMRB CD 109 ‘Highway Link Design’ for an all-purpose single carriageway and a single sag curve with a K value of 26, the desirable minimum prescribed in Table 2.10 of DMRB CD 109 ‘Highway Link Design’ for a 100kph design speed.

Debris Flow Shelter (Ch. 900 to Ch. 3,450)

Figure 5-22 - Visualisation of the southern entrance to the Green Option Debris Flow Shelter, looking west towards Ben Donich

The debris flow shelter, and associated catchpit, described further in sub-section 5.3.3.2, commences at Ch. 990, approximately 395m north-to-northwest of the existing junction that allows access from the A83 to the OMR, used when the local diversion is in operation. From here the alignment progresses generally north loosely following the line of the existing Glen Croe lower forestry track, with some minor deviations to improve geometry. The horizontal alignment associated with the debris flow shelter is fully compliant with Table 2.10 of DMRB CD 109 ‘Highway Link Design’ for a 100kph design speed. The minimum radius specified is a 430m radius curve.

The vertical alignment within the debris flow shelter for the Green Option is compliant with Table 5.1 of DMRB CD 109 ‘Highway Link Design’ for an all-purpose single carriageway with gradients generally up to or less than 6% with only a short length, approximately 100m, with a maximum gradient of 8% which is in line with the allowable relaxed value prescribed in Table 5.1 of DMRB CD 109 ‘Highway Link Design’ for an all-purpose single carriageway. The vertical alignment utilises several sag and crest curves throughout the extents of the debris flow shelter, all fully compliant with the desirable minimum K values prescribed in Table 2.10 in DMRB CD 109 ‘Highway Link Design’ for a 100kph design speed.

Like the Brown Option, the alignment of the Green Option has been designed such that it removes the need for earthworks embankments on the downhill side of the alignment to avoid construction on potentially unstable existing debris flow deposits that are also a feature on the lower slopes of Ben Donich. As such, along the full extents of the debris flow shelter the cross section predominantly features significant earthworks cuttings on the uphill side of the debris flow shelter and catchpit.

Northern Viaduct (Ch. 3,450 to Ch. 3,715)

Figure 5-23 - Visualisation of the Green Option Northern Viaduct looking north towards Loch Restil

The northern viaduct, described further in sub-section 5.3.3.2, commences at Ch. 3,450, approximately 450m south of the Rest and Be Thankful viewpoint car park. The Green Option then continues in a northerly direction towards the existing A83 adjacent to Loch Restil. The horizontal alignment associated with the northern viaduct is generally straight. However, at the southern end the alignment is on transition out of a curve which is compliant with the standards presented in Table 2.10 of DMRB CD 109 ‘Highway Link Design’ for a 100kph design speed.

The vertical alignment over the northern viaduct is fully compliant with Table 2.10 and Table 5.1 of DMRB CD 109 ‘Highway Link Design’. It contains a grade of 3.5% which is less than the 6% maximum allowable in Table 5.1 of DMRB CD 109 ‘Highway Link Design’ for an all-purpose single carriageway and a single crest curve with a K value of 55, one step below the desirable minimum prescribed in Table 2.10 of DMRB CD 109 ‘Highway Link Design’ for a 100kph design speed.

Northern Tie-in (Ch. 3,715 to Ch. 4,220)

Figure 5-24 - Visualisation of the Green Option northern tie-in looking north towards Loch Restil

Unlike the Yellow and Brown Options, at the northern tie-in the proposed alignment of the Green Option bypasses the Rest and Be Thankful viewpoint car park on the western side, not re-joining the line of the existing A83 until north of the B828 junction. In doing so it avoids the worst of the sub-standard geometry associated with the sweeping right hand bend of the existing A83 that passes the Rest and Be Thankful viewpoint car park and the B828 junction. As such, the horizontal alignment associated with the northern tie-in is compliant with the standards set out in in Table 2.10 in DMRB CD 109 ‘Highway Link Design’ for a 100kph design speed. The minimum radius specified is a 380m radius curve.

To allow suitable forward visibility of the road ahead for drivers minor verge widening has been included in the southbound verge of the proposed alignment at the northern tie-in, slightly north of the junction with the B828.

The vertical alignment associated with the northern tie-in is fully compliant with DMRB CD 109 ‘Highway Link Design’ with a maximum gradient of 3.5% which is less than the 6% maximum allowable prescribed in Table 5.1 of DMRB CD 109 ‘Highway Link Design’ for an all-purpose single carriageway, a single crest curve with K value of 55 which is one step below the desirable minimum K value prescribed in Table 2.10 in DMRB CD 109 ‘Highway Link Design’ and a single sag curve with K value of 26, the desirable minimum prescribed in Table 2.10 of DMRB CD 109 ‘Highway Link Design’.

5.3.3.2. Structures

This section provides an overview of the anticipated structure requirements for the Green Option. There are three structures as part of the Green Option. Two viaducts, one at either end of Glen Croe to cross the existing A83, OMR and Croe Water in the south and a steep gulley at the head of Glen Croe in the north. Additionally, there is a debris flow shelter to provide protection of the route in the central portion that traverses the lower slopes of Ben Donich. The following provides a summary of the structures. Further development of structural options would be undertaken during DMRB Stage 3.

The location of structures required for the Green Option are indicated on the drawings listed in Table 5-3, below and presented in Volume 2 of this report.

Table 5-3 - Green Option Structures Drawings

Option Evaluated	Drawing Number	Title
Green Option (Bridge 1 – Steel Concrete Composite Southern Viaduct)	A83AAB-AWJ-SBR-LTS_LA0-DR-CB-000001	General Arrangement – Overview
	A83AAB-AWJ-SBR-LTS_LA0-DR-CB-000002	General Arrangement – Typical Details
	A83AAB-AWJ-SBR-LTS_LA0-DR-CB-000003	General Arrangement – East Abutment to Pier P02
	A83AAB-AWJ-SBR-LTS_LA0-DR-CB-000004	General Arrangement – Pier P02 to Pier P06
	A83AAB-AWJ-SBR-LTS_LA0-DR-CB-000005	General Arrangement – Pier P06 to West Abutment
Green Option (Debris Flow Shelter with Catchpit)	A83AAB-AWJ-SBR-LTS_LA0-DR-CB-000101	General Arrangement – Overview

Option Evaluated	Drawing Number	Title
	A83AAB-AWJ-SBR-LTS_LA0-DR-CB-000102	General Arrangement – Debris Flow Shelter – Typical Cross Sections
	A83AAB-AWJ-SBR-LTS_LA0-DR-CB-000106	General Arrangement – Longitudinal Elevation Chainage 0 – 300 (Sheet 1 of 8)
	A83AAB-AWJ-SBR-LTS_LA0-DR-CB-000107	General Arrangement – Longitudinal Elevation Chainage 300 – 600 (Sheet 2 of 8)
	A83AAB-AWJ-SBR-LTS_LA0-DR-CB-000108	General Arrangement – Longitudinal Elevation Chainage 600 – 900 (Sheet 3 of 8)
	A83AAB-AWJ-SBR-LTS_LA0-DR-CB-000109	General Arrangement – Longitudinal Elevation Chainage 900 – 1200 (Sheet 4 of 8)
	A83AAB-AWJ-SBR-LTS_LA0-DR-CB-000110	General Arrangement – Longitudinal Elevation Chainage 1200 – 1500 (Sheet 5 of 8)
	A83AAB-AWJ-SBR-LTS_LA0-DR-CB-000111	General Arrangement – Longitudinal Elevation Chainage 1500 – 1800 (Sheet 6 of 8)
	A83AAB-AWJ-SBR-LTS_LA0-DR-CB-000112	General Arrangement – Longitudinal Elevation

Option Evaluated	Drawing Number	Title
		Chainage 1800 – 2100 (Sheet 7 of 8)
	A83AAB-AWJ-SBR-LTS_LA0-DR-CB-000113	General Arrangement – Longitudinal Elevation Chainage 2100 – 2300 (Sheet 8 of 8)
Green Option (Bridge 2 – Steel Concrete Composite Northern Viaduct)	A83AAB-AWJ-SBR-LTS_LA0-DR-CB-000201	General Arrangement – Overview
	A83AAB-AWJ-SBR-LTS_LA0-DR-CB-000202	General Arrangement – Typical Details
	A83AAB-AWJ-SBR-LTS_LA0-DR-CB-000203	General Arrangement – South Abutment to Pier P02
	A83AAB-AWJ-SBR-LTS_LA0-DR-CB-000204	General Arrangement – Pier P02 to North Abutment

Southern Viaduct

The Southern viaduct would have a total length of 435m and would be an 8-span single lane road bridge carrying the proposed A83 over the existing A83, the OMR, the Croe Water and an existing forestry track. The spans range in length from 40m to 60m. It is proposed that the superstructure comprises of a steel ladder deck, composite with a reinforced concrete slab and reinforced concrete copes. It is proposed that the superstructure is articulated on solid, reinforced concrete piers and abutments with bored reinforced concrete piles. The carriageway comprises of a single lane in each direction with verges on either side. The parapets shall be 1.5m high.

Figure 5-25 - Visualisation of the Southern Viaduct of the Green Option, looking north-west towards Ben Donich

Debris Flow Shelter

The debris flow shelter would be 2.3km in length and would be a single span portal frame structure which the proposed A83 will pass through. It is proposed that the structure would comprise of a solid reinforced concrete protection wall and roof slab, with an open column wall facing the floor of the valley. A reinforced concrete catchpit is proposed on the uphill side of the structure, which would be connected to the solid wall of the debris flow shelter. Cushioning material, in the form of gabion baskets or similar, would be provided over the full height of the protection wall. The structure would likely be piled on the downhill side of the structure. The uphill wall of the structure would generally be supported on piles; however, some sections may be supported on spread foundations, depending on ground conditions. An access track with a layer of cushioning material would be present on top of the structure. The parapets would be 1.5m high.

Figure 5-26 - Visualisation of the southern entrance to the Green Option Debris Flow Shelter, looking west towards Ben Donich

Northern Viaduct

The Northern viaduct would be a 265m long, 4-span single lane road bridge, carrying the proposed A83 over an unnamed watercourse and steep gulley at the head of Glen Croe. The spans range in length from 45m to 56m. It is proposed that the superstructure comprises of a steel ladder deck composite with a reinforced concrete slab and reinforced concrete copes. It is proposed that the superstructure would be supported on solid reinforced concrete piers and abutments with bored reinforced concrete piles. It is proposed the parapets are 1.5m high.

Figure 5-27 - Visualisation of the Northern Viaduct of the Green Option, looking south down Glen Croe

5.3.3.3. Junctions

The Green Option mainline alignment passes through the existing B828 junction, and it will therefore be necessary to provide a new junction. This will take the form of a priority junction with a ghost island in accordance with the guidance set out in DMRB CD 123 'Geometric Design of At-Grade Priority and Signal-Controlled Junctions'. The layout incorporates the following key design parameters:

- 105m long diverge taper
- 40m exit radius
- Min 15m entry radius followed by 1:6 taper
- 3.5m wide ghost island

5.3.3.4. Local Roads and Accesses

The Green Option requires five new accesses, two at the southern tie-in, one at the northern tie-in and two maintenance access tracks, one at either end of the debris flow shelter.

At the southern tie-in the proposed Green Option alignment passes near an existing forestry track access and bypasses the current access to the OMR. It will be necessary to provide an upgraded access to the forestry tracks on the southbound side of the A83 and a new access to the OMR will be required on the northbound side of A83. Both will take the form of simple priority junctions in accordance with the guidance set out in DMRB CD 123 ‘Geometric Design of At-Grade Priority and Signal-Controlled Junctions’.

At the northern tie-in, similar to the Yellow and Brown Options, the Green Option will require an amended access to the Rest and Be Thankful viewpoint car park as the proposed mainline alignment passes through the current access. This will be located on the southbound side of the A83 and will take the form of a simple priority junction in accordance with the guidance set out in DMRB CD 123 ‘Geometric Design of At-Grade Priority and Signal-Controlled Junctions’.

It will also be necessary to provide an amended bus stop and turning area, reconfigured to work with the new B828 junction.

To allow cyclic maintenance of the catchpit at the rear of the debris flow shelter access is required to the debris flow shelter roof. This has been provided at both ends of the debris flow shelter. At the southern end this consists of an access from the A83 at the southern end of the debris flow shelter. The access is located approximately 30m north of the southern viaduct north abutment extending north to tie-in with the roof of the debris flow shelter.

Figure 5-28 - Visualisation of the southern maintenance access from the proposed A83 to the roof of the Green Option debris flow shelter

At the northern end access has been taken from an existing forestry track that links to the B828. It commences approximately 110m south of the forestry tracks junction with the B828 and heads east towards the proposed A83 of the Green Option in an existing forestry clearing. The track then swings south and runs parallel with the proposed A83 of the Green Option towards the debris flow shelter and connects to its roof at the northern extent.

Figure 5-29 - Visualisation of the northern maintenance access from an existing forestry track that links to the B828 to the roof of the Green Option debris flow shelter

5.3.3.5. Earthworks Volumes

Approximate bulk earthworks volumes for the permanent and temporary works associated with the Green Option are included below. Further breakdown of these figures is included in Section 5.4.

- Cut Volume: 503,671m^3
- Fill Volume: 79,288m^3

5.3.4. General Option Summary - Purple

5.3.4.1. Mainline

The horizontal and vertical alignment geometry information associated with the Purple Option mainline is presented on drawings A83AAB-AWJ-HML-LTS_LD1-DR-CH-000002 to A83AAB-AWJ-HML-LTS_LD1-DR-CH-000004 included in Volume 2 of this report. The mainline alignment of the Purple Option can be split into four sections; the southern tie-in to the existing A83, the viaduct, the tunnel and the northern tie-in to the existing A83.

Southern Tie-in (Ch. 0 to Ch. 390)

Figure 5-30 - Visualisation of the Purple Option southern tie-in looking west towards Ben Donich

The Purple Option ties-in to the existing A83 on a straight section approximately 410m south-east of the existing bridge over the Croe Water. Like the Yellow Option, the alignment then diverges in a generally north-to-north-westerly direction towards the OMR and the Glen Croe Valley floor. The horizontal alignment associated with the southern tie-in is fully compliant with Table 2.10 of DMRB CD 109 ‘Highway Link Design’ for a 100kph design speed. The minimum radius specified is a 510m radius curve.

The vertical alignment within the southern tie-in section of the Purple Option is fully compliant with DMRB CD 109 ‘Highway Link Design’ with a maximum gradient of 5% which is less than the 6% maximum allowable prescribed in Table 5.1 of DMRB CD 109 ‘Highway Link Design’ for an all-purpose single carriageway and a single crest curve which is equal to the desirable minimum K value of 100 prescribed in Table 2.10 in DMRB CD 109 ‘Highway Link Design’ for 100kph design speed.

Viaduct (Ch. 390 to Ch. 1,865)

Figure 5-31 - Visualisation of the Purple Option Viaduct looking north up Glen Croe

The viaduct for the Purple Option, described further in sub-section 5.3.4.2, commences at Ch. 390, approximately 40m south-east of the Croe Water. Over its 1.475km length the horizontal alignment includes a right-hand curve at the southern end to allow a skewed crossing of the OMR followed by a long straight that runs parallel with the OMR and a right-hand curve at the northern end taking the alignment towards the lower slopes of Beinn Luibhean below the OMR and existing A83. The horizontal alignment associated with the viaduct is fully compliant with Table 2.10 of DMRB CD 109 ‘Highway Link Design’ for a 100kph design speed. The minimum radius specified is a 720m radius curve.

The vertical alignment on the viaduct for the Purple Option is fully compliant with DMRB CD 109 ‘Highway Link Design’ with a maximum gradient of 2% which is less than the 6% maximum allowable prescribed in Table 5.1 of DMRB CD 109 ‘Highway Link Design’ for an all-purpose single carriageway and a single crest curve which is equal to the desirable minimum K value of 100 prescribed in Table 2.10 in DMRB CD 109 ‘Highway Link Design’ for a 100kph design speed.

Tunnel (Ch. 1,865 to Ch. 3,105)

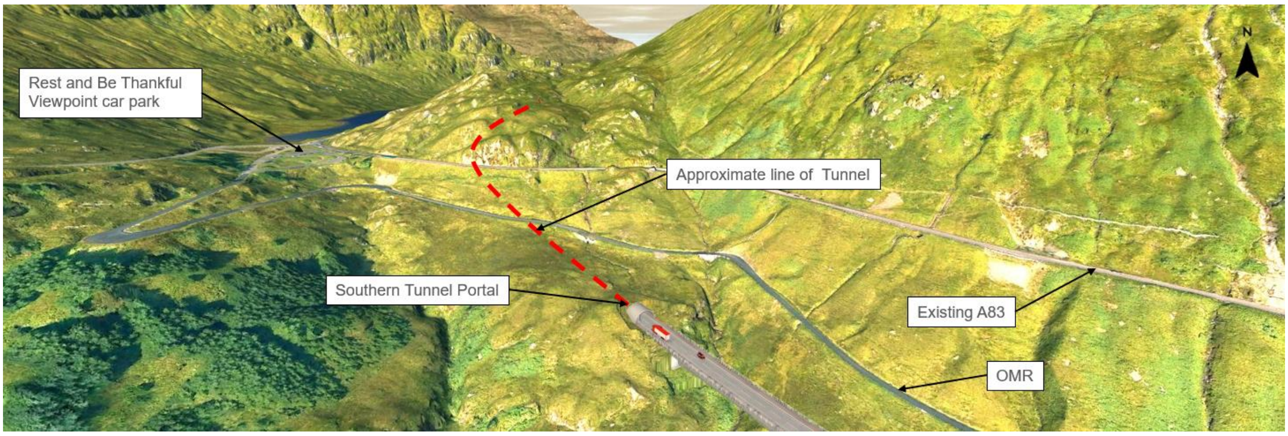

Figure 5-32 - Visualisation of the southern entrance to the Purple Option Tunnel, looking north towards the Rest and Be Thankful Viewpoint car park and Loch Restil

The tunnel for the Purple Option, described further in sub-section 5.3.4.2, commences at Ch. 1,900, approximately 320m south-east of the Rest and Be Thankful viewpoint car park. From here the alignment progresses generally north-to-northeast below the OMR, the existing A83 and the lower slopes of Beinn Luibhean. The Purple Option alignment then runs parallel and to the east of Loch Restil and the existing A83 to the tunnels northern entrance at Ch. 3,105 approximately 150m north-east of Loch Restil to the east of the existing A83. The horizontal alignment associated with the tunnel for the Purple Option is fully compliant with Table 2.10 of DMRB CD 109 ‘Highway Link Design’ for a 100kph design speed. The minimum radius specified is a 720m radius curve.

The vertical alignment within the tunnel for the Purple Option is compliant with Table 5.1 of DMRB CD 109 ‘Highway Link Design’ for an all-purpose single carriageway with a maximum gradient of 5% which is less than the 6% maximum allowable prescribed in Table 5.1 of DMRB CD 109 ‘Highway Link Design’ for an all-purpose single carriageway. The vertical alignment utilises a single sag curve which is equal to the desirable minimum K value of 26 prescribed in Table 2.10 in DMRB CD 109 ‘Highway Link Design’ for a 100kph design speed and a single crest curve with a K value equal to 55 which is one step below the desirable minimum K value prescribed in Table 2.10 in DMRB CD 109 ‘Highway Link Design’ for a 100kph design speed.

Northern Tie-in (Ch. 3,105 to Ch. 3,700)

Figure 5-33 - Visualisation of the Purple Option northern tie-in looking south towards Loch Restil

Upon exiting the tunnel, the Purple Option continues in a northerly direction to the east of the existing A83 in a section of open road for 595m before it ties-in on an existing right-hand curve as the road begins to drop towards Glen Kinglas. The horizontal alignment associated with the northern tie-in of the Purple Option is compliant over most of its length with only a short right-hand curve with a radius of 255m, matching the existing A83, which is greater than two steps below the desirable minimum 360m radius prescribed for a 100kph design speed in Table 2.10 in DMRB CD 109 ‘Highway Link Design’.

The vertical alignment associated with the northern tie-in of the Purple Option is fully compliant with DMRB CD 109 ‘Highway Link Design’ with a maximum gradient of 5.4% which is less than the 6% maximum allowable prescribed in Table 5.1 of DMRB CD 109 ‘Highway Link Design’ for an all-purpose single carriageway and a single crest curve with K value of 55 which is one step below the desirable minimum K value prescribed in Table 2.10 in DMRB CD 109 ‘Highway Link Design’ for a 100kph design speed.

5.3.4.2. Structures

This section provides an overview of the anticipated structure requirements for the Purple Option. Further development of structural options will be undertaken during DMRB Stage 3.

The location of structures required for the Purple Option are indicated on the drawings listed in Table 5-4, below and presented in Volume 2 of this report.

As discussed in sub-section 5.3.1.2, for the Yellow Option, the DMRB Stage 2 assessment process has considered both a post tensioned concrete balanced cantilever and steel-concrete composite deck solution for the viaduct. The initial assessment has concluded that they both have the potential to meet the functional requirements of the structure and the overall footprint, and construction programme would be similar. For illustrative purposes, throughout the report, the images reflect the balanced cantilever solution, but the following section provides a summary of both forms of construction. The choice of structural form would be further considered during DMRB Stage 3 should this be the Preferred Option.

Table 5-4 - Purple Option Structures Drawings

Option Evaluated	Drawing Number	Title
Purple Option (Post Tensioned Concrete Balanced Cantilever Viaduct Deck)	A83AAB-AWJ-SBR-LTS_LD1-DR-CB-000001	General Arrangement – Overview
	A83AAB-AWJ-SBR-LTS_LD1-DR-CB-000002	General Arrangement – Typical Details
	A83AAB-AWJ-SBR-LTS_LD1-DR-CB-000003	General Arrangement – South Abutment to Pier P02
	A83AAB-AWJ-SBR-LTS_LD1-DR-CB-000004	General Arrangement – Pier P02 to Pier P05
	A83AAB-AWJ-SBR-LTS_LD1-DR-CB-000005	General Arrangement – Pier P05 to Pier P08
	A83AAB-AWJ-SBR-LTS_LD1-DR-CB-000006	General Arrangement – Pier P08 to Pier P11
	A83AAB-AWJ-SBR-LTS_LD1-DR-CB-000007	General Arrangement – Pier P11 to Pier P14
	A83AAB-AWJ-SBR-LTS_LD1-DR-CB-000008	General Arrangement – Pier P14 to North Abutment
Purple Option (Steel-Concrete Composite Viaduct Deck)	A83AAB-AWJ-SBR-LTS_LD1-DR-CB-000101	General Arrangement – Overview

Option Evaluated	Drawing Number	Title
	A83AAB-AWJ-SBR-LTS_LD1-DR-CB-000102	General Arrangement – Typical Details
	A83AAB-AWJ-SBR-LTS_LD1-DR-CB-000103	General Arrangement – South Abutment to Pier P02
	A83AAB-AWJ-SBR-LTS_LD1-DR-CB-000104	General Arrangement – Pier P02 to Pier P05
	A83AAB-AWJ-SBR-LTS_LD1-DR-CB-000105	General Arrangement – Pier P05 to Pier P08
	A83AAB-AWJ-SBR-LTS_LD1-DR-CB-000106	General Arrangement – Pier P08 to Pier P11
	A83AAB-AWJ-SBR-LTS_LD1-DR-CB-000107	General Arrangement – Pier P11 to Pier P14
	A83AAB-AWJ-SBR-LTS_LD1-DR-CB-000108	General Arrangement – Pier P14 to North Abutment
Purple Option (Tunnel Cross Sections)	A83AAB-AWJ-STU-LTS_GEN-DR-CT-000001	Mined Tunnel Cross Section – Carriageway Camber Arrangement A
	A83AAB-AWJ-STU-LTS_GEN-DR-CT-000002	Mined Tunnel Cross Section – Carriageway Camber Arrangement B
	A83AAB-AWJ-STU-LTS_GEN-DR-CT-000003	Mined Tunnel Cross Section with Substation and Transformer Room
	A83AAB-AWJ-STU-LTS_GEN-DR-CT-000004	Cross Section – Cut-and-Cover Tunnel

Option Evaluated	Drawing Number	Title
	A83AAB-AWJ-STU-LTS_GEN-DR-CT-000005	General Arrangement – Cut-and-Cover Tunnel

Viaduct

The proposed A83 viaduct illustrated in Figure 5-34 would be a 16-span road bridge located in the Glen Croe valley on the lower slopes of Beinn Luibhean. The viaduct would cross the OMR, and various watercourses, notably the Croe Water. The carriageway has a single lane in each direction with verges on either side. It is recommended that the parapets be 1.5m high.

Figure 5-34 - Visualisation of the Purple Option Post Tensioned Concrete Balanced Cantilever Viaduct looking north up Glen Croe

The viaduct would be 1.48km long, with three distinctive geometric elements: a constant radius southern curve about 370m long, a straight section about 945m long, and a constant radius northern curve around 160m long. The following summarises both potential forms of construction.

Post Tensioned Concrete Balanced Cantilever

Using the balanced cantilever method, the viaduct would consist of north and south abutments, 15 rectangular hollow piers and 16 box girder spans, ranging from 70 to 100m in length. The piers will be founded on pile foundations ranging in depth dependant on the current ground make up at the pier locations.

The piers for this method may be constructed using slip form construction and the bridge superstructure is built using cantilever form travellers which allows construction of the deck structure in a series of segments. When constructing the deck, segments are constructed evenly starting at the pierhead and cantilevering outwards towards the next pier. Each segment constructed in one direction has an equivalent balancing segment constructed in the opposite direction. This is to ensure the structure is balanced at all times during construction. Cantilevered spans are then stitched together with concrete to form one continuous span. A schematic of the process is shown in Figure 5-12 within sub-section 5.3.1.2, above.

Debris flow deflection structures will be constructed at an early stage of the pier construction sequence to provide a suitable base for the construction tower crane and to deflect any potential debris flow and landslide events away from the piers during construction.

Steel-Concrete Composite

For the steel-concrete composite viaduct expansion joints are present between each of the curved sections and the straight section.

The proposed superstructure is designed to be comprised of two steel trapezoidal box beams connected by a reinforced concrete slab with reinforced concrete copes. The superstructure is designed to be articulated on hollow reinforced concrete piers and solid abutments with drilled reinforced concrete piles.

The height of the concrete piers would vary along the viaduct, reaching a maximum of 53m above ground level. To overcome existing constraints, the piers would be located with spans ranging from 70m to 100m throughout the route.

Debris flow deflector structures are proposed at the base of each pier have been proposed to steer debris flow and landslide events away from the piers.

Tunnel

The Purple Option enters a tunnel approximately 325m south-east of the Rest and Be Thankful viewpoint car park below the OMR and existing A83. The tunnel is 1.19km in length and consists of a mined tunnel section, 1.01km in length and two cut-and-cover sections, 50m and 120m in length at the southern and northern ends of the tunnel, respectively.

The mined tunnel lies completely in rocky strata and is proposed to be constructed using drill and blast technique. In the temporary case, the tunnel will be supported by temporary supports composed of rock bolts, shotcrete and, if necessary, lattice girders. A reinforced concrete secondary lining will be installed for permanent support. No load share between the permanent and temporary support was assumed and the permanent tunnel lining was designed to carry all the loads in long term.

The cut-and-cover section of the tunnel will maintain the same internal profile as the main mined tunnel. The cut-and-cover tunnel will comprise of a permanent cast in-situ reinforced concrete tunnel lining with an external sheet waterproofing membrane and drainage geotextile. Drainage channels will be provided adjacent to the invert on either side of the tunnel. Compacted rock backfill will be used to reinstate the ground and provide the necessary confinement.

5.3.4.3. Junctions

As the Purple Option bypasses the existing B828 junction and Rest and Be Thankful viewpoint car park access as a consequence of it being within the tunnel, a new junction will be required to maintain access. The connection between the Purple Option and the B828 would use a length of the existing A83 with a new junction with the Purple Option provided to the north-east of Loch Restil.

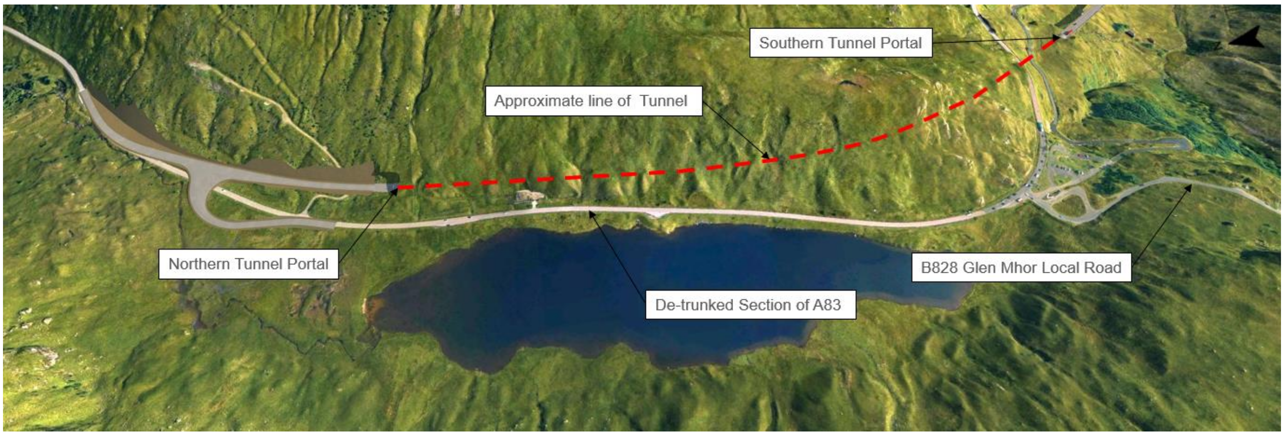

Figure 5-35 - Visualisation of the proposed B828 Glen Mhor local road junction with the Purple Option to the north-east of Loch Restil

This will take the form of a priority junction with a ghost island in accordance with the guidance set out in DMRB CD 123 ‘Geometric Design of At-Grade Priority and Signal-Controlled Junctions’. The layout incorporates the following key design parameters:

- 105m long diverge taper
- 40m exit radius
- Min 15m entry radius followed by 1:6 taper
- 3.5m wide ghost island

5.3.4.4. Local Roads and Accesses

As a result of the re-located B828 junction further consideration of the location of the bus stop and any turning facilities will be needed in consultation with bus services and users. It is likely the bus stop and turning area will be moved closer to the proposed junction location. However, this will be considered further during DMRB Stage 3 design development should the Purple Option be taken forward as the Preferred Option.

Additionally, the Purple Option affects access to an existing forestry track to the east of the existing A83 adjacent to the northern tie-in. A new access will be required and this will take the form of a simple priority junction in accordance with the guidance set out in DMRB CD 123 ‘Geometric Design of At-Grade Priority and Signal-Controlled Junctions’.

5.3.4.5. Earthworks Volumes

Approximate bulk earthworks volumes for the permanent and temporary works associated with the Purple Option are included below. Further breakdown of these figures is included in Section 5.4.

- Cut Volume: 450,990m^3
- Fill Volume: 94,239m^3

5.3.5. General Option Summary – Pink

5.3.5.1. Mainline

The horizontal and vertical alignment geometry information associated with the Pink Option mainline is presented on drawings A83AAB-AWJ-HML-LTS_LEA-DR-CH-000002 to A83AAB-AWJ-HML-LTS_LEA-DR-CH-000004 included in Volume 2 of this report. The mainline alignment of the Purple Option can be split into three sections; the southern tie-in to the existing A83, the tunnel and the northern tie-in to the existing A83.

Southern Tie-in (Ch. 0 to Ch. 370)

Figure 5-36 - Visualisation of the Pink Option southern tie-in looking north up Glen Croe towards the tunnel entrance

The Pink Option ties-in to the existing A83 on a straight section approximately 750m north of the of the existing junction that allows access from the A83 to the OMR, used when the local diversion is in operation. The alignment then diverges in a northerly direction into the lower slopes of Beinn Luibhean. The horizontal alignment associated with the southern tie-in is fully compliant with Table 2.10 of DMRB CD 109 'Highway Link Design' for a 100kph design speed. The minimum radius specified is a 2880m radius curve.

The vertical alignment within the southern tie-in section of the Pink Option is fully compliant with DMRB CD 109 'Highway Link Design' with a maximum gradient of 5% which is less than the 6% maximum allowable prescribed in Table 5.1 of DMRB CD 109 'Highway Link Design' for an all-purpose single carriageway and a single crest curve which is equal to the desirable minimum K value of 100 prescribed in Table 2.10 in DMRB CD 109 'Highway Link Design' for 100kph design speed.

Tunnel (Ch. 370 to Ch. 3,360)

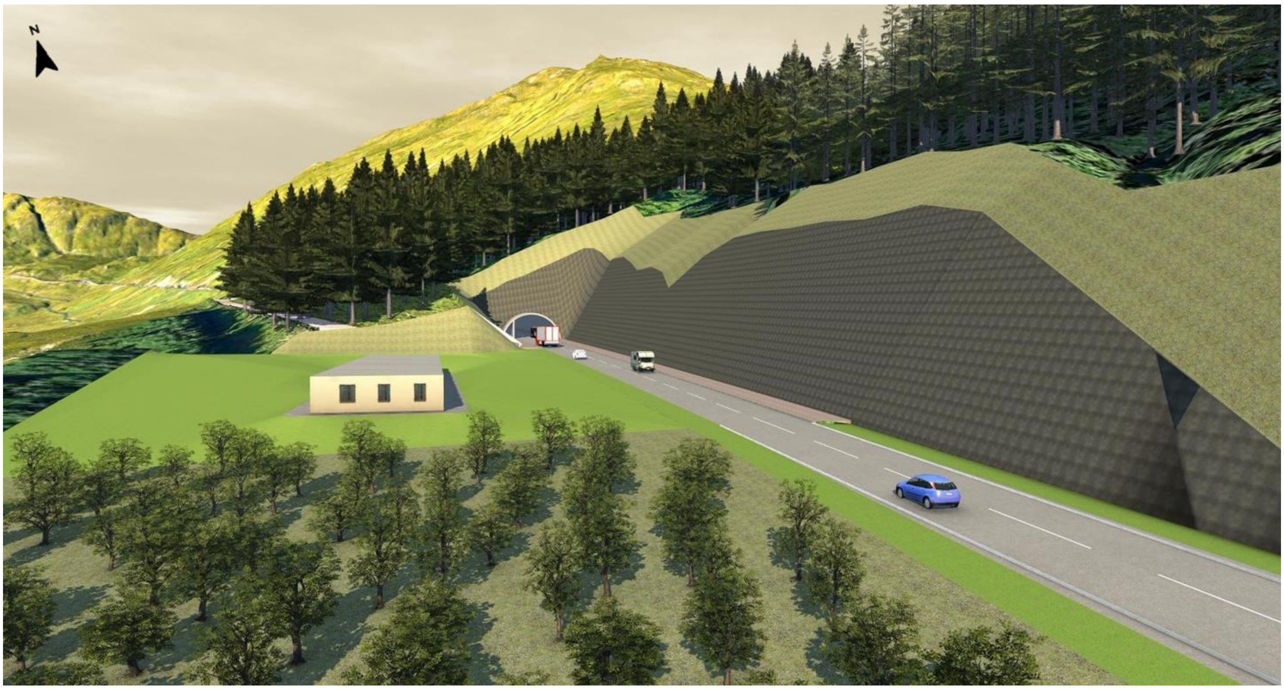

Figure 5-37 - Visualisation of the southern entrance to the Pink Option Tunnel, looking north-east towards Beinn Luibhean

The tunnel for the Pink Option, described further in sub-section 5.3.5.2, commences at Ch. 370. From here the alignment progresses generally north-to-northwest below the lower slopes of Beinn Luibhean parallel to the existing A83 until Ch. 2400. At this point the alignment bends north towards the northern tunnel entrance at Ch. 3,360 approximately 150m north-east of Loch Restil to the east of the existing A83, bypassing the large rock outcrop to the east of the Rest and Be Thankful viewpoint car park. The horizontal alignment associated with the tunnel for the Pink Option is fully compliant with Table 2.10 of DMRB CD 109 'Highway Link Design' for a 100kph design speed. The minimum radius specified is a 1020m radius curve.

The vertical alignment within the tunnel for the Pink Option is compliant with Table 5.1 of DMRB CD 109 'Highway Link Design' for an all-purpose single carriageway with a maximum gradient of 3.7% which is less than the 6% maximum allowable prescribed in Table 5.1 of DMRB CD 109 'Highway Link Design' for an all-purpose single carriageway. The vertical alignment utilises a single crest curve with a K value equal to 85 which is one step below the desirable minimum K value prescribed in Table 2.10 in DMRB CD 109 'Highway Link Design' for a 100kph design speed.

Northern Tie-in (Ch. 3,360 to Ch. 3,940)

Figure 5-38 - Visualisation of the Pink Option northern tie-in looking south towards Loch Restil

Upon exiting the tunnel, the Pink Option continues in a northerly direction to the east of the existing A83 in a section of open road for 580m before it ties-in on an existing right-hand curve as the road begins to drop towards Glen Kinglas. Like the Purple Option, the horizontal alignment associated with the northern tie-in of the Pink Option is compliant over most of its length with only a short right-hand curve with a radius of 255m, matching the existing A83, which is greater than two steps below the desirable minimum 360m radius prescribed for a 100kph design speed in Table 2.10 in DMRB CD 109 'Highway Link Design'.

The vertical alignment associated with the northern tie-in of the Pink Option is fully compliant with DMRB CD 109 'Highway Link Design' with a maximum gradient of 5.6% which is less than the 6% maximum allowable prescribed in Table 5.1 of DMRB CD 109 'Highway Link Design' for an all-purpose single carriageway and a single crest curve with K value of 85 which is one step below the desirable minimum K value prescribed in Table 2.10 in DMRB CD 109 'Highway Link Design' for a 100kph design speed.

5.3.5.2. Structures

This section provides an overview of the anticipated structure requirements for the Pink Option. Further development of structural options will be undertaken during DMRB Stage 3.

The location of structures required for the Pink Option are indicated on the drawings listed in Table 5-5, below and presented in Volume 2 of this report.

Table 5-5 - Pink Option Structures Drawings

Option evaluated	Drawing Number	Title
Pink Option (Tunnel Cross Sections)	A83AAB-AWJ-STU-LTS_GEN-DR-CT-000001	Mined Tunnel Cross Section – Carriageway Camber Arrangement A
	A83AAB-AWJ-STU-LTS_GEN-DR-CT-000002	Mined Tunnel Cross Section – Carriageway Camber Arrangement B
	A83AAB-AWJ-STU-LTS_GEN-DR-CT-000003	Mined Tunnel Cross Section with Substation and Transformer Room
	A83AAB-AWJ-STU-LTS_GEN-DR-CT-000004	Cross Section – Cut-and-Cover Tunnel
	A83AAB-AWJ-STU-LTS_GEN-DR-CT-000005	General Arrangement – Cut-and-Cover Tunnel

Tunnel

The tunnel for the Pink Option is 2.99km in length. The tunnel is wholly to the east of the existing A83 below the lower slopes of Beinn Luibhean. It consists of a mined tunnel section, 2.73km in length and two cut-and-cover sections, 80m and 200m in length at the southern and northern ends of the tunnel, respectively.

Like the Purple Option, the mined tunnel lies completely in rocky strata and is proposed to be constructed using drill and blast technique. In the temporary case, the tunnel will be supported by temporary supports composed of rock bolts, shotcrete and, if necessary, lattice girders. A reinforced concrete secondary lining will be installed for permanent support. No load share between the permanent and temporary support was assumed and the permanent tunnel lining was designed to carry all the loads in long term.

The cut-and-cover section of the tunnel will maintain the same internal profile as the main mined tunnel. The cut-and-cover tunnel will comprise of a permanent cast in-situ reinforced concrete tunnel lining with an external sheet waterproofing membrane and drainage geotextile. Drainage channels will be provided adjacent to the invert on either side of the tunnel. Compacted rock backfill will be used to reinstate the ground and provide the necessary confinement.

5.3.5.3. Junctions

Like the Purple Option, the Pink Option bypasses the existing B828 junction and Rest and Be Thankful viewpoint car park access as a consequence of it being within the tunnel, a new junction will be required to maintain access. The connection between the Pink Option and the B828 would use a length of the existing A83 with a new junction with the Pink Option provided to the north-east of Loch Restil.

Figure 5-39 - Visualisation of the proposed B828 Glen Mhor local road junction with the Pink Option to the north-east of Loch Restil

This will take the form of a priority junction with a ghost island in accordance with the guidance set out in DMRB CD 123 'Geometric Design of At-Grade Priority and Signal-Controlled Junctions'. The layout incorporates the following key design parameters:

- 105m long diverge taper
- 40m exit radius
- Min 15m entry radius followed by 1:6 taper
- 3.5m wide ghost island

5.3.5.4. Local Roads and Accesses

As a result of the re-located B828 junction further consideration of the location of the bus stop and any turning facilities will be needed in consultation with bus services and users. It is likely the bus stop and turning area will be moved closer to the proposed junction location. However, this will be considered further during DMRB Stage 3 design development should the Pink Option be taken forward as the preferred option.

Additionally, the Pink Option, like the Purple Option, affects access to an existing forestry track to the east of the existing A83 adjacent to the northern tie-in. A new access will be required, and this will take the form of a simple priority junction in accordance with the guidance set out in DMRB CD 123 'Geometric Design of At-Grade Priority and Signal-Controlled Junctions'.

5.3.5.5. Earthworks Volumes

Approximate bulk earthworks volumes for the permanent and temporary works associated with the Pink Option are included below. Further breakdown of these figures is included in Section 5.4.

- Cut Volume: 761,332m^3
- Fill Volume: 142,575m^3

5.4. Geotechnics and Earthworks

5.4.1. Comparison of Options

A summary of the ground conditions and issues affecting the five route options are presented in Table 2-3.

Detailed information supporting the summaries below is shown in the following drawings:

- Superficial Geology (Drawing ref A83AAB-AWJ-EGT-LTS_GEN-DR-VT-000125)
- Solid Geology (Drawing ref. A83AAB-AWJ-EGT-LTS_GEN-DR-VT-000124)
- Geotechnical Constraints and Hazards (Drawing ref A83AAB-AWJ-EGT-LTS_GEN-DR-VT-000123)
- Green Option - Exploratory hole plan and profile (Drawing ref. A83AAB-AWJ-HGT-LTS_LA0-DR-GE-000001 to A83AAB-AWJ-HGT-LTS_LA0-DR-GE-000003)
- Yellow Option - Exploratory hole plan and profile (Drawing ref. A83AAB-AWJ-HGT-LTS_LB3-DR-GE-000001 and A83AAB-AWJ-HGT-LTS_LB3-DR-GE-000002)
- Brown Option - Exploratory hole plan and profile (Drawing ref. A83AAB-AWJ-HGT-LTS_LC3-DR-GE-000001 and A83AAB-AWJ-HGT-LTS_LC3-DR-GE-000002)
- Purple Option - Exploratory hole plan and profile (Drawing ref. A83AAB-AWJ-HGT-LTS_LD1-DR-GE-000001 to A83AAB-AWJ-HGT-LTS_LD1-DR-GE-000003)
- Pink Option - Exploratory hole plan and profile (Drawing ref. A83AAB-AWJ-HGT-LTS_LEA-DR-GE-000001 to A83AAB-AWJ-HGT-LTS_LD1-DR-GE-000003)

5.4.1.1. Earthworks design and construction

Cuttings

In general, cut slopes have been modelled at 1 vertical in 1.5 horizontal (1v:1.5h). This is due to the Scheme Options requiring construction on predominantly side-long ground, where slackened slopes would result in excessive slope heights and very large earthwork footprints. At 1v:1.5h, the slopes in superficial deposits will generally require special measures to ensure stability.

For rock cuttings, slopes have been modelled at a nominal 60°, which is broadly consistent with the rock slopes at the existing catchpits at the A83.

Slackening or tightening of the cut slopes may be considered as the preferred option is developed at Stage 3.

For consistency of assessment, the same form of stabilisation measures has been considered throughout. These measures include:

- Soil nailing at 1.5m centres for slopes in superficial deposits at 1v:1.5h;
- Soil nailing at 1.5m centres for 60° slopes in thin superficial deposits;
- Soil nailing at 1.5m centres and sprayed concrete with mesh reinforcement for 60° slopes in thick superficial deposits;
- Rock dowels / bolting at 1m centres for 60° slopes in bedrock considered at risk of failure.

Kinematic analyses have been carried out for the catchpit slopes of the Green and Brown Options based on the proposed slope geometry. The discontinuity datasets used in the analyses consists of rock mapping data recorded along the forestry track by Jacobs/AECOM in 2021, rock mapping measurements carried out by MHB Consultants for the Phase 3, 5, 7 and 9 basins (April and June 2017) and rock mapping data from an AWJV site visit in January 2023, which focused on the Phase 1 catchpit and the disused quarry above the A83. Four mechanisms of failure were analysed (planar sliding failure, wedge failure, direct toppling failure and flexural toppling) and an aggregated slope failure risk has been taken forward to the assessment of potential stabilisation requirements.

The location and approximate maximum height of the significant cuttings for each route option are summarised in Table 5-6, below.

Table 5-6 - Cutting Summary

Option	Chainage		Approx. Maximum height (m)	Description
	From	To		
Green	1030	3280	23	Catchpit slopes with 60° slopes
	3750	4220	22	Northern tie-in with 1v:1.5h slopes
Yellow	2160	2527	31	Northern abutment to northern tie-in 60° slopes
Brown	0	310	11.5	Southern tie-in with 1v:1.5h slopes
	310	1880	32	Catchpit slopes with 60° slopes
	1880	2350	17	Northern tie-in 60° slopes, includes widening for B828 junction improvement
Purple	0	260	7	Southern tie-in with 1v:1.5h slopes
	1870	1950	12	Transition from viaduct to tunnel with 1v:1.5h slopes
	1950	1990	20	Southern cut and cover section - 60° temporary slopes
	3010	3120	23	Northern cut and cover section - 60° temporary slopes
	3120	3699	20	Northern section open cut with 1v:1.5h slopes
Pink	0	320	31	Southern tie-in with 1v:1.5h slopes
	320	440	30	Southern cut and cover section - 60° temporary slopes
	3170	3350	26	Northern cut and cover section - 60° temporary slopes
	3350	3940	21	Northern section open cut with 1v:1.5h slopes

Excavatability and Bulking Assessment

Based on the material descriptions and particle size distribution test data it is assumed that the excavatability of the superficial deposits will most likely be easy digging with a high rate of excavatability. Some large boulders are expected to be present within the colluvium and glacial deposits, which are likely to require breaking to smaller fragments prior to excavation and haulage from site.

Where bedrock is at surface the BGS Civils dataset indicates excavatability as requiring ripping, which is consistent with medium strong to strong rock identified in the intrusive ground investigations. Rock excavatability assessments have been carried out based on rock quality measurements from core recovered from boreholes along the options and relevant strength results from the Preliminary Ground Investigation. The results of the assessment are summarised by rock type as follows:

- Metamorphic (Psammite/Pelite/Semi-pelite): Generally easy to very hard ripping with possible blasting required
- Igneous (Diorite/Dolerite): Generally easy to very hard ripping with some easy and hard digging.

Given that the available ground investigation does not indicate any significant trends in strength or rock quality with depth, there is unlikely to be any notable change in excavatability with depth. The available data suggests little differences in excavatability between the five options.

Due to the potential risk of initiating landslide or boulder fall events, blasting as not been considered at this time on the west facing slopes of Beinn Luibhean and The Cobbler or the eastern slopes of Ben Donich. Whilst this may be reconsidered later, at this time it is expected that excavation methods will be limited to ripping and breaking, with pre-drilling and splitting used to assist the excavation. This is similar to the previous excavation works undertaken for the existing catchpits. It has been acknowledged that precluding the use of blasting will have a significant effect on the excavation rates and this has been reflected in the programming and cost estimates for each Scheme Option.

The excavation of rock or soil is usually accompanied by an increase in volume, referred to as bulking. The BGS Civils dataset identifies six bulking classes based on typical lithology characteristics. For superficial deposits across the study area the bulking class is 1 or 2, which have bulking factors ranging 5-20% and 20-40% respectively. For the bedrock across the study area the bulking class is 5, typical of strong rocks that form blocky material when excavated, which have bulking factors >65%. Taking into consideration the BGS Civils data and bulking factors identified in literature for metamorphic and igneous rocks, the following factors have been used to assess the volume of surplus materials to be taken off-site for each of the Scheme Options:

- Superficial deposits – 20%
- Bedrock – 65%

Embankments

Embankments are required on the approaches to the viaducts for the Green, Yellow and Purple Options. These earthworks have been modelled with side slopes at 1v:1.5h and will require special measures such as high friction fill or additional reinforcement to ensure stability. For consistency of assessment, reinforced earth solutions have been considered all options where the embankment slope height exceeds 2m.

Construction of the Pink Option will require a temporary diversion of the existing A83 to facilitate excavation of the southern tunnel portal. The proposed diversion comprises a single 880m long embankment on side-long ground immediately downslope of the existing A83. The maximum height of the embankment is approximately 16m and the maximum slope gradient in 1v:2h. It is expected that the embankment will be constructed from crushed rock fill excavated from the northern section of open cut and cut and cover sections.

Where existing embankments require widening, for example at tie-ins or crossings, benching into the existing slope faces will be required. If the existing fill is proven to be of inadequate strength to withstand increased loads, it may be necessary to partially remove it by increasing the extent of benching into the existing slope and replacing the material with appropriate general fill as stated in the Specification for Highway Works (SHW), Volume 1, Series 600).

The location and approximate maximum height significant embankments for each route option are summarised in Table 5-7, below.

Table 5-7 - Embankment Summary

Option	Chainage		Approx. Maximum height (m)	Description
	From	To		
Green	150	470	14	Widening on RHS for southern tie-in and southern approach embankment to south viaduct with 1v:1.5h slopes
	900	970	18	Northern approach embankment to south viaduct with 1v:1.5h slopes
	3720	3770	12	Northern approach embankment to north viaduct with 1v:1.5h slopes
Yellow	0	310	21	Widening on RHS for southern tie-in and southern approach embankment to viaduct with 1v:1.5h slopes
Brown	n/a	n/a	n/a	n/a
Purple	0	360	12	Widening on RHS for southern tie-in and southern approach embankment to viaduct with 1v:1.5h slopes
Pink	0	880	20	Temporary diversion route with 1v:2h slopes

5.4.1.2. Cut/fill Volumes

General

Approximate earthworks volumes have been estimated to allow a reasonable comparison between the five options. An overview of the estimated cut/fill balance is presented in Table 5-8, below.

All options have a significant surplus of excavated materials, with the Yellow Option having the lowest surplus and the Pink Option having the highest surplus of the five options. Further discussion on earthworks materials and potential waste is provided in Part 3.

The cut/fill quantities will be refined and optimised following ground investigation and further earthworks design development for the preferred option.

Table 5-8 - Cut/Fill Volume Summary

	Yellow Option	Brown Option	Green Option	Purple Option	Pink Option
Cut volume	227,719m^3	311,168m^3	503,671m^3	450,990m^3	761,332m^3
Fill volume	100,196m^3	3,274m^3	79,288m^3	94,239m^3	142,575m^3
Cut/Fill difference	127,523m^3 Surplus	307,894m^3 Surplus	424,383m^3 Surplus	356,751m^3 Surplus	618,757m^3 Surplus
Maximum cut height	30.7m	31.9m	23.5m	23.3m	31.0m
Maximum fill height	21.3m	5.6m	18.4m	12.2m	19.8m

Re-use of Materials

Based on available information, the cuttings are typically within areas of granular superficial deposits, including debris flow deposits (colluvium) and glacial till, and areas of shallow bedrock. The potential volume of topsoil to be stripped and requirements for re-soiling of embankments and cut slopes has not been calculated for the Stage 2 assessment. Due to the hummocky topography and general steep gradients, it is unlikely that the topsoil could be excavated separately from the underlying superficial deposits.

For the purposes of the Stage 2 assessment, it has been assumed that shallow superficial deposits are generally unacceptable for re-use, on the basis of relatively high moisture content, potential for significant organic content and potential mixing with topsoil. A proportion of the deeper superficial deposits is likely to be acceptable for re-use as-dug, without the need for treatment.

Excavated colluvium and glacial deposits may be acceptable to be used as a Class 1 or 2 general fill, or Class 4 landscape fill, subject to classification testing in accordance with Table 6/1 of the SHW, Volume 1, Series 600 and chemical suitability testing. However, it should be noted that these materials can be moisture susceptible and may need processing to deal with the larger boulders. The percentage acceptability for superficial deposits can only be confirmed by ground investigations planned to be carried out during the DMRB Stage 3 assessment once a preferred option has been selected.

For all five options, the majority of excavated bedrock is expected to comprise metamorphic rock (psammites, semi-pelites and pelites) with minor quantities of igneous strata, which have generally been identified as dolerites. Pelites and semi-pelites are argillaceous rock types, which are precluded from re-use as constituents of Class 6 fills. Although the psammites are not generally categorised as argillaceous, these strata are interbedded with argillaceous units and are unlikely to be processed separately. It is noted that recent experience of re-using excavated metamorphic rock from the A83 catchpits to construct bunds in Glen Kinglas suggests that this material can be prone to disintegration during processing and handling, or over-compaction.

Class 6 selected granular fill materials may be derived from the igneous bedrock, subject to rock composition and grading, suitable handling and compaction practices. In general, it is anticipated that the excavated bedrock can be processed for re-use as SHW Class 1 general fill.

Given that the excavated bedrock is generally considered to be unsuitable for processing to Class 6 selected granular fills, backfill to structures (Class 6N/6P) and any fill to reinforced earth structures (Class 6I/J) will need to be imported. All imported fill will be subject to material approvals for the site. The requirement for imported fill will impact the quantity of materials required for re-use on site, leading to an increase in the volume of material surpluses.

Unacceptable Material and Potential Contaminated Materials

Excavated unacceptable materials (Class U1), which cannot be used in the main earthworks construction could include but are not limited to, peat and soft clays and silts (e.g. alluvium). Due to the large surpluses of excavated materials it is likely that these materials will be disposed of off-site. However, there is potential for limited re-use elsewhere on site in the form of landscaping (where suitable).

Where materials are deemed unsuitable as a bearing formation material for embankments or structures, the impact on excavated volumes can be minimised through:

- Excavation and replacement with suitable excess material sourced from site;
- Soil reinforcement – e.g. geogrids; or,
- Piling.

Minor quantities of made ground will be excavated, generally related to the existing road construction at the tie-in locations for all route options. For the Brown Option, it is expected that the majority of the existing A83 road construction will be removed over the full length of the route. The suitability of any made ground for re-use will need to be assessed on a location-specific basis. Any made ground intended for re-use should comply with testing requirements of the SHW, Volume 1, Series 600. In addition to compliance with SHW testing requirements, re-use of made ground should be subject to compliance with the SEPA Land remediation and waste management guidelines and the SEPA, Civil Engineering Contractors Association (Scotland) (CECA) and the Environment Industries Commission (EIC) regulatory guidance on promoting the sustainable reuse of greenfield soils in construction.

It is expected that existing road materials could be re-used, subject to appropriate classification and assessment. An exception to this would be the presence of coal tars within the asphalt. In this instance the potential for the materials to be reused under Clause 947 or 948 of the Specification for Highway Works as a cold recycled bound material would require further consideration or the material be treated as hazardous waste and be disposed of off-site appropriately.

At this stage of assessment, no contaminated materials (Class U2) have been identified for disposal. A review of historical mapping has not identified any significant potentially contaminative developments/land uses within the study area or identified any specific point sources of land contamination. However, there is the possibility of localised or diffuse contamination/spills associated with agricultural or commercial forestry activity or anthropogenic materials within the existing road infrastructure construction materials (A83 and OMR), including the potential for asphalt to contain coal tar binders. In addition, there may be contaminated ground associated with the two possible historical gravel pits and a disused quarry which have been identified (ref. Geotechnical Constraints plan).

5.4.1.3. Geotechnical Engineering Risks and Mitigation

Geotechnical Risk Registers have been developed for each of the options, building on the register presented in the Preliminary Sources Study Report.

Natural Geohazards

All route options are located partially or entirely along slopes which are subject to potential geohazards. The nature and degree of hazard varies depending on the location of the route option within the glen and whether the route is on viaduct, open road, beneath a debris shelter or within a tunnel. Consideration of the geohazards in relation to both the construction and operation phases has been undertaken during the development of the options to inform the design of appropriate earthworks, structural and protective elements. In addition, where the proposed mitigation to protect the route deflects the debris away from the route rather than capturing it, the effects of this passage of debris over the slope and whether this may result in undermining of the route option and/or damage to other infrastructure has been considered.

Other constructability considerations that have influenced the designs include challenging access, steep side long ground and the management of the numerous watercourses, which cross the route options. The watercourses facilitate normal hillside drainage and potentially also the passage of debris flows. The potential for forestry cover to obscure evidence of historic instability, and for the felling activity required to accommodate the scheme to alter the ground and groundwater conditions on the slopes has also been taken into consideration.

Where natural terrain hazard mitigation measures are proposed as part of the scheme, detailed ground investigations will be required to provide sufficient information on ground and groundwater conditions to support detailed options development. Consideration will also be given to the long-term maintenance requirements of mitigation measures, including provision of access for inspection and to enable debris to be removed following an event.

If the mitigation measures were to be damaged during a debris flow, landslide or other geohazard event, access may be required to effect repairs and/or replacement of elements of the system. Consequently, the protection afforded to the route may be temporarily reduced and temporary route closures may be required.

Adverse Ground Conditions

Made Ground

Made Ground deposits comprising engineered and non-engineered fill are anticipated across the study area in association with existing infrastructure. Available data shows the existing

OMR, A83 and Forestry tracks are underlain by fill, most likely derived from locally sourced material. All options are likely to encounter made ground at the tie-in locations for the A83, with made ground likely to be excavated along the full length of the Brown Option, which is on-line.

Made Ground deposits are typically heterogeneous and can have low bearing resistance and potentially high differential and total settlement characteristics. Further ground investigation is required to confirm the extent and properties (geotechnical and contamination) of the made ground.

Peat

Layers of peat have been encountered in some exploratory holes located in the lower areas of Glen Croe, which would potentially affect the pier foundations of the viaducts for the Yellow and Purple Options. The peat is typically interbedded with colluvium, with a maximum recorded thickness of 1.5 m. Peat is also expected to be encountered adjacent to Loch Restil and may affect the northern tie-in location for the Pink and Purple Options.

Peat has low bearing resistance, is highly compressible and has poor engineering properties. Therefore, it requires consideration of special measures for stability and settlement issues for structure foundations and earthworks. For the Stage 2 assessment, piling has been assumed for the viaduct foundations which avoids the risk of potential adverse settlement of peat. Significant temporary works may be required for any excavations required to provide an area for the piling platform.

It should be noted that the removal of substantial areas of peat would likely require a peat management plan and represents an environmental constraint to the scheme.

Alluvium and River Terrace Deposits

Alluvium and River Terrace Deposits are anticipated to be present locally within the Glen Croe valley floor and in the vicinity of watercourses. Therefore, these deposits may be encountered along the southern extents of the Green, Yellow and Purple Options and unlikely to be encountered along the route of the Brown and Pink options.

Investigations undertaken to date have not identified any deposits of cohesive alluvium. However, there remains the potential for localised pockets of soft, highly compressible materials associated with Croe Water and adjacent to Loch Restil.

Due to the potential for alluvial deposits to have varying, potentially poor, engineering properties, ground investigation should be undertaken to assess the thickness and engineering properties of the alluvial soils within the route of the Green, Yellow and Purple Options if taken through for the Stage 3 assessment.

Colluvium

Colluvium is comprised of unsorted material washed down slopes during failure events. Large boulders are often observed during failure events and it is likely that these are present within the colluvium. Colluvium may overlie lower strength, compressible soils such as alluvium or peat.

Further GI is required to assess the engineering properties of the colluvium. The material can be loose and therefore a hazard to excavations, and sensitive to vibrations from construction. Excavations into the colluvium may require dewatering and support to ensure stability depending on the depth and duration of excavation. Colluvium encountered in the cut slopes for the catchpits associated with the Brown and Green Option will require additional support for long term stability. Soil nailing and sprayed concrete facings have been proposed depending on the depth of the deposits. Similar levels of support have been assumed for the cut slopes at the tunnel portals for the Pink and Purple Options and may also be required for any excavations related to the foundations of the piers for the Yellow and Purple Options.

In addition, the colluvium may not provide a suitable founding stratum especially for structures. Depending on the thickness of the deposits, it may be possible to remove and replace the colluvium locally. Alternative geotechnical solutions are dependent on the proposed works and thickness/nature of the colluvium deposits but could include basal reinforcement, ground improvement or piled solutions.

Glacial Deposits

The difference between the colluvium and undisturbed glacial deposits has been inferred from changes in relative density and cobble and boulder content. The distinction is approximate and there may be some overlap. Generally, the glacial deposits are expected at depth in areas of thick superficial deposits, locally overlain by reworked material nearer to and at the ground surface. Available test data suggests similarities in the engineering properties of the glacial deposits and the colluvium. As such, it is reasonable to anticipate similar issues with stability and foundations as identified above.

Bedrock

Strong, intact bedrock and limitations on blasting/vibrations in areas of landslide risk will present challenges for excavation for all five options.

Structural deformation, particularly faulting, is likely to pose a significant challenge to excavations and tunnelling. Faults form zones of highly fractured bedrock which can either form a fault breccia, providing a preferential pathway for groundwater, or form a welded fault rock which may significantly impact excavations and tunnelling. Aerial photography and geophysical surveys indicate that unmapped faults are likely to be present within the study area.

Groundwater and Flood Risk

In general, it is anticipated that shallow groundwater levels will be encountered local to existing watercourses. GI will be undertaken to provide details on groundwater levels and characteristics across the Preferred Route. High groundwater tables could pose a significant risk to excavations for all five options and groundwater pressures in fracture networks could pose a significant risk to tunnels for the Pink and Purple Options.

Several watercourses located within the Glen Croe valley floor, locally along minor watercourses on the lower slopes and Loch Restil are located within areas susceptible to river and surface water flooding. For all options, flooding and surface water run off may cause instability of foundations and slopes, therefore appropriate control measures would be adopted in the design of structures and embankments. Areas of flood risk in the lower part of Glen Croe may impact the Yellow, Purple and Green Options, requiring consideration for special measures for embankments and additional drainage/surface water management where cuttings are proposed. Furthermore, flood storage compensation may be required local to areas of significant flood risk.

Geo-environmental and Geochemical Risks

A qualitative geo-environmental assessment was undertaken for the PSSR. This identified the risk to receptors of potentially coming across harmful elements/ contamination as low to moderate with specific risks as follows:

- The primary potential risk identified within the study area is the presence of ground gas within naturally occurring pockets of organic soils and peat. The risk to identified receptors of potentially coming across harmful gases has been assessed as varying between low and moderate. GI and gas monitoring may be required to determine if there is any ground gas at potentially explosive or asphyxiating concentrations within the route of the preferred option and the risk it poses primarily to construction workers.
- Given the intended use as a trunk road, there will be limited potential exposure pathways to site end users post construction. The presence of hardstanding on the carriageway will limit the direct exposure of future site users to underlying soils and effectively break any potential pollutant linkage. Furthermore, the soft landscaped embankments adjacent to the carriageway are unlikely to be used by site end users and hence, providing the soils in these areas are not exposed and remain vegetated to restrict dust generation. Site end user interaction is likely to be limited. The risks posed to end users will be considered during the design and construction stages of the scheme as more information becomes available and construction methods are finalised.
- On the existing road alignments, construction workers will be exposed to the existing road construction, made ground/ engineering fill and underlying natural soils during excavation works. The made ground materials are anticipated to be of limited thickness associated with road construction. Locally more extensive deposits of re-worked natural deposits/ colluvium from previous mass movement events are likely to be present. The existing road construction materials and colluvium have the potential to represent a potential source of contamination.
- Construction works completed outwith the footprint of existing road infrastructure will be primarily in natural or locally reworked natural soils. Whilst of relatively low likelihood, it is also possible that locally contaminated soils could be encountered by the construction workers associated with localised spills of fuels or agricultural chemicals arising from the agricultural and forestry land uses, specifically in the vicinity of existing buildings.

It is recommended that soil and groundwater geo-environmental analysis should be taken where future geotechnical site investigative works are scheduled.

In addition to geo-environmental analysis requirements, laboratory testing within groundwater and soil will be required to determine the presence of chemicals such as sulphate likely to cause deterioration of buried structural concrete and / or corrosion of steel reinforcement. Limited testing undertaken in soil to date suggest the Design Sulphate Class DS-1 is applicable within the tested areas.

Depending on the composition of the existing road make up, the asphalt may be contaminated with tar or tar-bitumen binders rendering the material unsuitable for re-use. It is therefore recommended that the composition of any asphalt encountered is confirmed as part of future ground investigations. This relates to the tie-in sections of all options and the full length of the Brown Option, which is entirely on-line.

5.4.2. Summary

Taking due consideration of the geotechnical constraints discussed above, there are no significant differentials between the five Scheme Options. The Yellow Option is marginally more favourable in terms of having the lowest total volume of earthworks, and the geotechnical works are comparably slightly less complex.

The Green Option is least favourable as with the Pink Option it produces the highest total volume of earthworks and similar to the Brown Option also requires excavation into a hillside that is considered vulnerable to landslide therefore is considered a complex geotechnical operation.

5.4.3. Scope of Stage 3 Assessment

During Stage 3, further ground investigations are anticipated to be undertaken to inform the development of the Preferred Route.

The issues to be considered at Stage 3 include:

- Detailed geohazard susceptibility assessment considering possible failure locations, volumes of material and travel velocities to inform the design of structures, and the capacity and extent of mitigation measures.
- Development of the earthworks design, particularly with regards to reviewing opportunities to slacken or steepen side slopes, to improve the overall cut/fill balance.
- Develop design for rock cuts and protection measures where appropriate.
- Review ground conditions affecting structures and assess foundation options.
- Review acceptability of excavated material.

5.5. Structures

5.5.1. Summary

Each Scheme Option is fundamentally different, in terms of the way it protects the roads users from landslide and rock fall and its resultant structural from, ie tunnels, viaducts and flow shelters.

Section 5.3 provides a full engineering description of the principal structures associated with each Scheme Option and Section 5.2 summarises how the Scheme Options have evolved considering the design of the structure, with a focus on its construction operation and maintenance.

The form of structure has therefore driven the footprints of the Scheme Options which have been assessed against the various engineering and environmental criteria. It has also driven the scheme cost estimate as presented in Section 3.2.

The form of structure is not therefore considered to be a specific differentiator in its own right, as the impacts and benefits of the structure which as noted above is integral to the Scheme Options have been considered elsewhere.

It should be noted however that the design complexity of the structures does vary between the Scheme Options, with the Yellow, Purple and Green Options all containing major viaducts which by their nature are more structurally complex. Conversely, whilst the geotechnical aspects of the Brown and Pink options are complex, the structural aspects of these are less so and therefore are considered more favourable in the context of structures alone. The debris flow shelter also provides greater opportunity for modular or offsite construction.

5.5.2. Scope of Stage 3 Assessment

During DMRB Stage 3, a targeted ground investigation will be undertaken which will enable us to refine our understanding of the static and dynamic loadings cause by landslide, rock fall and the water environment, which will allow further refinement of the structure. Innovative techniques involving modular or offsite construction will also be considered and assessed to reduce the construction duration and therefore disruption to road users.

5.6. Departures and Relaxations to Standards

5.6.1. General

The geometric design of roads adopts a hierarchical approach consisting of compliance with standard, relaxations from standard and departures from standard. The DMRB recognises in some situations coincident relaxations constitute a departure.

Generally, relaxations from standard may be adopted at the discretion of the designer where these can be justified on environmental, engineering and economic grounds without adversely impacting upon safety and level of service. In situations of exceptional difficulty, which cannot be overcome by relaxations, it may be possible to overcome them by introducing departures from standard. Departures from standard require formal approval from the Overseeing Organisation (Transport Scotland for Trunk Roads and the local authority, Argyll and Bute Council for all local and access roads within the project extents) before being incorporated into a design layout.

The assessment of whether relaxations or departures from standard are appropriate is often directly associated to the adopted design speed of the road as defined in DMRB CD109 ‘Highway Link Design’.

Many of the existing side roads within the scheme extents were constructed prior to the implementation of modern design standards. To achieve acceptable tie-ins, it is likely that the new side roads will require departures from standard which will be considered in more detail during DMRB Stage 3.

As part of the Stage 2 Scheme Assessment, consideration was given to the impact of compliant and non-compliant designs in terms of the effect on earthworks extents, environmental designations, land boundaries and other existing constraints. Where appropriate, mitigation such as verge widening has been introduced to maximise the standard provided. Where adequate mitigation cannot be practically identified and it was considered safe and appropriate to do so, relaxations and departures from standard have been introduced. Table 5-9 and

Table 5-10 below outline the relaxations and departures currently adopted in the Stage 2 Scheme Options.

Beyond the identified relaxations and departures in Table 5-9 and

Table 5-10, the envisaged classified routes of the Stage 2 options are expected to achieve full compliance with the DMRB for horizontal geometry, vertical geometry, superelevation, SSD, visibility splays and junction layouts. However, these will be subject to more detailed consideration during DMRB Stage 3.

As the mainline geometry and junction layouts are developed in more detail during DMRB Stage 3, identification of relaxations and departures will be prioritised to allow for appropriate consultations to be undertaken with Transport Scotland Standards Branch and Argyll and Bute Council as relevant early within the programme.

5.6.2. Departure Summary Table

Table 5-9 below outlines the relaxations from standards and

Table 5-10 outlines the departures from standard for each of the DMRB Stage 2 Scheme Options.

Table 5-9 - Relaxations from Standards

Option	Reference Number	Direction	Location	Type
Green Option	GREEN_RLX_ML_001	NB and SB	Mainline Ch. 0+000m to Ch. 0+010m	Relaxation of horizontal curvature
	GREEN_RLX_ML_002	NB and SB	Mainline Ch. 0+960m to Ch. 1+010m	Relaxation of horizontal curvature
	GREEN_RLX_ML_003	NB and SB	Mainline Ch. 1+250m to Ch. 1+330m	Relaxation of vertical curvature
	GREEN_RLX_ML_004	NB and SB	Mainline Ch. 1+570m to Ch. 1+630m	Relaxation of horizontal curvature
	GREEN_RLX_ML_005	NB and SB	Mainline Ch. 1+810m to Ch. 2+020m	Relaxation of vertical curvature
	GREEN_RLX_ML_006	NB and SB	Mainline Ch. 3+050m to Ch. 3+150m	Relaxation of vertical curvature
	GREEN_RLX_ML_007	NB and SB	Mainline Ch. 3+180m to Ch. 3+410m	Relaxation of horizontal curvature
	GREEN_RLX_ML_008	NB	Mainline Ch. 4+120m to Ch. 4+150m	Relaxation of stopping sight distance

Option	Reference Number	Direction	Location	Type
	GREEN_RLX_ML_009	NB	Mainline Ch. 4+190m to Ch. 4+200m	Relaxation of horizontal curvature
	GREEN_RLX_ML_010	SB	Mainline Ch. 3+680m to Ch. 3+870m	Relaxation of vertical curvature
	GREEN_RLX_ML_011	SB	Mainline Ch. 4+160m to Ch. 4+200m	Relaxation of horizontal curvature
Yellow Option	YELLOW_RLX_ML_001	NB and SB	Mainline Ch. 0+080m to Ch. 0+270m	Relaxation of horizontal curvature
	YELLOW_RLX_ML_002	NB	Mainline Ch. 1+700m to Ch. 1+780m	Relaxation of stopping sight distance
	YELLOW_RLX_ML_003	NB	Mainline Ch. 2+350m to Ch. 2+430m	Relaxation of horizontal curvature
	YELLOW_RLX_ML_004	SB	Mainline Ch. 1+720m to Ch. 1+820m	Relaxation of stopping sight distance
	YELLOW_RLX_ML_005	SB	Mainline Ch. 2+410m to Ch. 2+430m	Relaxation of horizontal curvature
Brown Option	BROWN_RLX_ML_001	NB	Mainline Ch. 1+640m to Ch. 1+810m	Relaxation of stopping sight distance

Option	Reference Number	Direction	Location	Type
	BROWN_RLX_ML_002	NB	Mainline Ch. 2+370m to Ch. 2+380m	Relaxation of stopping sight distance
	BROWN_RLX_ML_003	SB	Mainline Ch. 1+910m to Ch. 1+930m	Relaxation of stopping sight distance
	BROWN_RLX_ML_004	SB	Mainline Ch. 1+940m to Ch. 1+950m	Relaxation of vertical curvature
Purple Option	PURPLE_RLX_ML_001	NB	Mainline Ch. 0+000m to Ch. 0+060m	Relaxation of stopping sight distance
	PURPLE_RLX_ML_002	NB	Mainline Ch. 0+420m to Ch. 0+520m	Relaxation of stopping sight distance
	PURPLE_RLX_ML_003	SB	Mainline Ch. 2+380m to Ch. 2+750m	Relaxation of stopping sight distance
	PURPLE_RLX_ML_004	SB	Mainline Ch. 2+990m to Ch. 3+110m	Relaxation of vertical curvature
Pink Option	PINK_RLX_ML_001	NB	Mainline Ch. 3+130m to Ch. 3+180m	Relaxation of vertical curvature
	PINK_RLX_ML_002	NB	Mainline Ch. 3+690m to Ch. 3+770m	Relaxation of vertical curvature
	PINK_RLX_ML_003	NB	Mainline Ch. 3+840m	Relaxation of vertical curvature

Option	Reference Number	Direction	Location	Type
	PINK_RLX_ML_004	NB	Mainline Ch. 3+920m to Ch. 3+940m	Relaxation of stopping sight distance
	PINK_RLX_ML_005	SB	Mainline Ch. 0+000m to Ch. 0+010m	Relaxation of stopping sight distance
	PINK_RLX_ML_006	SB	Mainline Ch. 2+560m to Ch. 3+010m	Relaxation of stopping sight distance
	PINK_RLX_ML_007	SB	Mainline Ch. 3+130m to Ch. 3+220m	Relaxation of vertical curvature

Table 5-10 - Departures from Standards

Option	Reference Number	Direction	Location	Type
Green Option	GREEN_DEP_ML_001	NB	Mainline Ch. 3+670m to Ch. 4+050m	Relaxation of vertical curvature on the immediate approach to a junction
	GREEN_DEP_ML_002	NB	Mainline Ch. 4+070m to Ch. 4+110m	Relaxation of stopping sight distance on the immediate approach to a junction
	GREEN_DEP_ML_003	NB	Mainline Ch. 4+160m to Ch. 4+180m	Combination of horizontal curvature and stopping sight distance relaxations
	GREEN_DEP_ML_004	SB	Mainline Ch. 3+880m to Ch. 4+070m	Combination of vertical curvature and SSD relaxations on the immediate approach to a junction
Yellow Option	YELLOW_DEP_ML_001	NB	Mainline Ch. 1+790m to Ch. 2+220m	Combination of vertical curvature and SSD

Option	Reference Number	Direction	Location	Type
				relaxations on the immediate approach to a junction
	YELLOW_DEP_ML_002	NB and SB	Mainline Ch. 2+230m to Ch. 2+270m	Combination of horizontal curvature and vertical curvature relaxations on the immediate approach to a junction
	YELLOW_DEP_ML_003	NB	Mainline Ch. 2+280m to Ch. 2+340m	Combination of horizontal curvature and vertical curvature relaxations
	YELLOW_DEP_ML_004	SB	Mainline Ch. 1+830m to Ch. 2+220m	Combination of vertical curvature and SSD relaxations on the immediate approach to a junction
	YELLOW_DEP_ML_005	SB	Mainline Ch. 2+280m to Ch. 2+400m	Combination of horizontal curvature, vertical

Option	Reference Number	Direction	Location	Type
				curvature and SSD relaxations on the immediate approach to a junction
Brown Option	BROWN_DEP_ML_001	NB	Mainline Ch. 1+820m to Ch. 1+900m	Combination of horizontal curvature and SSD relaxations on the immediate approach to a junction
	BROWN_DEP_ML_002	NB	Mainline Ch. 1+910m to Ch. 1+930m	Relaxation of SSD on the immediate approach to a junction
	BROWN_DEP_ML_003	NB	Mainline Ch. 1+940m to Ch. 2+250m	Combination of horizontal curvature, vertical curvature and SSD relaxations on the immediate approach to a junction
	BROWN_DEP_ML_004	NB and SB	Mainline Ch. 2+260m	Combination of horizontal

Option	Reference Number	Direction	Location	Type
			to Ch. 2+300m	curvature, vertical curvature and SSD relaxations on the immediate approach to a junction
	BROWN_DEP_ML_005	NB	Mainline Ch. 2+310m to Ch. 2+360m	Combination of horizontal curvature and SSD relaxations
	BROWN_DEP_ML_006	NB	Mainline Ch. 2+390m to Ch. 2+400m	Relaxation of SSD
	BROWN_DEP_ML_007	SB	Mainline Ch. 1+820m to Ch. 1+900m	Combination of horizontal curvature and SSD relaxations
	BROWN_DEP_ML_008	SB	Mainline Ch. 1+960m to Ch. 2+250m	Combination of horizontal curvature, vertical curvature and SSD relaxations on the immediate

Option	Reference Number	Direction	Location	Type
				approach to a junction
	BROWN_DEP_ML_009	SB	Mainline Ch. 2+310m to Ch. 2+400m	Combination of horizontal curvature and SSD relaxations on the immediate approach to a junction
Purple Option	PURPLE_DEP_ML_001	NB	Mainline Ch. 2+990m to Ch. 3+590m	Combination of horizontal curvature, vertical curvature and SSD relaxations on the immediate approach to a junction
	PURPLE_DEP_ML_002	SB	Mainline Ch. 3+120m to Ch. 3+630m	Combination of horizontal curvature, vertical curvature and SSD relaxations on the immediate approach to a junction

Option	Reference Number	Direction	Location	Type
Pink Option	PINK_DEP_ML_001	NB	Mainline Ch. 3+190m to Ch. 3+680m	Combination of vertical curvature and SSD relaxations on the immediate approach to a junction
	PINK_DEP_ML_002	NB	Mainline Ch. 3+780m to Ch. 3+830m	Combination of horizontal curvature and vertical curvature
	PINK_DEP_ML_003	NB	Mainline Ch. 3+850m to Ch. 3+910m	Combination of vertical curvature and SSD relaxations
	PINK_DEP_ML_004	SB	Mainline Ch. 3+230m to Ch. 3+640m	Combination of vertical curvature and SSD relaxations on the immediate approach to a junction
	PINK_DEP_ML_005	SB	Mainline Ch. 3+650m to Ch. 3+740m	Relaxation of vertical curvature on the immediate

Option	Reference Number	Direction	Location	Type
				approach to a junction
	PINK_DEP_ML_006	SB	Mainline Ch. 3+750m to Ch. 3+830m	Combination of horizontal curvature, vertical curvature and SSD relaxations on the immediate approach to a junction
	PINK_DEP_ML_007	SB	Mainline Ch. 3+840m to Ch. 3+910m	Relaxation of vertical curvature on the immediate approach to a junction

5.7. Climate, Topography and Land Use

5.7.1. Summary

The effects of the Scheme Options on climate, topography and land use are considered in detail in Part 3 chapters 11 and 12.

Each Scheme Option is fundamentally different, in terms of its structural from, ie tunnels, viaducts and flow shelters, and this structural form drives the alignment and associated features. The way each option seeks to integrate into the topography is again fundamentally different. However, whilst the way this integration is achieved is different, the outcome for each is considered comparable and therefore climate and topography is not considered a differentiator between options in the context of the engineering assessment, noting the environmental assessment is reported separately.

With respect to land use, the Brown Option is principally online of the existing A83 and therefore represents the smallest change to the existing condition. This is further considered with Part 3 chapter 11.

5.7.2. Scope of Stage 3 Assessment

The DMRB Stage 3 assessment will include for more detailed consideration of the earthworks profile, with particular focus on the form of excavation into the hillside. It will also look for opportunities to promote sustainable travel and to maintain or improve private access within the influence of the Preferred Route.

5.8. Hydrology, Hydrogeology and Drainage

5.8.1. Summary

Based on the assessment to date it is considered that all Scheme Options have the potential to be developed in accordance with the relevant legalisation and guidance with respect to the water environment, drainage and flooding.

The Green and Brown Options are considered least favourable as they both include debris flows shelters which require more complex solutions to maintain water and sediment transfer from the upper to lower slopes, which is not as great an issue for the viaduct and tunnel options.

It should be noted however the Green Option is further complicated as the terrain on the west side of the glen, coupled with its increased length, will make traditional SuDS more difficult to incorporate.

5.8.2. Scope of Stage 3 Assessment

The DMRB Stage 3 assessment will include for more detailed consideration of the water environment, including the proposed drainage networks for both the trunk road and side road networks, the passage of watercourses, and the catchment including the movement of sediment through the structure and a detailed assessment of flood risk. This will include continued consultation with SEPA and Argyll and Bute Council, in addition to other key stakeholders.

Additional information will be collated to supplement the baseline data collected during the current phase of the assessment in order to provide more robust data for developing the DMRB Stage 3 assessment and specimen design.

Cumulative and indirect impacts will also be considered as part of the Stage 3 assessment and any required mitigation; embedded, or otherwise will be considered in the design.

5.9. Public Utilities

5.9.1. Summary

In general, there are no major or significant items of utility apparatus or assets present within the Preferred Corridor which are considered to have a high cost or programme impact should diversion or protection measures be required.

The lack of existing utilities in the area, particularly with respect to power and water, does represent an challenge for all Scheme Options, as both power and water supplies will need to be brought to site to facilitate construction.

In the case of the tunnel options; Pink and Purple Options; water and power is also required to facilitate the ongoing operation of the asset which may include the requirement for redundant supplies by means of an independent supply or on site generator/reservoir.

Utilities are therefore not considered a significant differentiator between Scheme Options, however the Pink and Purple Options are considered least favourable as significant permanent and potentially redundant supplies are also required.

5.9.2. Scope of Stage 3 Assessment

The DMRB Stage 3 assessment will include for a more detailed assessment of the impact on utility apparatus following the procedures set out in New Roads and Street Works Act 1991 - Diversionary Works.

Initially this will involve obtaining a C3 Budget Estimate from each undertaker where apparatus is affected, and an assessment of where new supplies are required.

Thereafter, as the project develops in conjunction with the Statutory Process, a C4 Detailed Estimate will be obtained.

5.10. Constructability

Each Scheme Option has undergone significant design development, driven in part by an assessment of construction, operation, and maintenance. The following section outlines an indicative construction methodology associated with each Scheme Option and presents a summary of the resultant assessment including overall construction duration estimates.

It is noted that the construction methodology will be subject to refinement and change as the Scheme develops and a Contractor is appointed.

5.10.1. Yellow Option Construction Methodology and Sequencing

The DMRB assessment process has considered both a balanced cantilever and steel composite deck solution for the viaduct. Whilst the construction methodology and sequence would vary between each form of construction, the initial assessment has concluded that they both have the potential to meet the functional requirements of the structure and the overall footprint, and construction programme would be similar.

The total estimated construction period for the Yellow Option is estimated to be 3.5 years.

The following section contains a general construction sequence for both forms of construction. This is based on the following assumptions which are applicable to both forms of construction.

5.10.1.1. General Assumptions

- 7 Day working
- 15% downtime allowance for weather
- Assuming piers will be hollow and constructed using slipform technology
- Piled foundation and debris flow deflectors required at all piers
- Abutments will be formed on pad foundations
- The end cantilever half span at abutments will be cast over scaffolding
- Assumed N2 Parapets (min 1.5m High) for full length of the viaduct
- No wind deflection currently allowed – assessment required but assumed road kept opened
- Temporary haul road required for construction minimally over convoy section of OMR

5.10.1.2. Balanced Cantilever – Indicative Construction Sequence

- Set up platform to construct the piled foundations in Groups of 4-5 e.g., Group A, B, C & D
- Set up piling rigs at two ends (north and south) and progressively construct the piles and pile caps for Group A piers - P01, P03, P05, P15 and P17
- Once piling for first group of piers (i.e., Group A) is complete, move the rigs to construct next set of piles and pilecap for Group B piers
- Set up the formwork to cast the piers over the completed pilecap at Group A piers using slip or jump-form construction
- Set up tower cranes and Alimak or similar hoisting system at each pier as construction progresses
- Once full pier height is cast, construct the pier crosshead using pre-formed formwork
- Once the pier crosshead archives the minimum strength, set up the cantilever traveller formwork at the two ends
- Cast the cantilever decks incrementally following an agreed cycle, generally 1 week
- Construct the cantilever deck at Group A piers - P01, P03, P05, P15 and P17
- Repeat the above sequence to form the foundations, pier columns, crossheads and cantilever decks for the next group, i.e., Group B piers - P02, P04, P16 and P18
- Complete the in-situ stitch as the last segment to form the deck continuity from P01 to P05 and P15 to P18
- Next construct the Group C piers- P07, P09, P11, P13 simultaneously and complete the cantilever deck at each pier
- Group C is followed by Group D piers comprising of P06, P08, P10, P12
- Following similar sequence to Group A, complete the cantilever decks at each pier from Group D and cast the in-situ stitch at the last
- The continuity stitches for Piers P06 and P14 are cast last in the sequence
- Cast the half span towards the abutment over temporary formwork. This is to be either integral or cast over bearings on abutments
- Complete the approach to the viaduct
- Construct the parapets and finishes

This is based on the following specific assumptions:

- The end cantilever half span at abutments will be cast over scaffolding.

- Post-tensioned balanced cantilever will include profiled deck soffit with total depth varying from 8m at support to 5.5m at mid span.
- Assumed that bearings and expansion joints will be limited to two locations.
- Temporary haul road required for construction minimally over convoy section of OMR
- At least 5 no. Alimak and tower cranes will be required to be set-up at the same time.
- At least 10 no. Cantilever Traveller Formwork will be required to be set-up at the same time.

5.10.1.3. Steel Composite Superstructure – Indicative Construction Sequence

- Construct south approach embankment
- Realign existing A83 adjacent to north abutment
- Set up assembly area and launching platforms on approach to north curve and south curve
- Form a 40 x 30m flat area at each pier
- Construct piles and pile caps
- Construct south abutment and piers 1 – 4
- Assemble temporary cable stayed tower for leading curved beam on south curve
- Launch south curve
- Construct piers 5 and 6 and 15 – 18
- Crane spans 5 and 6 into place
- Form concrete deck in spans 1 - 6
- Construct piers 7 - 14
- Transport leading straight beam along formed deck in spans 1- 6 and assemble on span 6
- Assemble temporary cable stayed tower for leading straight beam
- Incrementally launch spans 7 – 14 of straight section from spans 5 and 6
- Remove temporary cable stayed tower and lower deck in spans 7 – 14 onto permanent bearings
- Assemble temporary cable stayed tower for leading curved beam on north curve
- Launch north curve
- Form concrete deck in spans 7 – 19
- Finishes

This is based on the following specific assumptions:

- 2no. tower cranes – 1 at each pier being slip formed and moving with slip form units
- 2no. 1000 tonne cranes for craning straight sections into place
- 2.no personnel hoists
- 1no. temporary cable stayed launching tower
- Horizontal and vertical jacks at each pier
- Superstructure articulated on bearings at piers and abutments
- Beams delivered to site in 25 or 50m segments and welded/spliced on site
- Spans 1 – 6 concreted before spans 7 – 14 launched
- Remaining spans concreted after all launching has been completed
- Bare steel deck launched as a double box section with all temporary and permanent bracing

5.10.2. Brown Option Construction Methodology and Sequencing

The total estimated construction period for the Brown Option is 3 to 4 years.

The estimated range is based on an assessment of potential stand down time, with the stand down time in this context defined as the time during which major construction work cannot progress due to potential instability of the hill side. This is in addition to the more typical construction down time for weather and other related activities that has been built into all construction estimates.

Given the Brown Option is online of the existing A83, there is good access from either end along the A83 itself. Appreciating the urgency of the project, it is currently assumed that the debris flow shelter will be constructed by 3 independent work fronts, working simultaneously.

The extent of each work front varies to account for the varying volume of excavation and geotechnical complexity along the route. The extent of each assumed work front is shown in Figure 5-40, below.

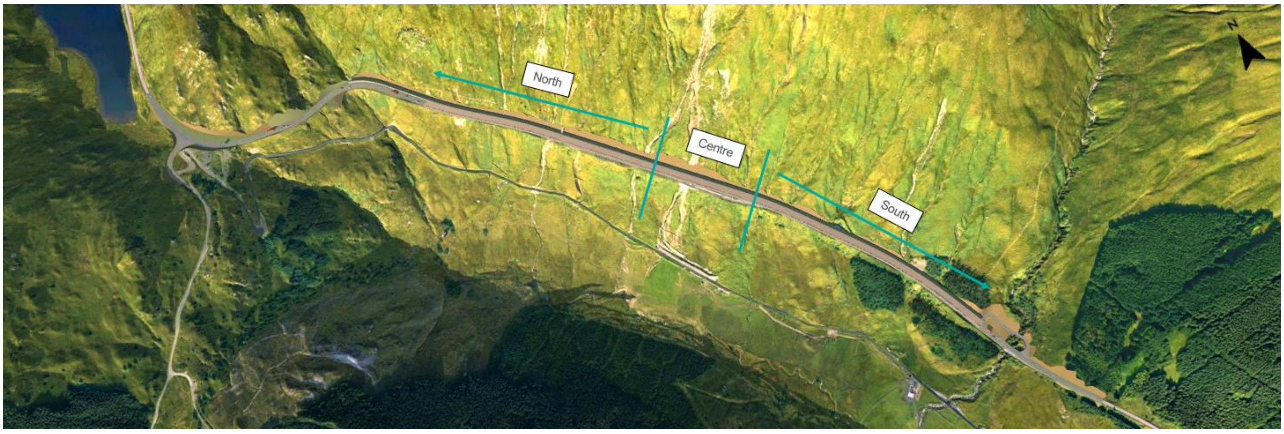

Figure 5-40 - Brown Option Work fronts

Within each work front, it is considered that there will be a rolling programme of activities, with each activity generally working 50m to 100m in front of the next. The main activities are as follows;

- Catch fence construction at the crest of cutting. The purpose of the catch fence it to protect the workforce during construction.
- Top-down excavation for shelter and catchpit. The approach to excavation and stabilisation is designed to reduce the risk of failure of the slope.

  - Excavation of superficial deposits
  - Stabilisation of superficial deposits by soil nailing (additional support with sprayed concrete, as required)
  - Excavation of bedrock
  - Rock face stabilisation (rock bolts, dentition, etc)

- Cast piles and pad foundations where required for protection wall.
- Install rock anchors and cast slab in catchpit.
- Cast protection wall.
- Cast piles and pad foundations for outer columns.
- Cast sidewall and columns.
- Cast deck (roof) slab and upper capping beam.
- Install drainage inlet and outlet structures.

To facilitate the processes noted above, it is considered that road users will need to be diverted to the Medium-Term Solution for the majority of the construction phase. As a minimum a lane closure of the A83 is required for the remainder of the construction phase. This disruption has been considered in the traffic and economic performance of the Scheme Options as presented in Part 4.

5.10.3. Green Option Construction Methodology and Sequencing

The total estimated construction period for the Green Option is 5 to 7 years. The estimated range is based on an assessment of potential stand down time, with the stand down time in this context defined as the time during which major construction work cannot progress due to potential instability of the hill side.

This is in addition to the more typical construction down time for weather and other related activities that has been built into all construction estimates.

As noted previously, the Green Option generally consists of 3 principal elements, namely 2 viaducts connected by a debris flow shelter. In addition, there are 2 short lengths of road on embankment at either end to tie back into the existing A83. The following outlines the proposed construction methodology for each principal element.

5.10.3.1. Debris Flow Shelter

The debris flow shelter includes a significant volume of excavation to create the necessary cross section and because of this is the longest single construction activity associated with the Green Option. As the flow shelter can be accessed from either side along the existing forestry track, it is proposed that the flow shelter is constructed by two parallel work fronts starting in the middle and working out as illustrated on Figure 5-41, below.

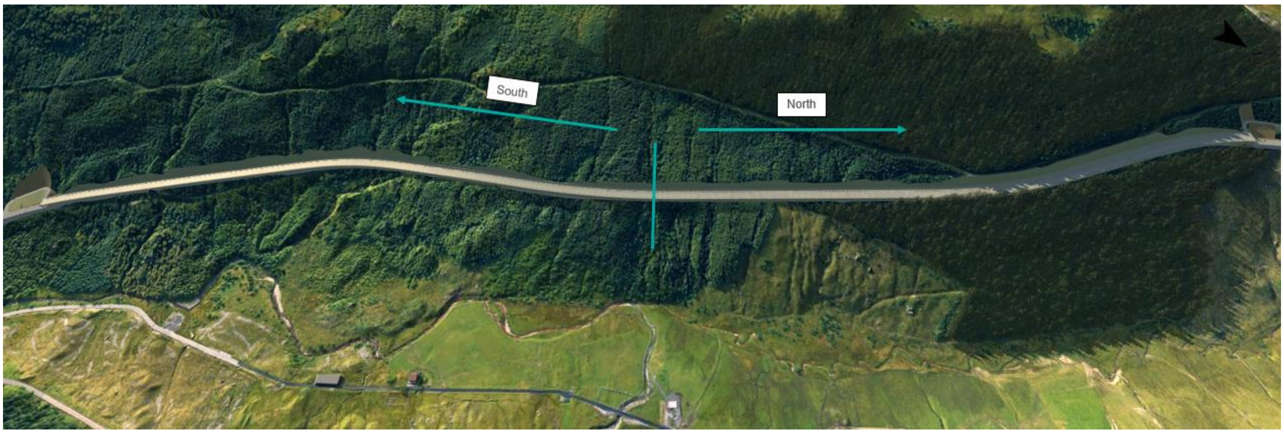

Figure 5-41 - Green Option Work fronts

Additional works fronts are not considered practical as the forestry track does not represent sufficient width to move plant and materials through a work front.

As with the Brown Option, it is considered that there will be a rolling programme of activities within each work front, with each activity generally working 50m to 100m in front of the next.

The main activities are as follows:

- Catch fence construction at the crest of cutting. The purpose of the catch fence is to protect the workforce during construction.
- Top-down excavation for shelter and catchpit. The approach to excavation and stabilisation is designed to reduce the risk of failure of the slope.
  - Excavation of superficial deposits
  - Stabilisation of superficial deposits by soil nailing (additional support with sprayed concrete, as required)
  - Excavation of bedrock
  - Rock face stabilisation (rock bolts, dentition, etc)
- Cast piles and pad foundations where required for protection wall.
- Install rock anchors and cast slab in catchpit.
- Cast protection wall.
- Cast piles and pad foundations for outer columns.
- Cast sidewall and columns.
- Cast deck (roof) slab and upper capping beam.
- Install drainage inlet and outlet structures.

5.10.3.2. Viaducts

Given the form of structure and adjacent topography it is considered that the majority of the deck for both viaducts will be launched. As access along the forestry track from the south should be retained for access to construct the debris flow shelter, it is considered that the southern viaduct and will be constructed in two phases with the 2nd phase comprising all works that could potentially restrict access along the forestry track. Phase 2 of the southern viaduct would then be constructed once the majority of the debris flow shelter is in place.

The general construction methodology for both viaducts are contained below:

Southern Viaduct

- Construct south approach embankment
- Excavate to pile cap base level
- Set up piling platform
- Construct piles
- Construct pile cap
- Construct piers and abutments through traditional construction method
- Set up beam assembly area and launching platform
- Beam sections delivered to site for assembly
- Beam sections braced and craned onto position on launching platform
- Bare steel launched one span at a time. Assembly of next span carried out while preceding span is being launched.
- Launching paused while debris flow shelter earthworks interface with north abutment is completed
- Remainder of deck launched
- Concrete deck and finishes once bare steel in final position

Northern Viaduct

- Excavate at north approach to create launching platform area
- Construct access track from OMR to pier construction areas
- Excavate to pile cap base level
- Construct pile cap
- Construct piers through slipform construction method
- Construct abutments through traditional concrete pours
- Set up beam assembly area and launching platform
- Beam sections delivered to site for assembly
- Beam sections craned into position and braced on launching platform
- Beams launched one span at a time. Assembly of next span carried out while preceding span is being launched.
- Concrete deck and finishes once bare steel in final position

5.10.3.3. General

As the Green Option is generally offline, the bulk of construction can be undertaken with little disturbance to the A83 and OMR. Some localised disruption in the form of traffic management and lane closures will be required at the tie-ins to the existing A83 and during specific launching operations for the southern viaduct.

5.10.4. Purple Option Construction Methodology and Sequencing

The tunnel for the Purple Option is significantly shorter than the Pink Option and will be constructed in parallel with a viaduct to the South.

The Purple Option consists of both a viaduct and tunnel. Due to the location, it is considered that both structures, viaduct and tunnel, can be constructed in parallel with limited interdependency except at the transition (i.e., northern abutment/southern portal) and in the context of material supply, specifically concrete supply.

The total estimated construction period for the Purple Option is 3.5 years.

The construction methodology for the viaduct and tunnel is contained below.

5.10.4.1. Viaduct

Like the Yellow Option, the DMRB assessment process has considered both a balanced cantilever and steel composite deck solution for the viaduct. Whilst the construction methodology and sequence would vary between each form of construction, the initial assessment has concluded that they both have the potential to meet the functional requirements of the structure and the overall footprint, and construction programme would be similar.

As such the choice of structural form would be further considered during DMRB Stage 3 should this be the Preferred Option.

The following section contains a general construction sequence for both forms of construction. This is based on the following assumptions which are applicable to both forms of construction.

General Assumptions

- 7 Day working
- 15% downtime allowance for weather
- Assuming piers will be hollow and constructed using slipform technology
- Piled foundation and debris flow deflectors required at all piers

- Abutments will be formed on pad foundations
- The end cantilever half span at abutments will be cast over scaffolding
- Assumed N2 Parapets (min 1.5m High) for full length of the viaduct
- No wind deflection currently allowed – assessment required but assumed road kept opened
- Temporary haul road required for construction minimally over convoy section of OMR

Balanced Cantilever – Indicative Construction Sequence

- Set up platform to construct the piled foundations in Groups e.g., Group A, B, C & D
- Set up piling rigs at two ends (north and south) and progressively construct the piles and pile caps for Group A piers - P02, P04, P12 and P14
- Once piling for first group of piers (i.e., Group A) is complete, move the rigs to construct next set of piles and pilecap for Group B piers
- Set up the formwork to cast the piers over the completed pilecap at Group A piers using slip or jump-form construction
- Set up tower cranes and Alimak or similar hoisting system at each pier as construction progresses
- Once full pier height is cast, construct the pier crosshead using pre-formed formwork
- Once the pier crosshead archives the minimum strength, set up the cantilever traveller formwork at the two ends
- Cast the cantilever decks incrementally following an agreed cycle, generally a week
- Construct the cantilever deck at Group A piers - P02, P04, P12 and P14
- Repeat the above sequence to form the foundations, pier columns, crossheads and cantilever decks for the next group, i.e., Group B piers – P13, P15, P01 and P03
- Complete the in-situ stitch as the last segment to form the deck continuity from P01 to P04 and P12 to P15
- Next construct the Group C piers- P06, P08 and P10 simultaneously and complete the cantilever deck at each pier
- Group C is followed by Group D piers comprising of P05, P07, P09 and P11
- Following similar sequence to Group A, complete the cantilever decks at each pier from Group D and cast the in-situ stitch at the last
- The continuity stitches for Piers P05 and P11 are cast last in the sequence
- Cast the half span towards the abutment over temporary formwork. This is to be made integral with the abutments.

- Complete the approach to the viaduct
- Construct the parapets and finishes

This is based on the following specific assumptions:

- The end cantilever half span at abutments will be cast over scaffolding.
- Post-tensioned balanced cantilever will include profiled deck soffit with total depth varying from 8m at support to 5.5m at mid span.
- Assumed that bearings and expansion joints will be limited to two locations.
- Temporary haul road required for construction minimally over convoy section of OMR
- At least 4 no. Alimak and tower cranes will be required to be set-up at the same time.
- At least 8 no. Cantilever Traveller Formwork will be required to be set-up at the same time.

Steel Composite Superstructure – Indicative Construction Sequence

- Construct south approach embankment
- Excavate at tunnel south approach to create launching platform and assembly area
- Set up assembly area and launching platforms on approach to north curve and south curve
- Set up 40 x 30m flat area at each pier
- Construct piles and pile caps
- Construct south abutment and piers 1 – 4
- Assemble temporary cable stayed tower for leading curved beam on south curve
- Launch south curve
- Construct piers 5, 6 and 15
- Crane spans 5 and 6 into place
- Form concrete deck in spans 1 - 6
- Construct piers 7 - 14
- Transport leading straight beam along formed deck in spans 1- 6 and assemble on span
- Assemble temporary cable stayed tower for leading straight beam
- Incrementally launch spans 7 – 14 of straight section from spans 5 and 6
- Launch north curve
- Form concrete deck in spans 7 – 15
- Finishes

This is based on the following general assumptions:

- 2no. tower cranes – 1 at each pier being slip formed and moving with slip form units
- 2no. 1000 tonne cranes for craning straight sections into place
- 2.no personnel hoists
- 1no. temporary cable stayed launching tower
- Horizontal and vertical jacks at each pier
- Superstructure articulated on bearings at piers and abutments
- Beams delivered to site in 25 or 50m segments and welded/spliced on site
- Spans 1 – 6 concreted before spans 7 – 14 launched
- Remaining spans concreted after all launching has been completed
- Bare steel deck launched as a double box section with all temporary and permanent bracing
- Hollow Piers formed by slip forming
- Piled substructure

5.10.4.2. Tunnel

For the tunnel operation, 2 works fronts will be established in both the north and south to facilitate the tunnel drives. Due to the spatial constraints in the south and the need for the worksite to support both tunnel and viaduct construction activities, it is proposed that majority of the tunnel drive will be undertaken from the north.

The southern work front will service a stub tunnel drive which passes under the OMR and A83. The stub tunnel will be constructed using mechanical excavation with multiple headings in order to minimise disruption to the road above.

Permanent tunnel lining construction will be supplied by a concrete batching plant in the north and carried out from north to south.

The high-level construction philosophy for the tunnelling components of the Purple Route can be summarised as follows:

- Independent construction worksites are established in the North and South.
- Southern and Northern open-cut and cut-and-cover sections are excavated and exposed slopes are stabilised.

- Drill-and-blast main tunnel drive is undertaken from the Northern worksite until converging with a stub tunnel drive using mechanical excavation from the Southern worksite.
- Permanent tunnel lining is constructed from the North to South for both the mined and cut-and-cover tunnel sections.
- Tunnel fit-out, auxiliary civils and pavement construction is carried out from both Northern and Southern worksites. Cut-and-cover tunnel sections are backfilled and compacted.
- Tunnel testing and commissioning undertaken whilst undertaking permanent road embankment construction in the North and connecting to existing A83 and new viaduct.
- Worksites are demobilised and landscapes are reinstated. Tunnel is opened to the road users.

5.10.5. Pink Option Construction Methodology and Sequencing

The total estimated construction period for the Purple Option is 4.25 years.

Due to the length of the tunnel for the Pink Option and scheme urgency, it is proposed that the excavation, fit out and commissioning activities are carried out from independent worksites in the north and south. The spatial constraints at the southern worksite location are managed by constructing an earth embankment on which the A83 can be temporarily diverted prior to commencement of slope excavation.

Permanent tunnel lining construction will be supplied by a concrete batching plant in the south and carried out in a single direction due to the linear nature of the activities.

The high-level construction methodology for the tunnelling components of the Pink Option can be summarised as follows:

- Independent construction worksites are established in the North and South with embankment construction and temporary road diversion in the Southern section.
- Northern open-cut and cut-and-cover sections are excavated during construction of the embankment to provide fill for the temporary road diversion.
- Southern open-cut and cut-and-cover sections are excavated, and exposed slopes are stabilised.
- Drill-and-blast tunnel drives are undertaken from both the Northern and Southern worksites until converging approximately mid-way through the alignment.

- Permanent tunnel lining is constructed from the South to North for both the mined and cut-and-cover tunnel sections.
- Tunnel fit-out, auxiliary civils and pavement construction is carried out from both Northern and Southern worksites. Cut-and-cover tunnel sections are backfilled and compacted.
- Tunnel testing and commissioning undertaken whilst undertaking permanent road embankment construction in the North and connecting to existing A83.
- Worksites are demobilised and landscapes are reinstated. Tunnel is opened to the road users.

5.10.6. Summary

All options have significant engineering measures associated with them as described in Section 5.3.

Due to the type of options considered, a key part of the DMRB Stage 2 was an assessment of constructability, which drove a series of design developments and refinements both respect of the permanent and temporary works.

The engineering measures, including the form of structure, excavation and resultant traffic management has therefore driven the footprints of the Scheme Options which have been assessed against the various engineering and environmental criteria. It has also driven the scheme cost estimate as presented in Section 3.2 and the construction programmes summarised above and, in the table, below.

Table 5-11 - Estimated construction durations

Scheme Option	Yellow Option	Brown Option	Green Option	Purple Option	Pink Option
Construction Period	3.5yrs	3 – 4yrs*	5 – 7yrs*	3.5yrs	4.25yrs

*Indicates most likely estimated range due to potential stand down period caused by potential instability of the hillside.

As the constructability of the option is generally considered as part of the broader assessment, the main differentiator is the potential disruption to road users during construction of the Scheme Options.

As the Brown Option is online of the existing A83, this represents the biggest disruption to road users during construction as traffic will be diverted to the Medium-Term Solution (improved OMR) for significant periods of construction.

All other options are predominately offline of the existing A83 meaning the disruption to road users will be limited to the two tie-ins.

The disruption caused by the Pink and Green Options is considered the least of all options as the extent of works required at the tie-ins are the most limited.

Conversely the Yellow and Purple Options have proportionally higher disruption at the tie-ins and also require access along part of the OMR for construction vehicles, noting the OMR will remain as the local diversion to the A83.

5.10.7. Scope of Stage 3 Assessment

A key focus area during DMRB Stage 3 is to explore ways to optimise the overall construction programme and mitigate disruption to road users during construction.

This will include further targeted ground investigation, and monitoring to refine the approach to excavation which is critical to development of the construction programme.

Further assessment of traffic management will also be undertaken based on the refined approach to excavation. The purpose of this assessment is to explore ways to maintain a lane of the A83 open for as long as possible during construction.

The DMRB Stage 3 will also consider the use modular or off-site construction processes to improve quality and reduce the construction programme.

5.11. Operation and Maintenance

The operation and maintenance requirements of tunnels, viaducts and debris flow shelters varies considerably. However, regardless of the main engineering intervention, many of the general construction processes are shared across each Scheme Option, such as pavement, embankments and street furniture.

The following section summarises the operational and maintenance requirements associated with each Scheme Option, focusing on the areas of difference.

5.11.1. Yellow Option Description

The DMRB assessment process has considered both a balanced cantilever and steel composite deck solution for the viaduct. Whilst the extent of some of the specific maintenance requirements would vary between each form of construction, the initial assessment has concluded that they both have the potential to meet the functional requirements of the structure and overall, the maintenance requirements are equivalent.

As such the structural form would be further considered during DMRB Stage 3 should this be the Preferred Option.

The following section contains a list of the specific maintenance activities specific to each form of construction.

- Waterproofing reapplication
- Drainage Maintenance
- Bearing replacement
- Expansion joint replacement
- Painting reapplication

5.11.2. Brown Option Description

The Brown Option consists of a debris flow shelter with catchpit. The principal maintenance activities associated with this intervention are as follows:

- Clearing of superficial deposits/rock fall from the catchpit/roof - Routine inspection and as required after event.
- Maintenance of the cushioning material on the roof and the sacrificial components of the protection wall - Routine inspection and as required after event.
- Clearing of sediment from drainage channels - Routine inspection and as required after event.
- Maintenance of anti-scour on downstream slope - Routine inspection and as required after event.
- Special inspection of rock anchors - Routine inspection and as required after event.
- Deck soffit, side wall and columns inspection using MEWP for General and Principal inspections. For other areas drones can be used.
- Waterproofing reapplication.

- Finishes: Wet/Dry surface preparation and re-application of finish.

5.11.3. Green Option Description

The Green Option consists of a debris flow shelter with catchpit, in addition to 2 major steel ladder framed viaducts. The principal maintenance activities associated with this intervention are as follows.

Debris Flow Shelter

- Clearing of superficial deposits/rock fall from the catchpit/roof - Routine inspection and as required after event.
- Maintenance of the cushioning material on the roof and the sacrificial components of the protection wall - Routine inspection and as required after event.
- Clearing of sediment from drainage channels – Routine inspection and as required after event.
- Maintenance of anti-scour on downstream slope – Routine inspection and as required after event.
- Special inspection of rock anchors – Routine inspection and as required after event.
- Deck soffit, side wall and columns inspection using MEWP for General and Principal inspections. For other areas drones can be used.
- Waterproofing reapplication.
- Finishes: Wet/Dry surface preparation and re-application of finish.

Viaducts

- Waterproofing reapplication
- Drainage maintenance
- Bearing replacement
- Expansion joint replacement
- Painting reapplication

5.11.4. Purple Option Description

The Purple Option consists of a tunnel and viaduct The principal maintenance activities associated with this intervention are as follows.

Tunnel

The tunnel requires a programme of interventions both with respect to its structural components and Mechanical, Electrical and Plumbing components, some of which requires the tunnel to be closed to carry out said testing and maintenance. The following is a list of those operations including commentary on where closure of the tunnel is required

- Waterproofing reapplication – 38 years. Likely lane closure
- Drainage Maintenance – 16 years and every 4 years thereafter. Likely lane closure
- Routine Planned maintenance – Quarterly – Usually 2-3 No, 8hr night-time closures
- General Inspection – Annually – Usually 1-2 No, 8hr night-time closures
- Principal Inspection – Every 4 years – Usually 4-5 No, 8hr night-time closures
- Emergency exercise/test – Every 4 years – Usually 2-3 No 8hr night-time closures

It should be noted that equivalent inspections are required for the other principal structures (viaducts and flow shelter etc) however these can generally be undertaken under traffic management without full closure of the road.

Viaduct

The DMRB assessment process has considered both a balanced cantilever and steel composite deck solution for the viaduct. Whilst the extent of some of the specific maintenance requirements would vary between each form of construction, the initial assessment has concluded that they both have the potential to meet the functional requirements of the structure and overall, the maintenance requirements are equivalent.

As such the structural form would be further considered during DMRB Stage 3 should this be the Preferred Option.

The following section contains a list of the specific maintenance activities specific to each form of construction.

- Waterproofing reapplication
- Drainage Maintenance
- Bearing replacement
- Expansion joint replacement
- Painting reapplication

5.11.5. Pink Option Description

The Pink Option consists predominantly of a tunnel which requires a programme of interventions both with respect to its structural components and Mechanical, Electrical and Plumbing components, some of which requires the tunnel to be closed to carry out said testing and maintenance. The following is a list of those operations including commentary on where closure of the tunnel is required

- Waterproofing reapplication – 38 years. Likely lane closure
- Drainage Maintenance – 16 years and every 4 years thereafter. Likely lane closure
- Routine Planned maintenance – Quarterly – Usually 2-3 No, 8hr night-time closures
- General Inspection – Annually – Usually 1-2 No, 8hr night-time closures
- Principal Inspection – Every 4 years – Usually 4-5 No, 8hr night-time closures
- Emergency exercise/test – Every 4 years – Usually 2-3 No 8hr night-time closures

It should be noted that equivalent inspections are required for the other principal structures (viaducts and flow shelter etc) however these can generally be undertaken under traffic management without full closure of the road.

5.11.6. Summary

All Scheme Options have significant engineering measures associated with them a described in Section 5.2.

Due to the type of options considered, a key part of the DMRB Stage 2 was an assessment of constructability, operation and maintenance which drove a series of design developments and refinements both respect of the permanent and temporary works.

The operation and maintenance requirements of tunnels, viaducts and debris flow shelters varies considerably. However, regardless of the main engineering intervention, many of the general operation and maintenance requirements are shared across each option, such as pavement, embankments and street furniture. The relative costs associated with the operation and maintenance of each option is illustrated in Table 5-12, below, with the lowest cost option benchmarked at 100%.

Table 5-12 - Operation and Maintenance Cost Comparison of Scheme Options

Scheme Option	Yellow Option	Brown Option	Green Option	Purple Option	Pink Option
Option Comparison	144%	100%	256%	564%	477%

It is noted that the tunnel options also require either an on or off-site control facility to provide full time monitoring of the asset. The cost of such facility has been estimated in table 5-12 above.

5.12. Sustainable Travel

5.12.1. Summary

Within the preferred route corridor there is a variety of recreational walking and cycling routes in addition to bus provision close to the Rest and be Thankful viewpoint car park.

In terms of walking and cycling routes, the Green and Pink Options are considered neutral as they both require a diversion in the operational phase to existing routes. For the Green Option this relates to Local Route1 for which mitigation would likely be diversion to the parallel core path and for the Pink Option this relates to road cyclists who wish to use the A83 which is precluded by tunnels. Possible mitigation for road cyclists would include diversion to the OMR.

The Brown, Yellow and Purple Options are all considered favourable as during operation there will be no material impacts to the existing routes, noting the Purple Tunnel can be bypassed by road cyclists by joining the existing A83 which will be de-trunked from the northern end of the viaduct. Some impacts are expected during construction from all options but again there are various opportunities available to mitigate these during Stage 3.

All options have the potential to consider opportunities for walking, cycling and wheeling within the corridor including the OMR on the eastern side and the Core Path on the western side of the glen.

All options will also retain and have the potential to improve bus integration.

5.12.2. Scope of Stage 3 Assessment

As part of the DMRB assessment process, AWJV will continue to develop the WCHAR Assessment and Review Report in accordance with DRMB GG142.The purpose of this assessment is to identify opportunities to improve walking cycling, and horse riding within the corridor and then to review this as the scheme progress. Then process through stage 3 will focus on developing the initial list of opportunities developed in consultation with key stakeholders, including the Loch Lomond and Trossachs National Park, Argyll and Bute Council and Active Travel groups. This assessment will be extended to consider how to best integrate the bus services to any improvements to existing walking, wheeling and cycle routes in the area.

5.13. Engineering Assessment Summary

The engineering assessment considered a comparative assessment of the Scheme Options against the defined engineering criteria noted above. This was informed by a 7-point scale assessment model.

An overview of the engineering assessment is provided in Table 5-13, below with the full assessment matrix contained in Part 6 Appendix A. For the purposes of the overview, the key included following the table has been applied to provide clarity with respect to which Scheme Options perform more or less favourably across the engineering assessment criteria.

Table 5-13 - Overview of Engineering Assessment of Scheme Options

Engineering Assessment	Green	Yellow	Brown	Purple	Pink
Duration	Least Favourable	Neutral	Neutral	Neutral	Neutral
Local Roads/ Accesses	Neutral	Neutral	Neutral	Least Favourable	Least Favourable
Resilience - events on Beinn Luibhean Slope	Neutral	Neutral	Neutral	Neutral	Neutral
Resilience - wider area	Favourable	Neutral	Neutral	Neutral	Neutral
Departures from Standard	Neutral	Neutral	Neutral	Neutral	Neutral
Topography & Land Use	Neutral	Neutral	Neutral	Neutral	Neutral
Geotechnics & Earthworks Complexity	Least Favourable	Favourable	Least Favourable	Neutral	Neutral
Geotechnics & Earthworks	Least Favourable	Favourable	Neutral	Neutral	Least Favourable
Hydrology	Least Favourable	Neutral	Least Favourable	Neutral	Favourable
Structure Complexity	Neutral	Neutral	Favourable	Neutral	Favourable
Utilities	Neutral	Neutral	Neutral	Least Favourable	Least Favourable

Engineering Assessment	**Green**	**Yellow**	**Brown**	**Purple**	**Pink**
Constructability (disruption)	Favourable	Neutral	Least Favourable	Neutral	Favourable
Operation & Maintenance	Neutral	Favourable	Neutral	Least Favourable	Least Favourable

FAVOURABLE (Most Favourable or Least Detrimental)
NEUTRAL (relatively insignificant variance between Options)
LEAST FAVOURABLE (Least Favourable or Most Detrimental)