A9 Dualling Programme: Pass of Birnam to Tay Crossing

DMRB Stage 2 Scheme Assessment Report

Volume 1: Main Report and Appendices

Part 2 - Engineering Assessment

A9P02-JAC-ZZZ-Z_ZZZZZ_ZZ-RP-ZZ-0008 | C03

October 2023

Transport Scotland

TS/MTRIPS/SER/2013/03

Jacobs

TRANSPORT SCOTLAND
CÒMHDHAIL ALBA

A9 Dualling Programme: Pass of Birnam to Tay Crossing

Project No:	A9P02
Document Title:	DMRB Stage 2 Scheme Assessment Report Volume 1: Main Report and Appendices Part 2 - Engineering Assessment
Document No.:	A9P02-JAC-ZZZ-Z_ZZZZZ_ZZ-RP-ZZ-0008
Revision:	C03
Document Status:	A
Date:	October 2023
Client Name:	Transport Scotland
Client No:	TS/MTRIPS/SER/2013/03
Project Manager:	E.McMILLAN
Author:	C.KERR
File Name:	A9P02-JAC-ZZZ-Z_ZZZZZ_ZZ-RP-ZZ-0008.docx

Jacobs U.K. Limited

95 Bothwell Street
Glasgow, Scotland G2 7HX
United Kingdom
T +44 (0)141 243 8000
F +44 (0)141 226 3109
www.jacobs.com

Contents

List of Figures

List of Tables

List of Abbreviations

AADT	-	Annual Average Daily Traffic
AEP	-	Annual Exceedance Probability
AOD	-	Above Ordnance Datum
bgl	-	Below Ground Level
BGS	-	British Geological Survey
BT	-	British Telecommunications
CCTV	-	Closed Circuit Television
CIRIA	-	Construction Industry Research and Information Association
CIS	-	Customer Information System
CFA	-	Continuous Flight Auger
CNPA	-	Cairngorms National Park Authority
D2AP	-	Dual 2-lane All Purpose
DMRB	-	Design Manual for Roads and Bridges
GDL	-	Gardens and Designed Landscape
GI	-	Ground Investigation
GSM-R	-	Global System for Mobile Communications - Railway
HES	-	Historic Environment Scotland
HVS	-	Hydrodynamic Vortex Separator
ICD	-	Inscribed Circle Diameter
kph	-	Kilometres per hour
mph	-	Miles per hour
mm/s	-	Millimetres per second
NATM	-	New Austrian Tunnelling Method
NCN	-	National Cycle Network
NSA	-	National Scenic Area
NTS	-	National Trust for Scotland
PES	-	Preliminary Engineering Services
PKC	-	Perth & Kinross Council
PPV	-	Peak Particle Velocity
PSSR	-	Preliminary Sources Study Reports
RCN	-	Regional Cycle Network
RMMS	-	Routine Maintenance Management System
SAC	-	Special Area of Conservation
SEA	-	Strategic Environmental Assessment
SEPA	-	Scottish Environment Protection Agency
SGN	-	Scottish Gas Networks
SSD	-	Stopping Sight Distance
SSE	-	Scottish and Southern Energy
SuDS	-	Sustainable Drainage Systems
TBM	-	Tunnel Boring Machine
WCH	-	Walkers, Cyclists and Horse-riders

5. Engineering Assessment

5.1 Introduction

5.1.1 In accordance with the Design Manual for Roads and Bridges (DMRB) (TD 37/93: Scheme Assessment Reporting) this Part 2 - Engineering Assessment presents the engineering assessment of the route options described in Volume 1, Part 1 - The Scheme, Chapter 4 (Description of Route Options). The engineering assessment considers the engineering advantages, disadvantages, opportunities and constraints associated with the route options under the key engineering features listed below. Details of the existing physical and environmental constraints, including details on the existing road network are contained within Volume 1, Part 1 - The Scheme, Chapter 2 (Existing Conditions).

- Walkers, Cyclists and Horse-riders (WCH);
- Lay-bys and Rest Areas;
- Relaxations and Departures from Requirements;
- Geotechnics and Earthworks;
- Hydrology, Hydrogeology and Drainage;
- Structures;
- Public Utilities; and
- Constructability.

5.2 General Scheme Information

General Scheme Description

5.2.1 The Pass of Birnam to Tay Crossing project commences at the northern extent of the current section of existing dual carriageway that extends from Perth to the Pass of Birnam. It extends approximately 8.4 kilometres, bypassing the towns of Birnam, Little Dunkeld and Dunkeld to the east and Inver and The Hermitage, which is a National Trust for Scotland (NTS) protected site, to the west. The tie-in point with the following scheme, Tay Crossing to Ballinluig, is approximately 0.75 kilometres north of the current River Tay crossing.

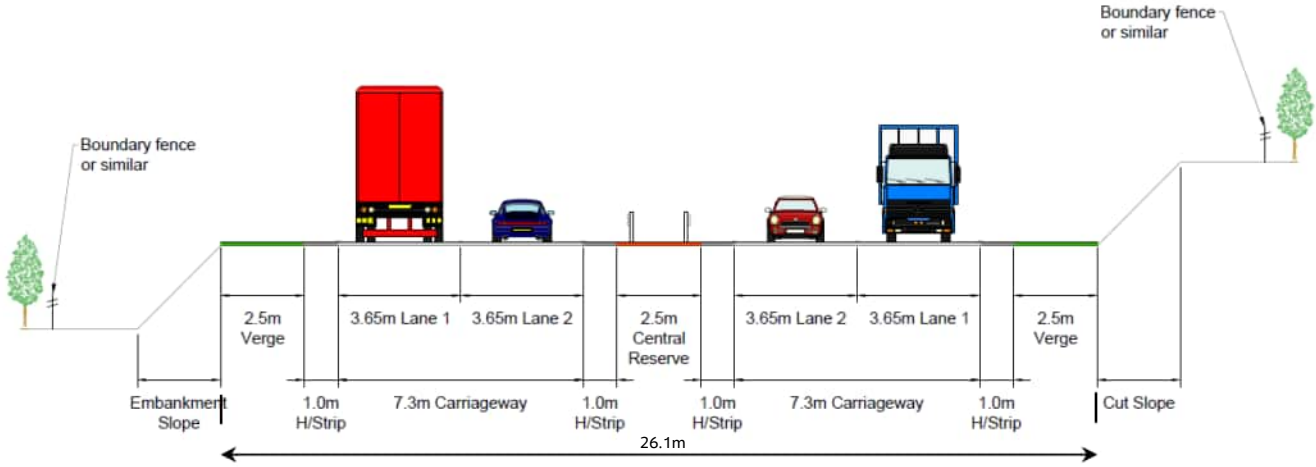
5.2.2 The proposed A9 will be a Dual 2-lane All-Purpose (D2AP) road (sub-category c) (formerly Category 7A), as defined in the DMRB (CD109: Highway link design), which means it will have no gaps in the central reserve and no at-grade minor junctions. It is also recommended that only grade separated junctions are provided on the route for safe access and egress to the A9. Isolated left-in left-out accesses may be provided for direct accesses. Compact grade separated junctions and at-grade roundabouts are not recommended for D2AP (sub-category c) dual carriageways.

Cross-section

5.2.3 The cross-section components for a D2AP dual carriageway are defined in the DMRB (CD127: Cross-sections and headrooms). The proposed A9 will have a Design Speed of 120 kilometres per hour (kph) (70 miles per hour (mph)) over its entire length. However, as noted in Volume 1, Part 1 - The Scheme, Chapter 4 (Description of Route Options), the Community's Preferred Route Option (Option ST2A) includes a section that has a Design Speed of 85kph (50mph) due to forward visibility constraints within the 1.5 kilometre cut and cover tunnel.

5.2.4 The cross-section for the proposed A9 is shown in Figure 5.1.

Figure 5.1: Proposed A9 Dual Carriageway Cross-section



5.2.5 Where necessary the central reserve and verges have been widened to ensure the necessary Stopping Sight Distance (SSD) is achieved.

5.2.6 The proposed A9 is a designated high load route. As a result, the headroom clearance for new structures over the dual carriageway will be a minimum of 6.45 metres, in accordance with the DMRB (CD127: Cross-sections and headrooms). The headroom clearance for structures under the proposed A9 and at side roads will be 5.3 metres.

5.3 Engineering Description of Route Options

Introduction

5.3.1 The four route options included in the DMRB Stage 2 assessment are described in detail below. The text should be read in conjunction with the relevant engineering drawings included in Volume 2: Engineering Drawings and listed in Table 5.1. The start chainage (Ch. 0) is at the southern extent of the scheme.

Table 5.1: Route Option Drawings

Route Option	Drawing Title	Drawing Number
Option ST2A	Option ST2A - Plan and Profiles, Ch. 0 – Ch. 8421.076	A9P02-JAC-HGN-A_ZZZZZ_ZZ-FG-RD-0001
	Option ST2A - Mainline Plan and Profiles	A9P02-JAC-HML-A_MLZZZ_ML-FG-RD-0001 A9P02-JAC-HML-A_MLZZZ_ML-FG-RD-0002 A9P02-JAC-HML-A_MLZZZ_ML-FG-RD-0003 A9P02-JAC-HML-A_MLZZZ_ML-FG-RD-0004 A9P02-JAC-HML-A_MLZZZ_ML-FG-RD-0005 A9P02-JAC-HML-A_MLZZZ_ML-FG-RD-0006
	Option ST2A - Murthly Junction, Plan and Profiles	A9P02-JAC-HML-A_JC01A_JC-FG-RD-0001
	Option ST2A - Dunkeld Junction, Plan and Profiles	A9P02-JAC-HML-A_JC02A_JC-FG-RD-0001
	Option ST2A - The Hermitage Junction, Plan and Profiles	A9P02-JAC-HML-Z_JC03A_JC-FG-RD-0001
	Option ST2A - Dalguise Junction, Plan and Profiles	A9P02-JAC-HML-Z_JC04A_JC-FG-RD-0001
Option ST2B	Option ST2B - Plan and Profiles, Ch. 0 – Ch. 8421.076	A9P02-JAC-HGN-B_ZZZZZ_ZZ-FG-RD-0001
	Option ST2B - Mainline Plan and Profiles	A9P02-JAC-HML-B_MLZZZ_ML-FG-RD-0001 A9P02-JAC-HML-B_MLZZZ_ML-FG-RD-0002

Route Option	Drawing Title	Drawing Number
		A9P02-JAC-HML-B_MLZZZ_ML-FG-RD-0003 A9P02-JAC-HML-B_MLZZZ_ML-FG-RD-0004 A9P02-JAC-HML-B_MLZZZ_ML-FG-RD-0005 A9P02-JAC-HML-B_MLZZZ_ML-FG-RD-0006
	Option ST2B - Birnam Junction, Plan and Profiles	A9P02-JAC-HML-B_JC01A_JC-FG-RD-0001
	Option ST2B - Dunkeld Junction, Plan and Profiles	A9P02-JAC-HML-B_JC02A_JC-FG-RD-0001
	Option ST2B - The Hermitage Junction, Plan and Profiles	A9P02-JAC-HML-Z_JC03A_JC-FG-RD-0001
	Option ST2B - Dalguise Junction, Plan and Profiles	A9P02-JAC-HML-Z_JC04A_JC-FG-RD-0001
Option ST2C	Option ST2C - Plan and Profiles, Ch. 0 – Ch. 8421.076	A9P02-JAC-HGN-C_ZZZZZ_ZZ-FG-RD-0001
	Option ST2C - Mainline Plan and Profiles	A9P02-JAC-HML-C_MLZZZ_ML-FG-RD-0001 A9P02-JAC-HML-C_MLZZZ_ML-FG-RD-0002 A9P02-JAC-HML-C_MLZZZ_ML-FG-RD-0003 A9P02-JAC-HML-C_MLZZZ_ML-FG-RD-0004 A9P02-JAC-HML-C_MLZZZ_ML-FG-RD-0005 A9P02-JAC-HML-C_MLZZZ_ML-FG-RD-0006
	Option ST2C - Birnam Junction, Plan and Profiles	A9P02-JAC-HML-C_JC01A_JC-FG-RD-0001
	Option ST2C - Dunkeld Junction, Plan and Profiles	A9P02-JAC-HML-C_JC02A_JC-FG-RD-0001
	Option ST2C - The Hermitage Junction, Plan and Profiles	A9P02-JAC-HML-Z_JC03A_JC-FG-RD-0001
	Option ST2C - Dalguise Junction, Plan and Profiles	A9P02-JAC-HML-Z_JC04A_JC-FG-RD-0001
Option ST2D	Option ST2D - Plan and Profiles, Ch. 0 – Ch. 8421.076	A9P02-JAC-HGN-D_ZZZZZ_ZZ-FG-RD-0001
	Option ST2D - Mainline Plan and Profiles	A9P02-JAC-HML-D_MLZZZ_ML-FG-RD-0001 A9P02-JAC-HML-D_MLZZZ_ML-FG-RD-0002 A9P02-JAC-HML-D_MLZZZ_ML-FG-RD-0003 A9P02-JAC-HML-D_MLZZZ_ML-FG-RD-0004 A9P02-JAC-HML-D_MLZZZ_ML-FG-RD-0005 A9P02-JAC-HML-D_MLZZZ_ML-FG-RD-0006
	Option ST2D - Birnam Junction, Plan and Profiles	A9P02-JAC-HML-D_JC01A_JC-FG-RD-0001
	Option ST2D - Dunkeld Junction, Plan and Profiles	A9P02-JAC-HML-D_JC02A_JC-FG-RD-0001
	Option ST2D - The Hermitage Junction, Plan and Profiles	A9P02-JAC-HML-Z_JC03A_JC-FG-RD-0001
	Option ST2D - Dalguise Junction, Plan and Profiles	A9P02-JAC-HML-Z_JC04A_JC-FG-RD-0001

Option ST2A (Ch. 0 to Ch. 2,150)

5.3.2 Option ST2A begins at its southern extent at the end of the existing dual carriageway section of the A9 from Perth to the Pass of Birnam, approximately 15 kilometres north of Inveralmond Roundabout in Perth. At this location, the alignment is on a right-hand horizontal curve of radius 1,357 metres to tie-in with the existing carriageway. The vertical alignment is generally at-grade with widening on the northbound side.

5.3.3 Almost immediately north of the southern tie-in point is the first junction on the scheme, Murthly Junction. The junction is located at the existing private access to Murthly Castle, which is on the southbound carriageway of the existing A9. The proposed junction is a grade separated diamond layout, with merge and diverge slip roads in the northbound and southbound directions, facilitating all vehicle movements. An overbridge is provided across the A9, connecting to the B867 to the west via an at-grade junction. A connection to Murthly Estate is also included to the east.

5.3.4 Beyond the 1,357 metres radius right-hand horizontal curve, the alignment transitions to a straight and is slightly off-line to the west, to improve the alignment by removing reverse curves. Option ST2A incorporates a 1.5 kilometre cut and cover tunnel, therefore vertically, the alignment begins to drop lower than existing ground levels and is in cutting as it approaches the southern portal, which is in the locality of the existing left/right staggered priority junction with the B867 and Perth Road at Birnam (Ch. 2,150). The B867 and Perth Road are connected, crossing over the lowered A9 at existing ground level on top of the cut and cover tunnel, immediately north of the southern portal.

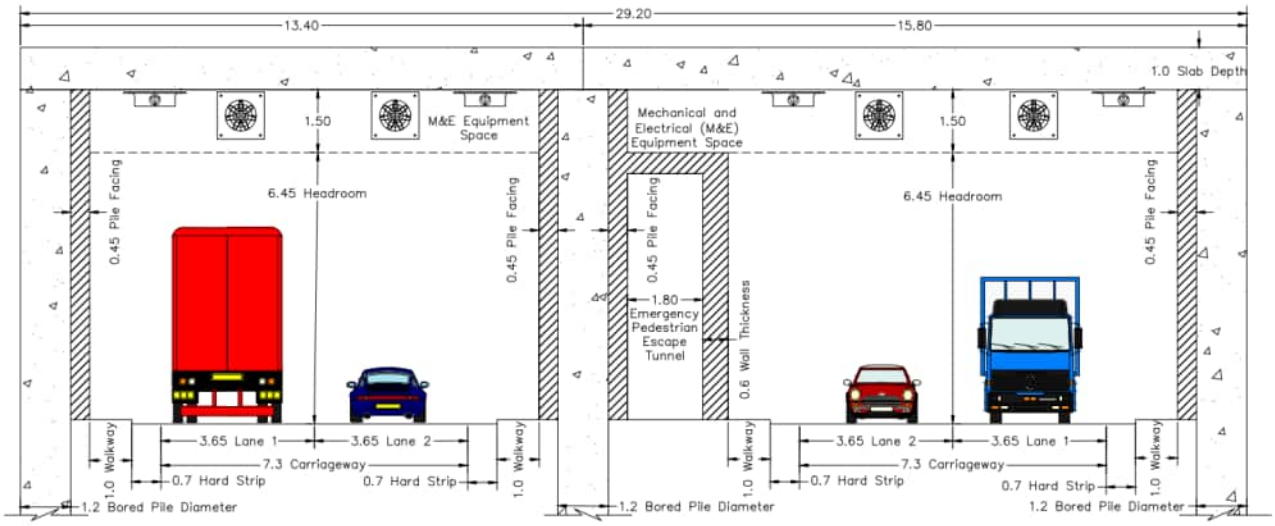
Option ST2A (Ch. 2,150 to Ch. 4,000)

5.3.5 At the southern extent of the cut and cover tunnel, the horizontal alignment continues on a straight, before travelling through a left-hand horizontal curve of radius 840 metres, which is below Desirable Minimum standards for tunnels with a 120kph (70mph) Design Speed. At this point, the alignment is constrained by the Highland Main Line railway to the immediate west and residential properties to the immediate east, which restricts the size of horizontal curve that can be utilised. To maintain safety, a Design Speed of 85kph and a speed limit of 50mph has therefore been adopted through the cut and cover tunnel. To avoid a sudden change in speed limit at the tunnel, which drivers may not adhere to, Option ST2A includes a 50mph speed limit from the southern extent of the scheme to the proposed Dunkeld Junction (Ch. 0 to Ch. 4,000). The proposed A9 dual carriageway is generally around 10 metres below existing ground level with the top of the cut and cover tunnel at existing carriageway level. As insufficient space exists for open excavation, retaining walls are required in the verges and central reserve to form the cut and cover tunnel structure. These retaining walls would be constructed using large diameter bored piles.

5.3.6 Continuing north through the cut and cover tunnel, the alignment travels through a narrow corridor on right-hand horizontal curves of radii 3,200 metres and 5,000 metres, with the Highland Main Line railway and Dunkeld & Birnam Station immediately adjacent to the west and Birnam Industrial Estate and residential properties on Gladstone Terrace and Station Cottages to the east. Widening through this section is to the west, towards Dunkeld & Birnam Station, impacting the station car park and encroaching closer to the station building, which is Category A Listed. Option ST2A allows Station Road to be extended across the cut and cover structure, providing direct access from the communities of Birnam and Dunkeld to the station. A replacement car park and vehicle turning provision is provided on top of the cut and cover tunnel. The existing railway sidings, located at Dunkeld & Birnam Station will be impacted, however these may be reinstated post construction. The proposed cross-section for the cut and cover tunnel, which includes provision for pedestrian emergency evacuation, is wider than an open road, and therefore results in the acquisition of Birnam Industrial Estate.

5.3.7 The proposed cross-section for the cut and cover tunnel is shown in Figure 5.2.

Figure 5.2: Proposed Cut and Cover Tunnel Cross-section



5.3.8 As the A9 is lowered in the vicinity of the station, Birnam Glen will be stopped-up at the location of the current A9 underbridge, immediately north of the station. Access to properties on Birnam Glen to the west of the station will therefore be provided via a new access road from the A822 (Old Military Road) that will be to the west of the Highland Main Line railway. A new underbridge structure is also included to cross Inchewan Burn. Inchewan Burn itself will be lowered by approximately 8 metres as a result of the cut and cover tunnel, crossing the A9 via a new vertical drop structure and culvert that will pass beneath the cut and cover tunnel.

5.3.9 To the north of the Inchewan Burn, the horizontal alignment transitions to a straight on approach to Dunkeld Junction, which is in the vicinity of the existing right/left staggered priority junction with the A923 and A822 (Old Military Road) at Little Dunkeld (Ch. 4,000). In this locality the alignment continues to be constrained by the Highland Main Line railway and residential properties, which are generally on higher ground than the existing A9 carriageway. The northern portal of the cut and cover tunnel is at Ch. 3,730, approximately 300 metres south of the proposed Dunkeld Junction. Beyond the northern portal of the cut and cover tunnel, the vertical alignment returns to existing ground level to tie-in to Dunkeld Junction.

Option ST2A (Ch. 4,000 to Ch. 5,000)

5.3.10 Dunkeld Junction is located at the site of the existing right/left staggered priority junction with the A923 and A822 (Old Military Road) at Little Dunkeld. Dunkeld Junction is an at-grade elongated roundabout that provides connections to the A9 (north and south), A923, A822 (Old Military Road) and the unclassified road to Inver. A segregated left turning lane is included between the A923 and A9 south to improve the overall capacity of the roundabout and to reduce queuing traffic during peak traffic periods.

5.3.11 To the north of the roundabout, Option ST2A is on a left-hand horizontal curve of radius 2,040 metres. It crosses the River Braan on a new wider structure, to accommodate the dual carriageway, and is approximately 3 metres higher than existing carriageway levels to ensure the A9 is not impacted by anticipated future flood levels.

Option ST2A (Ch. 5,000 to Ch. 8,400 (END))

5.3.12 At Ch. 5,000, the horizontal alignment transitions to a straight section of road as it passes Inver, which is on the west. Widening at this location is to the east, moving the A9 closer to the River Tay and impacting a residential property, Auchlou Cottage, which is already under the ownership of Scottish

Ministers. Although generally at-grade, widening results in earthwork embankment slopes on the southbound carriageway, largely due to existing topography, which falls towards the River Tay.

5.3.13 A left-in left-out junction is proposed on the northbound carriageway immediately north of Inver for access to The Hermitage. In this locality, the alignment is both generally at-grade and on a straight. North of The Hermitage, the alignment transitions to a right-hand horizontal curve of radius 726 metres, which is one step below Desirable Minimum for a 120kph (70mph) Design Speed. At the start of the curve, the dual carriageway crosses the Highland Main Line railway via the Inver Rail Underbridge. To accommodate the dual carriageway, the rail underbridge will be extended on the east side. The dual carriageway is off-line to the west around the horizontal curve, impacting areas of woodland. The topography of the existing ground results in sections of large cutting slopes on the northbound carriageway. The Highland Main Line railway is immediately adjacent to the A9 on the east.

5.3.14 The final junction, Dalguise Junction, is located on the 726 metres radius horizontal curve, south of the existing priority junction with the B898. The proposed junction is a grade separated layout, incorporating a loop in the northbound direction and slip roads in the southbound direction, facilitating all vehicle movements. The realigned B898 crosses under the A9 via an underbridge, connecting to a roundabout on the east side of the A9, which also connects to the southbound merge and diverge slip roads.

5.3.15 North of the Dalguise Junction underbridge, the A9 dual carriageway transitions to a straight and is generally at-grade as it crosses the Inch Rail Underbridge, which will be extended to the east, and the River Tay. A new structure will be constructed alongside the existing River Tay bridge to the east to accommodate the proposed southbound carriageway. The existing structure will therefore accommodate the northbound carriageway.

5.3.16 Immediately north of the River Tay crossing, the alignment passes through a left-hand horizontal curve of radius 1,700 metres and remains largely at-grade. The topography to the east results in significant earthwork cutting slopes on the southbound carriageway. Approximately 0.75 kilometres from the River Tay crossing is the tie-in point with the Tay Crossing to Ballinluig scheme.

Option ST2B (Ch. 0 to Ch. 2,500)

5.3.17 Option ST2B, like Option ST2A, begins at its southern extent at the end of the existing dual carriageway section of the A9 from Perth to the Pass of Birnam. At this location, the alignment is on a right-hand horizontal curve of radius 1,357 metres to tie-in with the existing carriageway. The vertical alignment is generally at-grade with widening on the northbound side. The current private access to Murthly Castle, located on the existing southbound carriageway is stopped-up and a new underbridge is constructed, which provides a new access to Murthly Castle from the B867, to the west.

5.3.18 Beyond the right-hand horizontal curve, the alignment transitions to a straight and is slightly off-line to the west, to improve the alignment by removing reverse curves on approach to Birnam Junction, the first grade separated junction of the scheme. As a result of the side long ground, falling towards the River Tay to the east, cutting slopes are introduced on the northbound carriageway. Birnam Junction is located at the site of the existing left/right staggered priority junction with the B867 and Perth Road at Birnam. The proposed junction is a grade separated layout, incorporating loops with merge and diverge tapers in the northbound direction and a merge slip road in the southbound direction. The junction does not include a southbound diverge slip road. The B867 and Perth Road are connected and realigned, crossing the A9 on an underbridge structure.

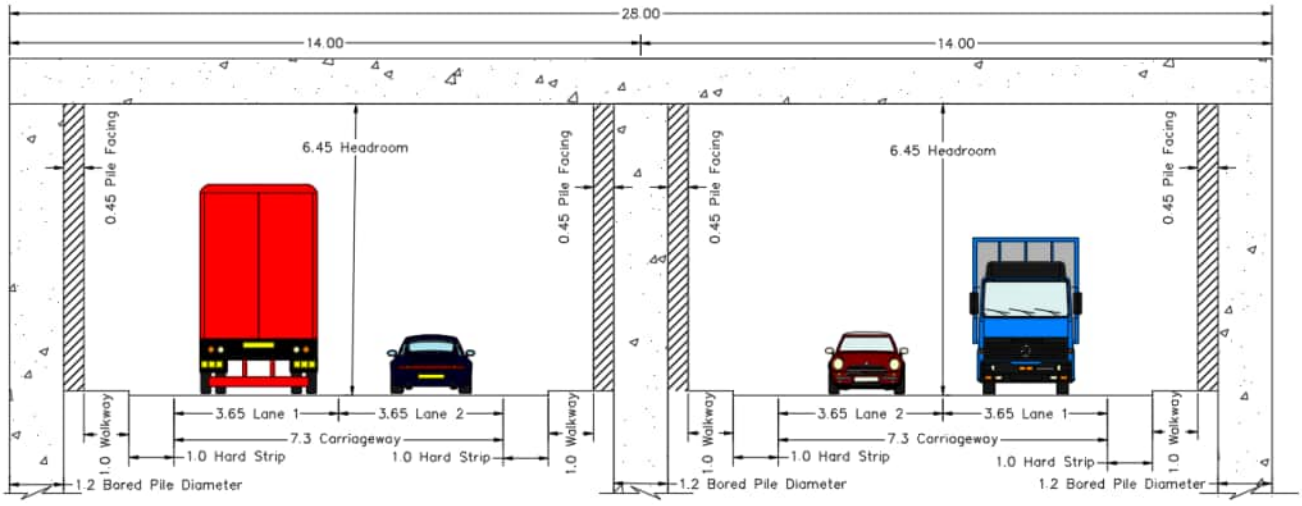
Option ST2B (Ch. 2,500 to Ch. 5,000)

5.3.19 North of Birnam Junction, Option ST2B travels through a left-hand horizontal curve of radius 720 metres, which is one step below Desirable Minimum for a 120kph Design Speed. At this point the alignment is constrained by the Highland Main Line railway to the immediate west and Birnam

Industrial Estate and residential properties to the immediate east, which restricts the size of horizontal curve, and curve widening for appropriate forward visibility, that can be employed. Vertically, the A9 alignment begins to fall as it navigates right-hand horizontal curves of radii 2,500 metres and 5,800 metres. Widening through this section is to the west, impacting the station car park and encroaching closer to the station building, which is Category A Listed. The A9 at the station is approximately 8 metres below existing ground level and a 150 metres long underpass structure is proposed over the A9, at existing ground level. To support the structure and avoid encroachment towards the Highland Main Line railway and Category A Listed station building to the west and residential and commercial properties to the east, large diameter bored piled walls will be required in both verges and the central reserve of the A9, resulting in a slightly wider cross-section than an open road.

5.3.20 The proposed cross-section for the underpass is shown in Figure 5.3.

Figure 5.3: Proposed Underpass Cross-Section



5.3.21 This arrangement allows Station Road to be extended across the underpass structure, providing direct access from the communities of Birnam and Dunkeld to the station. A replacement car park with vehicle turning provision is provided on top of the structure. The existing railway sidings, located at Dunkeld & Birnam Station will be impacted, with no opportunity for reinstatement.

5.3.22 As the A9 is lowered in the vicinity of the station, Birnam Glen will be stopped-up at the location of the current A9 underbridge, immediately north of Dunkeld & Birnam Station. Access to properties on Birnam Glen to the west of the station will therefore be provided via a new access road from the A822 (Old Military Road) that will be to the west of the Highland Main Line railway. The access road will traverse a new underbridge structure across Inchewan Burn. Inchewan Burn itself will be lowered by approximately 6 metres as a result of the A9 underpass, crossing the A9 via a new vertical drop structure and culvert that will pass beneath the proposed A9 dual carriageway.

5.3.23 To the north of the Inchewan Burn crossing, the horizontal alignment transitions to a straight on approach to Dunkeld Junction, which is in the vicinity of the existing right/left staggered priority junction with the A923 and A822 (Old Military Road) at Little Dunkeld (Ch. 4,000). In this locality the alignment continues to be constrained by the Highland Main Line railway and residential properties, which are generally on higher ground than the existing A9 carriageway. Beyond the underpass structure, the vertical alignment returns to existing ground levels to tie-in to Dunkeld Junction.

5.3.24 Dunkeld Junction is an at-grade elongated roundabout that provides connections to the A9 (north and south), A923, A822 (Old Military Road) and the unclassified road to Inver. A segregated left lane is included between the A923 and A9 south to improve the overall capacity of the roundabout and to reduce queuing traffic.

5.3.25 To the north of the roundabout, Option ST2B is on a left-hand horizontal curve of radius 2,040 metres. It crosses the River Braan on a new wider structure, to accommodate the dual carriageway, and is approximately 3 metres higher than existing ground levels to ensure the A9 is not impacted by anticipated future flood levels.

Option ST2B (Ch. 5,000 to Ch. 8,400 (End))

5.3.26 Between Ch. 5,000 and Ch. 8,400 (end), Option ST2B is the same as Option ST2A.

Option ST2C (Ch. 0 to Ch. 2,500)

5.3.27 Between Ch. 0 and Ch. 2,500, Option ST2C is the same as Option ST2B.

Option ST2C (Ch. 2,500 to Ch. 5,000)

5.3.28 North of Birnam Junction, Option ST2C follows the same horizontal alignment as Option ST2B. However, the proposed A9 dual carriageway is generally at-grade in the locality of Dunkeld & Birnam Station. Immediately north of the station, the A9 crosses Birnam Glen and Inchewan Burn via an underbridge as it transitions into a right-hand horizontal curve of radius 5,800 metres and begins to rise from existing ground levels to negotiate the proposed Dunkeld Junction, which is grade separated. The south facing slip roads of Dunkeld Junction begin immediately north of the Dunkeld & Birnam Station. The existing railway sidings, located at Dunkeld & Birnam Station will be impacted, and as the A9 is at-grade, there will be no opportunity to reinstate them in this location.

5.3.29 The existing access to properties on Birnam Glen to the west of Dunkeld & Birnam Station will remain as existing and the Inchewan Burn will not be directly impacted. A left-in left-out junction is proposed at the station to provide maintenance access to the station building. No public vehicular access to the building will be available.

5.3.30 Option ST2C incorporates a replacement car parking facility within the extent of Birnam Industrial Estate on Station Road to replace the facility that is lost at Dunkeld & Birnam Station as a result of the proposed dual carriageway. A pedestrian underpass structure below the A9, connecting the car park to the station is included, as well as lifts and/or ramps and stairs to provide access to platform level.

5.3.31 The alignment continues to be constrained to the immediate north of Dunkeld & Birnam Station by the Highland Main Line railway, parallel to the west, and residential properties of Stell Park Road, Telford Gardens and King Duncan's Place to the east. The existing A9 is in cutting through this section, with the proposed A9 elevated to a similar level to that of the adjacent railway and properties. Despite being elevated, the proposed A9 remains in cutting, with small sections of low height retaining walls necessary alongside residential properties to prevent encroachment.

5.3.32 Dunkeld Junction is located at the site of the existing right/left staggered priority junction with the A923 and A822 (Old Military Road) and incorporates an underbridge structure. The grade separated diamond layout incorporates northbound and southbound merge and diverge slip roads, facilitating all vehicle movements. A link to the unclassified road to Inver is also included. The A923 and A822 (Old Military Road) are connected, passing beneath the raised A9.

5.3.33 At the location of the underbridge, the A9 dual carriageway is approximately 10 metres above existing ground levels. The A9 remains above existing ground levels as it crosses the River Braan. The River Braan underbridge also carries the north facing slip roads associated with Dunkeld Junction, resulting in an imposing, prominent structure. Immediately south of the underbridge structure, on the southbound side, a further retaining wall, approximately 14 metres high, is required to avoid encroachment towards Dunkeld & Birnam Recreation Club.

5.3.34 The A9 returns to existing ground levels north of the River Braan on approach to Inver.

Option ST2C (Ch. 5,000 to Ch. 8,400 (End))

5.3.35 Between Ch. 5,000 and Ch. 8,400 (end), Option ST2C is the same as Options ST2A and ST2B.

Option ST2D (Ch. 0 to Ch. 2,500)

5.3.36 Between Ch. 0 and Ch. 2,500, Option ST2D is the same as Options ST2B and ST2C.

Option ST2D (Ch. 2,500 to Ch. 5,000)

5.3.37 North of Birnam Junction, Option ST2D follows the same horizontal alignment as Options ST2B and ST2C. Option ST2D is generally at-grade in the locality of Dunkeld & Birnam Station and remains at-grade to tie-in to Dunkeld Junction. As a result, the existing access to properties on Birnam Glen to the west of Dunkeld & Birnam Station is retained and there is no direct impact on Inchewan Burn. Widening through this section is also to the west, impacting the station car park and encroaching closer to the station building, which is Category A Listed. The existing railway sidings, located at the station, will be impacted and there will be no opportunity to reinstate them in this location.

5.3.38 Option ST2D, like Option ST2C, incorporates a replacement car parking facility within the extent of Birnam Industrial Estate on Station Road to replace the facility that is lost at Dunkeld & Birnam Station as a result of the proposed dual carriageway. A pedestrian underpass structure below the A9, connecting the car park to the station is included, as well as lifts and/or ramps and stairs to provide access to platform level.

5.3.39 Dunkeld Junction, in the locality of the existing right/left staggered priority junction with the A923 and A822 (Old Military Road), is an at-grade elongated roundabout that provides connections to the A9 (north and south), A923, A822 (Old Military Road) and the unclassified road to Inver. A segregated left lane is included between the A923 and A9 south to improve the overall capacity of the roundabout and to reduce queuing traffic.

5.3.40 To the north of the roundabout, Option ST2D is on a left-hand horizontal curve of radius 2,040 metres. It crosses the River Braan on a new wider structure, to accommodate the dual carriageway, and is approximately 3 metres higher than existing ground levels to ensure the A9 is not impacted by anticipated future flood levels.

Option ST2D (Ch. 5,000 to Ch. 8,400 (End))

5.3.41 Between Ch. 5,000 and Ch. 8,400 (end), Option ST2D is the same as Options ST2A, ST2B and ST2C.

Carriageway Widening

5.3.42 To ensure the necessary SSD is achieved, the central reserve and verge have been widened where necessary to accommodate sight lines. Tables 5.2 and 5.3 detail the central reserve and verge widening employed for each option.

Table 5.2: Central Reserve Widening

Route Option	Start Chainage	End Chainage	Maximum Widening (m)
ST2B	2,410	3,550	4.8
ST2C and ST2D	2,410	3,370	4.8
ST2C	3,700	5,000	3.6
ST2A, ST2B and ST2D	4,200	5,030	4.9
ST2A, ST2B, ST2C and ST2D	5,550	7,080	4.7

Table 5.3: Verge Widening

Route Option	Start Chainage	End Chainage	Maximum Widening (m)	Direction
ST2B, ST2C and ST2D	2,500	2,900	1.5	Northbound
ST2C	3,800	4,400	2.5	Northbound
ST2C	4,640	4,920	1.0	Northbound
St2A, ST2B, ST2C and ST2D	5,660	6,960	3.1	Southbound

5.4 Engineering Description of Junction Options

5.4.1 Junction layout designs have been prepared for the junction locations proposed at Murthly/Birnam, Dunkeld, The Hermitage and Dalguise. The junction layouts have been completed in accordance with the following design standards.

- Grade Separated Junctions - DMRB (CD122: Geometric design of grade separated junctions)
- At-grade Roundabout - DMRB (CD116: Geometric design of roundabouts)
- Left-in Left-out Junctions - DMRB (CD123: Geometric design of at-grade priority and signal-controlled junctions)

5.4.2 The junction layout designs for the Preferred Route Option will be developed further during the DMRB Stage 3 assessment.

Murthly/Birnam Junction

Murthly Junction (Option ST2A)

5.4.3 The proposed Murthly Junction for Option ST2A is in the locality of the existing private access to Murthly Castle, approximately 1.3 kilometres south of the existing left/right staggered priority junction with the B867 and Perth Road at Birnam. The junction is a diamond layout, with slip roads, incorporating merge and diverge taper arrangements, in both directions, facilitating all vehicle movements. An overbridge is provided across the A9, connecting to the B867 to the west via a priority junction. The overbridge also provides access into Murthly Estate on the east.

5.4.4 Due to space constraints, the northbound slip roads and the southbound slip roads form priority junctions with no stagger distance. While crossroads are considered suitable at simple junctions where traffic flows are low, staggered junctions are considered safer. In accordance with the DMRB (CD123: Geometric design of at-grade priority and signal-controlled junctions), priority junctions with no central treatment should have a minimum stagger distance of 50 metres.

5.4.5 As the ground to the east falls towards the River Tay, the southbound slip roads are on embankment, up to a maximum of 20 metres high in places.

Birnam Junction (Options ST2B, ST2C and ST2D)

5.4.6 The proposed Birnam Junction, for Options ST2B, ST2C and ST2D, is in the locality of the existing left/right staggered priority junction with the B867 and Perth Road. It is a grade separated junction incorporating a loop in the northbound direction and a southbound merge slip road. The junction does not include a southbound diverge slip road. The junction connects the B867 and Perth Road, crossing below the A9 on an underbridge structure. To avoid encroachment towards the Highland Main Line railway, reinforced earthworks slopes are included at the realigned B867/Perth Road to the immediate west of the A9.

5.4.7 The northbound loop has a radius of 50 metres and is a basic merge plus hook diverge layout. Merge and diverge tapers are included to provide safe access and egress from the A9 dual carriageway. A southbound slip road, incorporating a merge taper arrangement is included in the junction. The slip road connects to the realigned B867/Perth Road via priority junctions, in accordance with the DMRB (CD123: Geometric design of at-grade priority and signal-controlled junctions).

5.4.8 The northbound loop occupies a low-lying area of ground to the immediate west of the A9, therefore the alignment is on embankment. Verge widening is necessary to provide the required SSD through the loop. The southbound merge slip road is in cutting immediately south of the priority junction with the B867/Perth Road, up to a maximum 10 metres deep, before transitioning to embankment, up to 10 metres high, largely due to the existing topography.

Dunkeld Junction

5.4.9 The proposed Dunkeld Junction for Options ST2A, ST2B, ST2C and ST2D is in the locality of the existing right/left staggered priority junction with the A923 and A822 (Old Military Road).

Dunkeld Junctions (Option ST2A, ST2B and ST2D)

5.4.10 Options ST2A, ST2B and ST2D include an at-grade roundabout, in accordance with the DMRB (CD116: Geometric design of roundabouts). The roundabout has five-arms, connecting to the A9 (north and south), A923, A822 (Old Military Road) and the unclassified road to Inver and is largely at existing carriageway levels. To maximise capacity and reduce queues on approach, a segregated left turning lane is included between the A923 and A9 south.

5.4.11 The roundabout has a maximum Inscribed Circle Diameter (ICD) of approximately 90 metres, which is largely dictated by the number of arms and to maintain safety standards on entry to, and exit from, the roundabout. The realignment of the A822 (Old Military Road) and the A923 has been limited to avoid impacting the adjacent existing railway structure and junction with Perth Road. As such, horizontal and vertical curves below Desirable Minimum standards have been utilised.

5.4.12 The unclassified road to Inver is immediately adjacent to the Highland Main Line railway and reinforced earthworks slopes will be necessary to avoid encroachment.

Dunkeld Junction (Option ST2C)

5.4.13 The junction is a grade separated junction and is a variation of a diamond layout, which connects the A822 (Old Military Road) and the A923, crossing below the A9 on an underbridge structure. To limit the impact on surrounding infrastructure the realignment of the side road is restricted to the section between the existing railway underbridge on the A822 (Old Military Road) to the west, which has sub-standard headroom clearance for the road (approximately 4.73 metres), and the existing junction with Perth Road on the A923. The side road is therefore realigned over a length of only 275 metres. As the existing ground falls towards the River Tay, the realigned side road has a maximum gradient of 6%. This is above the desirable value (2%) quoted in the DMRB (CD123: Geometric design of at-grade priority and signal-controlled junctions) for siting priority junctions.

5.4.14 Slip roads, incorporating merge and diverge taper arrangements, are included in both directions. The northbound diverge slip road, southbound diverge slip road and southbound merge slip road all link to the realigned A923/A822 (Old Military Road) via priority junctions. The northbound merge slip road links to the road to Inver, which is realigned to meet the A923/A822 (Old Military Road) at a priority junction. The road to Inver is parallel and adjacent to the Highland Main Line railway and earthworks will be regraded between the road and railway, with some engineered solutions (retaining wall or reinforced earthwork slopes) necessary in the most constrained locations to avoid impacting the railway. Ghost islands will be considered to provide right turning vehicles with a degree of shelter from the through flow to improve safety. The priority junctions for the southbound diverge slip road and the

southbound merge slip road, which are located on the east of the A9, and the road to Inver and the northbound diverge slip road, which are on the west side, are approximately 30 metres apart. In accordance with the DMRB (CD123: Geometric design of at-grade priority and signal-controlled junctions), priority junctions with no central treatment should have a minimum stagger distance of 50 metres.

5.4.15 The A9 dual carriageway and the slip roads associated with the junction occupy a narrow corridor between the Highland Main Line railway and residential properties. Removing an earthwork bund between the road and railway allows a variable earthworks slope to be formed between the road and railway, avoiding the need for retaining walls on the northbound diverge slip road. 1 in 2 earthworks slopes can also be achieved between the road and adjacent property boundaries for the majority of the southbound merge slip road, however three short lengths of retaining wall up to 2 metres high are required to avoid encroachment towards adjacent properties to the east. A retaining wall structure of 14 metres is also necessary on the southbound diverge slip road to avoid impact on Dunkeld & Birnam Recreation Club. A mixture of natural slopes and reinforced earthwork slopes will be incorporated between the A9 and associated slip roads.

5.4.16 The northbound diverge slip road is only 300 metres long and does not provide Desirable Minimum SSD, which constitutes a Departure from requirements (see Chapter 5.8). Lengthening the slip road to provide the necessary SSD would impact the Highland Main Line railway, Category A Listed station building and involve further widening of the Birnam Glen and Inchewan Burn Underbridge.

The Hermitage Junction

5.4.17 A left-in left out junction is provided on the northbound carriageway to provide access to The Hermitage. This junction is identical for Options ST2A, ST2B, ST2C and ST2D. The Hermitage is an NTS site that attracts approximately 200,000 visitors each year (pre-COVID figures).

5.4.18 The junction is provided in the same location as the current access to the site. A 110 metre long nearside auxiliary lane is provided for diverging traffic and a nearside merging taper 130 metres long is provided for merging traffic.

Dalguise Junction

5.4.19 The proposed Dalguise Junction, for Options ST2A, ST2B, ST2C and ST2D, is located immediately south of the existing priority junction with the B898 and is identical in all options. It is a grade separated junction incorporating a loop in the northbound direction and slip roads in the southbound direction. A roundabout, with an ICD of 40 metres is included on the east of the A9, between the dual carriageway and the Highland Main Line railway. The B898, which currently forms an existing priority junction with the A9, is realigned, crossing below the A9 on a skewed underbridge structure to connect to the roundabout. The realigned B898 largely follows existing contours within the undulating landscape to the west of the A9, however earthwork cutting slopes of up to 17 metres high are included.

5.4.20 The northbound loop has a 50 metre radius and is a basic merge plus hook diverge layout. Merge and diverge tapers are included to provide safe access to, and egress from, the A9 dual carriageway. Both loops link to the realigned B898 via a priority junction. A ghost island will be considered to provide right turning vehicles with a degree of shelter from the through flow to improve safety.

5.4.21 The northbound loop is positioned on an existing plateau to limit associated earthworks in an area of steep topography. As a result, the loop has an earthwork cutting slope of approximately 7 metres. However, the northbound diverge taper generates a significant earthwork cutting slope up to 25 metres high, within land owned by Forestry and Land Scotland. Verge widening is necessary on the northbound loop to accommodate appropriate SSD on approach to the junction with the B898.

5.4.22 The southbound diverge slip road and the southbound merge slip road incorporate a taper merge and diverge and link to the roundabout on the east of the A9. The southbound diverge slip road begins on the widened Inch Rail Underbridge.

5.5 Dunkeld & Birnam Station Options

Options ST2A and ST2B

5.5.1 Options ST2A and ST2B lower the A9 dual carriageway in the vicinity of Dunkeld & Birnam Station, with widening applied to the west impacting the station car park and encroaching closer to the Category A Listed station building. The options propose a structure over the A9 at existing ground level to link Station Road with the railway station. This allows direct access to the station and provides a car parking facility on top of the structure. The car park would contain approximately fifty spaces with four accessible parking spaces. A vehicle pick-up/drop-off point and potential provision for a bus stop would be included to integrate public transport into the design and enhance local transport links.

5.5.2 No works would be undertaken to the station itself, including the Category A Listed station building. Access for maintenance, emergencies and to the signal box would be via Station Road. No works are proposed to the existing station infrastructure, including platforms, station building, pedestrian overbridge and track. However, direct vehicular and pedestrian connection provides opportunities for the sustainable re-use of the station building. There is also potential for providing Equality Act 2010 compliant access between station platforms, which will be investigated as part of the DMRB Stage 3 assessment, in conjunction with Network Rail and Transport Scotland.

Options ST2C and ST2D

5.5.3 Options ST2C and ST2D are at-grade in the locality of Dunkeld & Birnam Station, with widening applied to the west impacting the station car park and encroaching closer to the Category A Listed station building. With the station maintained in its current position, Options ST2C and ST2D propose to acquire Birnam Industrial Estate, utilising the area to provide a new station car parking facility. The car park would have provision for approximately fifty spaces, with a further four accessible parking spaces, a vehicle pick-up/drop-off point and potential provision for a bus stop. The new car park would be accessed from Station Road.

5.5.4 A new pedestrian underpass structure is proposed, constructed below the A9 dual carriageway, linking the new car park with Platform 1 (southbound) of the station. The underpass structure will incorporate lifts and stairs to facilitate WCH access from the underpass level to the station. No works are proposed to the existing station infrastructure, including platforms, station building, pedestrian overbridge and track. However, there is potential for the underpass structure to be extended to Platform 2 (northbound), providing Equality Act 2010 compliant access between station platforms. This will be investigated as part of the DMRB Stage 3 assessment, in conjunction with Network Rail and Transport Scotland.

5.5.5 There will be no public vehicular access direct to the station platforms and Category A Listed station building. A left-in left-out junction is proposed immediately south of the existing station junction. This access would be for Network Rail personnel and emergency services only, with a gate likely erected to prevent unauthorised entry. Planting may be considered at future stages of design development to make the access inconspicuous to road users. This junction would also provide access to the signal box, however access to the signal box, by foot, would also be available via the new pedestrian underpass.

5.6 Walkers, Cyclists and Horse-riders

5.6.1 There are a number of significant WCH routes within the Pass of Birnam to Tay Crossing section, comprising Core Paths, Rights of Way, National Cycle Network (NCN) Routes and Regional Cycle Network (RCN) Routes. The A9 dual carriageway and associated junctions impact the routes at various

locations and suitable mitigation to maintain connectivity has been considered. The majority of impacts are common to all route options with variable impacts in the locality of Dunkeld & Birnam Station. There are also variable impacts at Dunkeld Junction, primarily due to the different junction layouts considered.

5.6.2 The existing NCN Route 77 follows the route of the B867, which is generally parallel to the A9 on the west, at the southern extent of the scheme. In the vicinity of the existing left/right staggered priority junction with the B867 and Perth Road, NCN Route 77 transfers to a segregated section, occupying an area of land between the Highland Main Line railway and the A9. At Dunkeld & Birnam Station, NCN Route 77 joins Birnam Glen, negotiating the existing steps from the station, crosses beneath the A9 on an existing underbridge and connects to Perth Road. It should be noted that this route is also a Core Path (DUNK/142). Between Birnam Junction and Dunkeld & Birnam Station, carriageway widening for all options is applied adjacent to the northbound carriageway to avoid residential properties to the east, impacting the NCN and Core Path.

5.6.3 To maintain connectivity, it is proposed to divert NCN Route 77 and Core Path (DUNK/142) onto the realigned B867/Perth Road that forms part of the Birnam Junction for Options ST2B, ST2C and ST2D, crossing the A9 via the junction underbridge. For Option ST2A, NCN Route 77 and Core Path (DUNK/142) would utilise the connection of the B867 and Perth Road at the southern portal of the cut and cover tunnel. The NCN Route and Core Path (DUNK/142) would then continue north along Perth Road, re-joining the existing route at the junction with Birnam Glen. To mitigate replacement of a segregated route with an unsegregated route, it may be necessary to undertake work on Perth Road, however this will be considered further as part of the DMRB Stage 3 assessment, in consultation with relevant stakeholders, including Perth & Kinross Council (PKC). Core Path (DUNK/57), which is also a Right of Way, crosses the A9 at-grade to the immediate north of the existing Birnam Junction. This route would also be realigned onto the realigned B867/Perth Road for all options.

5.6.4 For Option ST2A there is an opportunity that NCN Route 77 and Core Path (DUNK/142) could be placed on top of the cut and cover tunnel on a segregated route, therefore following a similar route to the existing WCH routes. The WCH routes would then utilise Station Road to re-join the existing route on Perth Road. Core Path (DUNK/57) could also be placed on top of the cut and cover tunnel for Option ST2A.

5.6.5 All options retain the station in its current location. However, Options ST2A and ST2B incorporate a lowered A9 dual carriageway that facilitates a direct connection from Station Road to the railway station. This new connection will improve access for all WCH users. However, these options will not address the existing accessibility issues associated with the low platform heights at the station or access between platforms. As a result of the lowered A9 dual carriageway for Options ST2A and ST2B, Core Path (DUNK/11) and the Right of Way on Birnam Glen would be diverted along Station Road, via the top of the cut and cover tunnel or underpass.

5.6.6 Options ST2C and ST2D provide access to Dunkeld & Birnam Station via a pedestrian underpass structure beneath the A9, with a new car parking area in the locality of the existing Birnam Industrial Estate. The pedestrian underpass will link to Platform 1 (southbound) and will incorporate a lift and stairwell, allowing improved access for WCHs. This option will not address the current accessibility issues associated with the low platform heights at the station or access between platforms. However, given a new underpass structure is being provided to Platform 1 (southbound), there is potential that this may be extended to improve access to Platform 2 (northbound). This will be investigated further as part of the DMRB Stage 3 assessment, in consultation with relevant stakeholders. Core Path (DUNK/11) and the Right of Way on Birnam Glen would not be impacted by Options ST2C and ST2D.

5.6.7 All options impact Core Paths in the locality of the River Braan crossing due to carriageway widening, which will require a degree of realignment to maintain connectivity. The impact on these Core Paths (DUNK/10, DUNK/59 and DUNK/137) is heightened by Option ST2C as it includes a wider crossing, due to the slip roads associated with the grade separated junction at Dunkeld and is elevated above

existing carriageway levels. An existing footbridge, which forms part of Core Path (DUNK/23), crosses the River Braan immediately adjacent to the west of the existing road crossing. This structure will be impacted by all options. While the exact position of the replacement crossing will be finalised as part of the DMRB Stage 3 assessment, in consultation with relevant stakeholders, it is likely to be as close to its existing position as possible to maintain its connectivity with adjacent WCH routes.

5.6.8 The existing Core Path (DUNK/23) travels along the banks of the River Tay, crosses beneath the A9 at the River Tay structure and connects to the B898. There is an opportunity to provide an additional connection to Core Path (DUNK/23) across the A9 through utilising an existing railway underpass and the proposed underbridge for Dalguise Junction, linking to the B898. While this route would be slightly more direct, it will also provide a suitable alternative during construction works for the River Tay crossing. This will be considered further as part of the DMRB Stage 3 assessment.

5.6.9 All other WCH routes will be maintained. Where necessary, local diversions may be required as a result of the works and, where appropriate, routes will be made more attractive and comfortable to use. Temporary closures and diversions may be required during construction.

5.6.10 Table 5.4 identifies the WCH routes relevant to the A9 Pass of Birnam to Tay Crossing project and provides details of possible impacts and mitigation. The table should be read in conjunction with the drawings referenced in Table 5.1. To highlight any differentiators between route options, the following colour coding has been adopted for this table.

	All options affect WCH route to the same extent.
	A particular route option has a lesser engineering impact on an WCH route than a competing option.
	A particular route option has a greater engineering impact on an WCH route than a competing option.

Table 5.4: Impacted WCH Routes

WCH Reference	Existing WCH Location	Impact / Possible Mitigation Measures			
		Route Option ST2A	Route Option ST2B	Route Option ST2C	Route Option ST2D
NCN Routes					
NCN Route 77	NCN Route 77 is in close proximity to the northbound carriageway between the current left/right staggered priority junction with the B867 and Perth Road and Dunkeld & Birnam Station. It is segregated through this section, shared with Core Path (DUNK/142). Beyond the station, NCN Route 77 follows the route of Birnam Glen and joins Perth Road.	As a result of A9 widening, NCN Route 77 diverted on to Perth Road (unsegregated), re-joining the existing route at the junction of Perth Road and Birnam Glen. Access to Dunkeld & Birnam Station maintained via Station Road, accessed from Perth Road. (Note: Opportunity to re-route NCN Route 77 on top of the cut and cover tunnel once construction is complete.)	As a result of A9 widening, NCN Route 77 diverted on to Perth Road (unsegregated), re-joining the existing route at the junction of Perth Road and Birnam Glen. Access to Dunkeld & Birnam Station maintained via Station Road, accessed from Perth Road.	As a result of A9 widening, NCN Route 77 diverted on to Perth Road (unsegregated), re-joining the existing route at the junction of Perth Road and Birnam Glen. Access to Dunkeld & Birnam Station maintained via Station Road, accessed from Perth Road.	As a result of A9 widening, NCN Route 77 diverted on to Perth Road (unsegregated), re-joining the existing route at the junction of Perth Road and Birnam Glen. Access to Dunkeld & Birnam Station maintained via Station Road, accessed from Perth Road.
PKC Core Paths					
DUNK/142	Core Path (DUNK/142) is in close proximity to the northbound carriageway between the current left/right staggered priority junction with the B867 and Perth Road and Dunkeld & Birnam Station. It is a segregated path, shared with NCN Route 77.	As a result of A9 widening, Core Path (DUNK/142) is diverted on to Perth Road. Access to Dunkeld & Birnam Station is maintained via Station Road. (Note: Opportunity to re-route Core Path (DUNK/142) on top of the cut and cover tunnel once construction is complete.)	As a result of A9 widening, Core Path (DUNK/142) is diverted on to Perth Road. Access to Dunkeld & Birnam Station is maintained via Station Road.	As a result of A9 widening, Core Path (DUNK/142) is diverted on to Perth Road. Access to Dunkeld & Birnam Station is maintained via Station Road.	As a result of A9 widening, Core Path (DUNK/142) is diverted on to Perth Road. Access to Dunkeld & Birnam Station is maintained via Station Road.
DUNK/10 (Right of Way (TP102))	Core Path (DUNK/10) and Right of Way (TP102) provides a circular loop between Birnam and Little Dunkeld, running in close proximity to the River Tay. The route also links to Core Path (DUNK/23), providing a connection to the north of the River Braan.	No anticipated permanent impact.	No anticipated permanent impact.	Potential minor permanent realignment on section of the route due to layout of southbound diverge slip road that forms part of Dunkeld Junction.	No anticipated permanent impact.

WCH Reference	Existing WCH Location	Impact / Possible Mitigation Measures			
		Route Option ST2A	Route Option ST2B	Route Option ST2C	Route Option ST2D
DUNK/11 (Right of Way (TP106))	Core Path (DUNK/11) and Right of Way (TP106) link the communities of Birnam and Dunkeld with paths to the west of the A9. The routes also facilitate access to local properties.	Section of route closed due to Birnam Glen being stopped-up. Core Path (DUNK/11) and Right of Way (TP106) diverted via the new connection between Dunkeld & Birnam Station and Station Road on top of the cut and cover tunnel.	Section of route closed due to Birnam Glen being stopped-up. Core Path (DUNK/11) and Right of Way (TP106) diverted via the new connection between Dunkeld & Birnam Station and Station Road on top of the underpass structure.	No anticipated permanent impact. Potential requirement for temporary diversion through the construction phase.	No anticipated permanent impact. Potential requirement for temporary diversion through the construction phase.
DUNK/15 (Right of Way (TP94))	Core Path (DUNK/15) and Right of Way (TP94) provides a circular route around The Hermitage.	No anticipated permanent impact. Potential requirement for temporary diversion through the construction phase.	No anticipated permanent impact. Potential requirement for temporary diversion through the construction phase.	No anticipated permanent impact. Potential requirement for temporary diversion through the construction phase.	No anticipated permanent impact. Potential requirement for temporary diversion through the construction phase.
DUNK/137	Core Path (DUNK/137) is used to link Inver with the routes connecting to communities of Birnam and Dunkeld and DUNK/23, which follows the bank of the River Tay.	Potential minor amendments of the route due to the realignment of Core Path (DUNK/23) below the A9.	Potential minor amendments of the route due to the realignment of Core Path (DUNK/23) below the A9.	Amendments to the route due to the realignment of Core Path (DUNK/23) below the A9 and location of the proposed northbound merge slip road that forms part of Dunkeld Junction.	Potential minor amendments of the route due to the realignment of Core Path (DUNK/23) below the A9.
DUNK/23	Core Path (DUNK/23) is used to provide a circular route around Dunkeld and Birnam.	Replacement crossing of the River Braan required. Section of route realigned due to A9 widening. Potential minor realignment in the vicinity of Inver due to earthwork encroachment. Opportunity to provide a new connection to the B898 by utilising an existing structure on the Highland Main Line railway and the new structure proposed for Dalguise Junction, subject to further design and assessment.	Replacement crossing of the River Braan required. Section of route realigned due to A9 widening. Potential minor realignment in the vicinity of Inver due to earthwork encroachment. Opportunity to provide a new connection to the B898 by utilising an existing structure on the Highland Main Line railway and the new structure proposed for Dalguise Junction, subject to further design and assessment.	Replacement crossing of the River Braan required. Section of route realigned due to A9 widening. Potential minor realignment in the vicinity of Inver due to earthwork encroachment. Opportunity to provide a new connection to the B898 by utilising an existing structure on the Highland Main Line railway and the new structure proposed for Dalguise Junction, subject to further design and assessment.	Replacement crossing of the River Braan required. Section of route realigned due to A9 widening. Potential minor realignment in the vicinity of Inver due to earthwork encroachment. Opportunity to provide a new connection to the B898 by utilising an existing structure on the Highland Main Line railway and the new structure proposed for Dalguise Junction, subject to further design and assessment.

WCH Reference	Existing WCH Location	Impact / Possible Mitigation Measures			
		Route Option ST2A	Route Option ST2B	Route Option ST2C	Route Option ST2D
DUNK/57 (Right of Way (TP102))	Core Path (DUNK/57) and Right of Way (TP102) crosses the A9 to the immediate north of the existing Birnam Junction, connecting routes to the west of the A9 with WCH routes alongside the River Tay.	Section of route closed due to A9 widening. Core Path (DUNK/57) and Right of Way (TP102) diverted onto the realigned B867/Perth Road to re-join the existing route. (Note: Opportunity to re-route on top of cut and cover tunnel once construction is complete.)	Section of route closed due to A9 widening. Core Path (DUNK/57) and Right of Way (TP102) diverted onto the realigned B867/Perth Road to re-join the existing route.	Section of route closed due to A9 widening. Core Path (DUNK/57) and Right of Way (TP102) diverted onto the realigned B867/Perth Road to re-join the existing route.	Section of route closed due to A9 widening. Core Path (DUNK/57) and Right of Way (TP102) diverted onto the realigned B867/Perth Road to re-join the existing route.
DUNK/59 (Right of Way (32))	Core Path (DUNK/59) and Right of Way (32) is used to provide a connection between Core Paths (DUNK/10, DUNK/23 and DUNK/144), which connects to Dunkeld.	Potential temporary diversion required during the construction of the dualling works. No anticipated permanent impact.	Potential temporary diversion required during the construction of the dualling works. No anticipated permanent impact.	Section of route permanently re-aligned due to location of southbound diverge slip road at Dunkeld.	Potential temporary diversion required during the construction of the dualling works. No anticipated permanent impact.
DUNK/64	Core Path DUNK/64) is used to provide a connection between Inver and The Hermitage.	Potential requirement for temporary diversion through the construction phase. No anticipated permanent impact.	Potential requirement for temporary diversion through the construction phase. No anticipated permanent impact.	Potential requirement for temporary diversion through the construction phase. No anticipated permanent impact.	Potential requirement for temporary diversion through the construction phase. No anticipated permanent impact.
DUNK/100	Core Path (DUNK/100) is currently located on the existing River Tay structure.	No anticipated permanent impact. Temporary diversion may be required during construction. New route to be segregated from live traffic on A9 carriageway, subject to further design and assessment.	No anticipated permanent impact. Temporary diversion may be required during construction. New route to be segregated from live traffic on A9 carriageway, subject to further design and assessment.	No anticipated permanent impact. Temporary diversion may be required during construction. New route to be segregated from live traffic on A9 carriageway, subject to further design and assessment.	No anticipated permanent impact. Temporary diversion may be required during construction. New route to be segregated from live traffic on A9 carriageway, subject to further design and assessment.
DUNK/144	Core Path (DUNK/144) provides a connection between Core Paths (DUNK/59 and DUNK/10), whilst also providing a route into Dunkeld.	No anticipated permanent impact. Temporary diversion may be required during construction.	No anticipated permanent impact. Temporary diversion may be required during construction.	No anticipated permanent impact. Temporary diversion may be required during construction.	No anticipated permanent impact. Temporary diversion may be required during construction.
DUNK/145	Core Path (DUNK/145) provides a connection between either side of the A9, north of the River Tay crossing.	Potential impact during the construction of the dualling works. No anticipated permanent impact.	Potential impact during the construction of the dualling works. No anticipated permanent impact.	Potential impact during the construction of the dualling works. No anticipated permanent impact.	Potential impact during the construction of the dualling works. No anticipated permanent impact.

5.7 Lay-bys and Rest Areas

General

5.7.1 There are currently six parking lay-bys on the A9 within the Pass of Birnam to Tay Crossing section of A9 dualling, three in the northbound direction and three in the southbound direction. In addition, there are two further parking lay-bys (Lay-by 13 and Lay-by 14) on the existing dual carriageway section to the immediate south of the scheme extents. These lay-bys are located less than 1 kilometre from the southern tie-in and are Type B, in accordance with the DMRB (CD169: The design of lay-bys, maintenance hardstandings, rest areas, service areas and observation platforms).

5.7.2 The DMRB (CD169: The design of lay-bys, maintenance hardstandings, rest areas, service areas and observation platforms) details the considerations to be taken into account when siting a lay-by. This includes the minimum weaving distance between a lay-by and a junction (1 kilometre on rural roads), the minimum horizontal radius where a lay-by may be sited on a curve (2,040 metres at 120kph) and the recommended frequency that lay-bys should be provided (2.5 kilometres for a dual carriageway). Tables 5.5 to 5.8 detail the weaving distance between proposed junctions for each design option.

Table 5.5: Weaving Distance of Option ST2A Junctions

Option ST2A Junctions	Weaving Distance Between Junctions (metres)
Northbound Carriageway	
Lay-by 13 (existing dualled section) to Murthly Junction Diverge Taper	540
Murthly Junction Merge Taper to Dunkeld Roundabout Entry	2,730
Dunkeld Roundabout Exit to The Hermitage Junction Diverge Taper	935
The Hermitage Junction Merge Taper to Dalguise Junction Diverge Taper	990
Southbound Carriageway	
Dalguise Junction Merge Taper to Dunkeld Roundabout Entry	2,040
Dunkeld Roundabout Exit to Murthly Junction Diverge Taper	2,730
Murthly Junction Merge Taper to Lay-by 14 (existing dualled section)	530

Table 5.6: Weaving Distance of Option ST2B Junctions

Options ST2B Junctions	Weaving Distance Between Junctions (metres)
Northbound Carriageway	
Lay-by 13 (existing dualled section) to Birnam Junction Diverge Taper	1,720
Birnam Junction Merge Taper to Dunkeld Roundabout Entry	1,730
Dunkeld Roundabout Exit to The Hermitage Junction Diverge Taper	940
The Hermitage Junction Merge Taper to Dalguise Junction Diverge Taper	990
Southbound Carriageway	
Dalguise Junction Merge Taper to Dunkeld Roundabout Entry	2,040
Dunkeld Roundabout Exit to	2,182

Options ST2B Junctions	Weaving Distance Between Junctions (metres)
Birnam Junction Merge Taper	
Birnam Junction Merge Taper to Lay-by 14 (existing dualled section)	1,920

Table 5.7: Weaving Distance of Option ST2C Junctions

Option ST2C Junctions	Weaving Distance Between Junctions (metres)
Northbound Carriageway	
Lay-by 13 (existing dualled section) to Birnam Junction Diverge Taper	1,720
Birnam Junction Merge Taper to Dunkeld & Birnam Station Access Diverge Taper	620
Dunkeld & Birnam Station Access Merge Taper to Dunkeld Junction Diverge Taper	370
Dunkeld Junction Merge Taper to The Hermitage Junction Diverge Taper	410
The Hermitage Junction Merge Taper to Dalguise Junction Diverge Taper	990
Southbound Carriageway	
Dalguise Junction Merge Taper to Dunkeld Junction Diverge Taper	1,370
Dunkeld Junction Merge Taper to Birnam Junction Merge Taper	1,515
Birnam Junction Merge Taper to Lay-by 14 (existing dualled section)	1,920

Table 5.8: Weaving Distance of Option ST2D Junctions

Options ST2D Junctions	Weaving Distance Between Junctions (metres)
Northbound Carriageway	
Lay-by 13 (existing dualled section) to Birnam Junction Diverge Taper	1,720
Birnam Junction Merge Taper to Dunkeld & Birnam Station Access Diverge Taper	620
Dunkeld & Birnam Station Access Merge Taper to Dunkeld Roundabout Entry	970
Dunkeld Roundabout Exit to The Hermitage Junction Diverge Taper	940
The Hermitage Junction Merge Taper to Dalguise Junction Diverge Taper	990
Southbound Carriageway	
Dalguise Junction Merge Taper to Dunkeld Roundabout Entry	2,040
Dunkeld Roundabout Exit to Birnam Junction Merge Taper	2,182
Birnam Junction Merge Taper to Lay-by 14 (existing dualled section)	1,920

5.7.3 As detailed in Tables 5.5 to 5.8, the weaving distances in all options are insufficient to accommodate the provision of new lay-bys between junctions in accordance with DMRB (CD169: The design of lay-bys, maintenance hardstandings, rest areas, service areas and observation platforms). It should be noted that while the weaving distances between Murthly Junction and Dunkeld Junction in Option

ST2A appear sufficient, there is insufficient weaving distance between the proposed Murthly Junction and the southern cut and cover tunnel portal on both the northbound and southbound carriageways.

Lay-by Strategy

5.7.4 A lay-by strategy was developed as part of the Preliminary Engineering Services (PES) commission, which was the equivalent to a DMRB Stage 1 assessment. The strategy aimed to ensure a consistent approach to lay-by design and location along the A9 corridor for parking lay-bys. The strategy stated that lay-bys should be Type A with merge taper layout, in accordance with the DMRB (CD169: The design of lay-bys, maintenance hardstandings, rest areas, service areas and observation platforms). The strategy also stated that in considering lay-bys the following should be considered:

- Determine if an existing lay-by will remain, be removed or be modified;
- Combine lay-bys where feasible if there are no unacceptable impacts;
- Identify proposed locations, considering user demand and viewpoints; and
- Assess lay-by locations against broad ranging design and environmental criteria.

5.7.5 It is noted that this section of A9 dual carriageway occupies a narrow corridor, with environmental and physical constraints immediately adjacent, which restricts where a lay-by may be positioned. In addition, provision of parking lay-bys within the scheme would result in Departures from requirements, due to insufficient weaving distance and failure to satisfy other geometric parameters. Furthermore, a key aim of parking lay-bys is to provide drivers with a place to stop for a short time. The junctions proposed within the scheme, however, provide access to Birnam, Dunkeld and the surrounding area where drivers have an opportunity to stop and access local services. As a result, it is not proposed to provide any parking lay-bys within this section of A9 dualling.

5.7.6 As part of the DMRB Stage 3 assessment, consideration will be given to upgrading the existing lay-bys to the immediate south of the scheme (Lay-by 13 and Lay-by 14), within the existing dualled section, to Type A standard. It is noted that there would be a Departure from requirements for weaving distance for Option ST2A, between the existing lay-bys and the proposed junction at Murthly, should these lay-bys be upgraded.

Enhanced Lay-Bys

5.7.7 The Strategic Environmental Assessment (SEA) identified a number of locations for enhanced lay-bys within this section of A9 dualling, which are summarised below.

- Birnam, northbound carriageway, close to the existing private access to Murthly Castle. Provides footpath links to local landmarks;
- Birnam, southbound carriageway, close to the existing private access to Murthly Castle. Provides a picnic area to the rear and footpath links to existing paths around the River Tay;
- The Hermitage, northbound carriageway. Provides a non-standard layout with picnic area and viewpoint across the River Tay. Proposed toilet block and information point;
- River Tay, northbound carriageway, immediately north of the River Tay crossing. Provides footpath links to join existing tracks and a viewpoint across the River Tay; and
- River Tay, southbound carriageway, immediately north of the River Tay crossing. Provides footpath links to join existing tracks.

5.7.8 Option ST2A includes a junction south of the existing Birnam Junction in the locality of the existing private access to Murthly Castle. As such, for Option ST2A the enhanced lay-bys noted above at Birnam cannot be provided. There is also insufficient weaving distance between the proposed Murthly Junction and the southern cut and cover tunnel portal on both the northbound and southbound carriageways to provide an enhanced lay-by north of the junction.

5.7.9 As outlined in Tables 5.6 to 5.8 for Options ST2B, ST2C and ST2D, there are weaving distances of less than 2 kilometres between the existing lay-bys to the south of this section of A9 dualling and the proposed grade separated junction at Birnam. The enhanced lay-bys at Birnam are proposed within this distance, therefore the appropriate weaving distances either side of the lay-by would not be achieved. The proposed enhanced lay-bys would also be sited on the outside of a right-hand curve and the inside of a left-hand curve with a horizontal radius less than that stipulated in the DMRB (CD169: The design of lay-bys, maintenance hardstandings, rest areas, service areas and observation platforms), which would require a Departure from Standards. To accommodate the appropriate SSD on approach to the enhanced lay-bys central reserve and verge widening would also be required, increasing the overall land-take of the scheme within the River Tay (Dunkeld) National Scenic Area (NSA) and Murthly Castle Gardens and Designed Landscape (GDL).

5.7.10 A left-in left-out junction is proposed at The Hermitage, providing road users the opportunity to stop and access the NTS site. The initial design for the enhanced lay-by incorporates infrastructure works to provide a merge taper with a lay-by on the taper. Provision of such a link is complex given the topography of the area, which will have environmental impacts within a protected area. Incorporating an enhanced lay-by in this location on the junction merge taper is also a safety issue. The proposals for the enhanced lay-by include provision of toilet facilities, which would need to be agreed with the NTS who own the site and have expressed concerns, given the maintenance required.

5.7.11 The proposed enhanced lay-bys north of the River Tay crossing are on a horizontal curve less than that stipulated in the DMRB (CD169: The design of lay-bys, maintenance hardstandings, rest areas, service areas and observation platforms) for safe siting of a lay-by. The proposed vehicle parapet of the River Tay structure, which is in close proximity, will also restrict SSD on approach to the northbound enhanced lay-by and for egress from the southbound enhanced lay-by, which is a safety issue. Furthermore, the A9 is constrained in this area with the River Tay (designated as a Special Area of Conservation (SAC)) and its associated floodplain to the west and steep topography to the east. Provision of the lay-bys in such a location will therefore involve engineering works that may have an adverse effect on some environmental factors.

5.8 Relaxations and Departures from Requirements

General

5.8.1 To reduce impacts on the adjacent environment and other physical constraints, most notably the Highland Main Line railway and residential and commercial properties, and to lessen construction complexity and associated costs, geometry less than the Desirable Minimum values, as stipulated in the DMRB, have been utilised.

5.8.2 Reductions in design standards are assessed as either being Departures from requirements, Relaxations or Deviations from recommendations, as detailed in the DMRB (GG101: Introduction to the Design Manual for Roads and Bridges) and summarised below.

- Departures from requirements - Where the requirements set out in the DMRB are not met, a departure application shall be submitted before the design is finalised. Departures should be submitted where it can be justified, it would not have unintended adverse consequences, innovative methods or materials are proposed, or a requirement not detailed in the DMRB is proposed.

  All Departures must be approved by the Overseeing Organisation prior to being incorporated into the works.

- Relaxations - Relaxations shall be applied where they are permitted within the appropriate section of the DMRB, with suitable justification for its inclusion recorded.

- Deviations from recommendations - A Deviation is where recommendations contained within the DMRB are not followed. Suitable justification for the use of Deviations should be documented and include a comparison of costs and time of the proposed solution, compared to the approach recommended in the DMRB.

  A safety risk assessment should be undertaken where a Deviation is proposed.

5.8.3 Where Departures from requirements, Relaxations and Deviations from recommendations are applied, careful consideration must be given to the safety implications and any requirements for mitigation measures, such as additional signage or road markings, to reduce or eliminate potential hazards.

5.8.4 As part of the DMRB Stage 2 assessment, only Departures from requirements and Relaxations have been considered. Deviations from recommendations will be fully considered as part of the DMRB Stage 3 assessment for the Preferred Route Option. It is noted that the most evident Deviation from recommendations within the DMRB Stage 2 assessment is the inclusion of an at-grade roundabout at Dunkeld Junction for Options ST2A, ST2B and ST2D.

A9 Dual Carriageway, Option ST2A, Relaxations and Departures from Requirements

5.8.5 Option ST2A incorporates seven Relaxations and seven Departures from requirements, as detailed in Table 5.9 and 5.10.

Table 5.9: A9 Dual Carriageway, Option ST2A, Relaxations

Reference	Location & Chainage	Relaxation Type	DMRB Reference	Required Standard	Standard Provided
RLXA01	Ch. 5,750 to 6,880, Northbound & Southbound Carriageway	Horizontal Alignment	CD109: Highway link design, Table 2.10, Clause 4.5	R = 1,020 metres	R = 726 metres (1 step below)
RLXA02	Ch. 4,160 to 4,210, Northbound Carriageway, Lane 1	SSD	CD109: Highway link design, Table 2.10, Clause 3.5	SSD = 295 metres	SSD (Lane 1) = 281 metres (1 step below)
RLXA03	Ch. 5,470 to 5,750, Northbound Carriageway, Lanes 1 & 2	SSD	CD109: Highway link design, Table 2.10, Clause 3.5	SSD = 295 metres	SSD (Lane 1) = 265 metres (1 step below) SSD (Lane 2) = 220 metres (1 step below)
RLXA04	Ch. 5,750 to 6,860, Northbound Carriageway, Lanes 1 & 2	Combination: Horizontal Alignment & SSD	CD109: Highway link design, Table 2.10, Clause 2.12	R = 1,020 metres SSD = 295 metres	R = 726 metres (1 step below) SSD (Lane 1) = 265 metres (1 step below) SSD (Lane 2) = 220 metres (1 step below)
RLXA05	Ch. 7,620 to 8,120, Northbound Carriageway, Lane 1	SSD	CD109: Highway link design, Table 2.10, Clause 3.5	SSD = 295 metres	SSD (Lane 1) = 236 meters (1 step below)

Reference	Location & Chainage	Relaxation Type	DMRB Reference	Required Standard	Standard Provided
RLXA06	Ch. 5,770 to 6,880, Southbound Carriageway, Lanes 1 & 2	Combination: Horizontal Alignment & SSD	CD109: Highway link design, Table 2.10, Clause 2.12	R = 1,020 metres SSD = 295 metres	R = 726 metres (1 step below) SSD (Lane 1) = 219 metres (1 step below) SSD (Lane 2) = 268 metres (1 step below)
RLXA07	Ch. 7,920 to 8,350 (end), Southbound Carriageway, Lane 2	SSD	CD109: Highway link design, Table 2.10, Clause 3.5	SSD = 295 metres	SSD (Lane 2) = 197 metres (2 steps below)

Table 5.10: A9 Dual Carriageway, Option ST2A, Departures from Requirements

Reference	Location & Chainage	Departure Type	DMRB Reference	Required Standard	Standard Provided
DEPA01	Ch. 2,150 to 3,730, Cut and Cover Tunnel	Carriageway Cross-section	CD127: Cross-sections and headrooms, Figure 2.1.1N1e, Clause 3.1	1.0 metre hardstrip width	0.7 metre hardstrip width
DEPA02	Ch. 5450 to 6,440, Northbound Carriageway	Weaving Length (The Hermitage to Dalguise Junction)	CD122: Geometric design of grade separated junctions, Clause 4.1	1 kilometre	0.99 kilometres
DEPA03	Ch. 5,990 to 6,860, Northbound Carriageway, Lanes 1 & 2	SSD (On approach to and through Dalguise Junction)	CD109: Highway link design, Table 2.10, Clause 2.13	SSD = 295 metres	SSD (Lane 1) = 265 metres (1 step below) SSD (Lane 2) = 220 metres (1 step below)
DEPA04	Ch. 6,210 to 7,180, Southbound Carriageway, Lanes 1 & 2	SSD (On approach to and through Dalguise Junction)	CD109: Highway link design, Table 2.10, Clause 2.13	SSD = 295 metres	SSD (Lane 1) = 218 metres (1 step below) SSD (Lane 2) = 267 metres (1 step below)
DEPA05	Ch. 7,870 to 7,910, Southbound Carriageway, Lane 2	SSD (On approach to and through Dalguise Junction)	CD109: Highway link design, Table 2.10, Clause 2.13	SSD = 295 metres	SSD (Lane 2) = 243 metres (1 step below)
DEPA06	Ch. 0 to 360, Northbound Carriageway	Weaving Length (Existing Lay-by 13 to Murthly Junction)	CD122: Geometric design of grade separated junctions, Clause 4.1	1 kilometre	0.54 kilometres
DEPA07	Ch. 0 to 310, Southbound Carriageway	Weaving Length (Murthly Junction to Existing Lay-by 14)	CD122: Geometric design of grade separated junctions, Clause 4.1	1 kilometre	0.53 kilometres

5.8.6 There are seven Departures from requirements incorporated within the A9 dual carriageway for Option ST2A. DEPA01 relates to the carriageway cross-section proposed through the cut and cover tunnel.

The cut and cover tunnel is within a narrow corridor, particularly in the locality of Dunkeld & Birnam Station, with the Highland Main Line railway and Category A Listed station building to the west and residential and commercial properties to the east. The tunnel cross-section is wider than an open road, primarily due to the width of the bored piles (1.2 metre diameter) that are required to form the tunnel walls, and the requirement for an emergency pedestrian escape tunnel (1.8 metres wide). To limit further encroachment towards these constraints and to restrict the size of the tunnel, which would lead to significant increases in cost, a reduced hardstrip width of 0.7 metres has been proposed. It should be noted that the use of a hardstrip less than 1 metre wide is more applicable to an urban situation.

5.8.7 DEPA02 is for a reduced weaving length on the northbound carriageway between the left-in left-out junction proposed at The Hermitage and the grade separated junction at Dalguise. The junctions have been sited to avoid excessive impact on adjacent constraints, which include steep topography, habitat identified on the Ancient Woodland Inventory and the River Braan. A further three Departures from requirements (DEPA03, DEPA04 and DEPA05) have been incorporated for SSD on approach to Dalguise Junction. At this location, the A9 dual carriageway is on a 726 metre horizontal radius, with central reserve and verge widening applied. Provision of SSD of 295 metres would involve further widening, of approximately 6 metres, increasing land-take and impacting adjacent physical and environmental constraints, including the Highland Main Line railway, steep topography and Ancient Woodland sites.

5.8.8 DEPA06 and DEPA07 are for a reduced weaving length between the proposed Murthly Junction and existing lay-bys to the south of the scheme extents. Works to the existing lay-bys may be undertaken in the future, which could include closure. However, this will be considered further as part of the DMRB Stage 3 assessment.

5.8.9 It should be noted that, due to forward visibility constraints within the 1.5 kilometre cut and cover tunnel, Option ST2A has been designed for an 85kph Design Speed (50mph) between its southern extent and the proposed Dunkeld Junction. As a result of the reduced Design Speed, and therefore reduced geometric standards, the number of Relaxations and Departures is less than other options through this section.

5.8.10 For safety reasons, pedestrians, cyclists, motorbikes (with engines less than 50cc), animals and animal drawn vehicles are not permitted to use the cut and cover tunnel.

A9 Dual Carriageway, Option ST2B, Relaxations and Departures from Requirements

5.8.11 Option ST2B incorporates 15 Relaxations and six Departures from requirements, as detailed in Table 5.11 and 5.12.

Table 5.11: A9 Dual Carriageway, Option ST2B, Relaxations

Reference	Location & Chainage	Relaxation Type	DMRB Reference	Required Standard	Standard Provided
RLXB01	Ch. 5,750 to 6,880, Northbound & Southbound Carriageway	Horizontal Alignment	CD109: Highway link design, Table 2.10, Clause 4.5	R = 1,020 metres	R = 726 metres (1 step below)
RLXB02	Ch. 4,160 to 4,210, Northbound Carriageway, Lane 1	SSD	CD109: Highway link design, Table 2.10, Clause 3.5	SSD = 295 metres	SSD (Lane 1) = 281 metres (1 step below)

Reference	Location & Chainage	Relaxation Type	DMRB Reference	Required Standard	Standard Provided
RLXB03	Ch. 5,470 to 5,750, Northbound Carriageway, Lanes 1 & 2	SSD	CD109: Highway link design, Table 2.10 Clause 3.5	SSD = 295 metres	SSD (Lane 1) = 265 metres (1 step below) SSD (Lane 2) = 220 metres (1 step below)
RLXB04	Ch. 5,750 to 6,860, Northbound Carriageway, Lanes 1 & 2	Combination: Horizontal Alignment & SSD	CD109: Highway link design, Table 2.10, Clause 2.12	R = 1,020 metres SSD = 295 metres	R = 726 metres (1 step below) SSD (Lane 1) = 265 metres (1 step below) SSD (Lane 2) = 220 metres (1 step below)
RLXB05	Ch. 7,620 to 8,120, Northbound Carriageway, Lane 1	SSD	CD109: Highway link design, Table 2.10, Clause 3.5	SSD = 295 metres	SSD (Lane 1) = 236 metres (1 step below)
RLXB06	Ch. 5,770 to 6,880, Southbound Carriageway, Lanes 1 & 2	Combination: Horizontal Alignment & SSD	CD109: Highway link design, Table 2.10, Clause 2.12	R = 1,020 metres SSD = 295 metres	R = 726 metres (1 step below) SSD (Lane 1) = 219 metres (1 step below) SSD (Lane 2) = 268 metres (1 step below)
RLXB07	Ch. 7,920 to 8,350 (end), Southbound Carriageway, Lane 2	SSD	CD109: Highway link design, Table 2.10 Clause 3.5	SSD = 295 metres	SSD (Lane 2) = 197 metres (2 steps below)
RLXB08	Ch. 2,610 to 2,780, Northbound & Southbound Carriageway	Horizontal Alignment	CD109: Highway link design, Table 2.10 Clause 4.5	R = 1,020 metres	R = 720 metres (1 step below)
RLXB09	Ch. 0 to 830, Northbound Carriageway, Lane 2	SSD	CD109: Highway link design, Table 2.10, Clause 3.5	SSD = 295 metres	SSD (Lane 2) = 217 metres (1 step below)
RLXB10	Ch. 2,310 to 2,610, Northbound Carriageway, Lanes 1 & 2	SSD	CD109: Highway link design, Table 2.10, Clause 3.5	SSD = 295 metres	SSD (Lane 1) = 221 metres (1 step below) SSD (Lane 2) = 260 metres (1 step below)
RLXB11	Ch. 2,610 to 2,780, Northbound Carriageway, Lanes 1 & 2	Combination: Horizontal Alignment & SSD	CD109: Highway link design, Table 2.10, Clause 2.12	R = 1,020 metres SSD = 295 metres	R = 720 metres (1 step below) SSD (Lane 1) = 221 metres (1 step below) SSD (Lane 2) = 268 metres (1 step below)

Reference	Location & Chainage	Relaxation Type	DMRB Reference	Required Standard	Standard Provided
RLXB12	Ch. 2,780 to 2,870, Northbound Carriageway, Lanes 1 & 2	SSD	CD109: Highway link design, Table 2.10, Clause 3.5	SSD = 295 metres	SSD (Lane 1) = 242 metres (1 step below) SSD (Lane 2) = 260 metres (1 step below)
RLXB13	Ch. 250 to 1,090, Southbound Carriageway, Lane 1	SSD	CD109: Highway link design, Table 2.10, Clause 3.5	SSD = 295 metres	SSD (Lane 1) = 240 metres (1 step below)
RLXB14	Ch. 2,620 to 2,780, Southbound Carriageway, Lanes 1 & 2	Combination: Horizontal Alignment & SSD	CD109: Highway link design, Table 2.10, Clause 2.12	R = 1,020 metres SSD = 295 metres	R = 720 metres (1 step below) SSD (Lane 1) = 272 metres (1 step below) SSD (Lane 2) = 221 metres (1 step below)
RLXB15	Ch. 2,780 to 3,030, Southbound Carriageway, Lanes 1 & 2	SSD	CD109: Highway link design, Table 2.10, Clause 3.5	SSD = 295 metres	SSD (Lane 1) = 272 metres (1 step below) SSD (Lane 2) = 229 metres (1 step below)

Table 5.12: A9 Dual Carriageway, Option ST2B, Departures from Requirements

Reference	Location & Chainage	Departure Type	DMRB Reference	Required Standard	Standard Provided
DEPB01	Ch. 3,270 to 3,420, Underpass	Carriageway Cross-section	CD127: Cross sections and headrooms, Figure 2.1.1N1e, Clause 3.1	2.5 metre verge width	1.0 metre verge width
DEPB02	Ch. 5,450 to 6,440, Northbound Carriageway	Weaving Length (The Hermitage to Dalguise Junction)	CD122: Geometric design of grade separated junctions, Clause 4.1	1 kilometre	0.99 kilometres
DEPB03	Ch. 2,260 to 2,300, Northbound Carriageway, Lanes 1 & 2	SSD (On approach to and through Birnam Junction)	CD109: Highway link design, Table 2.10, Clause 2.13	SSD = 295 metres	SSD (Lane 1) = 268 metres (1 step below) SSD (Lane 2) = 279 metres (1 step below)
DEPB04	Ch. 5,990 to 6,860, Northbound Carriageway, Lanes 1 & 2	SSD (On approach to and through Dalguise Junction)	CD109: Highway link design, Table 2.10, Clause 2.13	SSD = 295 metres	SSD (Lane 1) = 265 metres (1 step below) SSD (Lane 2) = 220 metres (1 step below)
DEPB05	Ch. 6,210 to 7,180, Southbound Carriageway, Lanes 1 & 2	SSD (On approach to and through Dalguise Junction)	CD109: Highway link design, Table 2.10, Clause 2.13	SSD = 295 metres	SSD (Lane 1) = 218 metres (1 step below) SSD (Lane 2) = 267 metres

Reference	Location & Chainage	Departure Type	DMRB Reference	Required Standard	Standard Provided
					(1 step below)
DEPB06	Ch. 7,870 to 7,910, Southbound Carriageway, Lane 2	SSD (On approach to and through Dalguise Junction)	CD109: Highway link design, Table 2.10, Clause 2.13	SSD = 295 metres	SSD (Lane 2) = 243 metres (1 step below)

5.8.12 There are six Departures from requirements within the A9 dual carriageway for Option ST2B. DEPB01 relates to the carriageway cross-section proposed through the underpass at Dunkeld & Birnam Station. The underpass is located within a narrow corridor, with the Highland Main Line railway and Category A Listed station building to the west, and residential and commercial properties and Birnam Industrial Estate to the east. To form the underpass walls, 1.2 metre diameter bored piled walls are required, which results in a wider carriageway cross-section. To limit encroachment towards the station and the industrial estate, which potentially would involve acquisition of commercial properties within the industrial estate, a reduced verge width has been proposed through the structure. This Departure from requirements is only applicable over the length of the underpass structure.

5.8.13 DEPB02 is for a reduced weaving length between the left-in left-out junction proposed at The Hermitage and the grade separated junction at Dalguise. This Departure from requirements is the same as that applied to Option ST2A. DEPB04, DEPB05 and DEPB06 are also the same as DEPA03, DEPA04 and DEPA05 applied to Option ST2A and relate to the SSD on approach to and through Dalguise Junction.

5.8.14 DEPB03 is a Departure from requirements for SSD through Birnam Junction. The SSD in this locality is dictated by the vertical alignment and the change in superelevation. Changes to the vertical alignment may alter the associated earthworks, which would impact the adjacent Highland Main Line railway. Further investigation will be undertaken as part of the DMRB Stage 3 assessment to determine if this Departure from requirements could be removed.

A9 Dual Carriageway, Option ST2C, Relaxations and Departures from Requirements

5.8.15 Option ST2C incorporates 13 Relaxations and eight Departures from requirements, as detailed in Table 5.13 and 5.14.

Table 5.13: A9 Dual Carriageway, Option ST2C, Relaxations

Reference	Location & Chainage	Relaxation Type	DMRB Reference	Required Standard	Standard Provided
RLXC01	Ch. 2,610 to 2,780, Northbound & Southbound Carriageway	Horizontal Alignment	CD109: Highway link design, Table 2.10, Clause 4.5	R = 1,020 metres	R = 720 metres (1 step below)
RLXC02	Ch. 5,750 to 6,880, Northbound & Southbound Carriageway	Horizontal Alignment	CD109: Highway link design, Table 2.10, Clause 4.5	R = 1,020 metres	R = 726 metres (1 step below)
RLXC03	Ch. 0 to 830, Northbound Carriageway, Lane 2	SSD	CD109: Highway link design, Table 2.10, Clause 3.5	SSD = 295 metres	SSD (Lane 2) = 217 metres (1 step below)

Reference	Location & Chainage	Relaxation Type	DMRB Reference	Required Standard	Standard Provided
RLXC04	Ch. 2,310 to 2,610, Northbound Carriageway, Lanes 1 & 2	SSD	CD109: Highway link design, Table 2.10, Clause 3.5	SSD = 295 metres	SSD (Lane 1) = 221 metres (1 step below) SSD (Lane 2) = 260 metres (1 step below)
RLXC05	Ch. 2,610 to 2,780, Northbound Carriageway, Lanes 1 & 2	Combination: Horizontal Alignment & SSD	CD109: Highway link design, Table 2.10, Clause 2.12	R = 1,020 metres SSD = 295 metres	R = 720 metres (1 step below) SSD (Lane 1) = 221 metres (1 step below) SSD (Lane 2) = 268 metres (1 step below)
RLXC06	Ch. 5,470 to 5,750, Northbound Carriageway, Lanes 1 & 2	SSD	CD109: Highway link design, Table 2.10, Clause 3.5	SSD = 295 metres	SSD (Lane 1) = 265 metres (1 step below) SSD (Lane 2) = 220 metres (1 step below)
RLXC07	Ch. 5,750 to 6,860, Northbound Carriageway, Lanes 1 & 2	Combination: Horizontal Alignment & SSD	CD109: Highway link design, Table 2.10, Clause 2.12	R = 1,020 metres SSD = 295 metres	R = 726 metres (1 step below) SSD (Lane 1) = 265 metres (1 step below) SSD (Lane 2) = 220 metres (1 step below)
RLXC08	Ch. 7,620 to 8,120, Northbound Carriageway, Lane 1	SSD	CD109: Highway link design, Table 2.10, Clause 3.5	SSD = 295 metres	SSD (Lane 1) = 236 metres (1 step below)
RLXC09	Ch. 250 to 1,090, Southbound Carriageway, Lane 1	SSD	CD109: Highway link design, Table 2.10, Clause 3.5	SSD = 295 metres	SSD (Lane 1) = 240 metres (1 step below)
RLXC10	Ch. 2,620 to 2,780, Southbound Carriageway, Lanes 1 & 2	Combination: Horizontal Alignment & SSD	CD109: Highway link design, Table 2.10, Clause 2.12	R = 1,020 metres SSD = 295 metres	R = 720 metres (1 step below) SSD (Lane 1) = 272 metres (1 step below) SSD (Lane 2) = 221 metres (1 step below)
RLXC11	Ch. 2,780 to 3,030, Southbound Carriageway, Lanes 1 & 2	SSD	CD109: Highway link design, Table 2.10, Clause 3.5	SSD = 295 metres	SSD (Lane 1) = 272 metres (1 step below) SSD (Lane 2) = 229 metres (1 step below)

Reference	Location & Chainage	Relaxation Type	DMRB Reference	Required Standard	Standard Provided
RLXC12	Ch. 5,770 to 6,880, Southbound Carriageway, Lanes 1 & 2	Combination: Horizontal Alignment & SSD	CD109: Highway link design, Table 2.10, Clause 2.12	R = 1,020 metres SSD = 295 metres	R = 726 metres (1 step below) SSD (Lane 1) = 219 metres (1 step below) SSD (Lane 2) = 268 metres (1 step below)
RLXC13	Ch. 7,920 to 8,350 (end), Southbound Carriageway, Lane 2	SSD	CD109: Highway link design, Table 2.10, Clause 3.5	SSD = 295 metres	SSD (Lane 2) = 197 metres (2 steps below)

Table 5.14: A9 Dual Carriageway, Option ST2C, Departures from Requirements

Reference	Location & Chainage	Departure Type	DMRB Reference	Required Standard	Standard Provided
DEPC01	Ch. 2,260 to 2,300, Northbound Carriageway, Lanes 1 & 2	SSD (On approach to and through Birnam Junction)	CD109: Highway link design, Table 2.10, Clause 2.13	SSD = 295 metres	SSD (Lane 1) = 268 metres (1 step below) SSD (Lane 2) = 279 metres (1 step below)
DEPC02	Ch. 2,305 to 2,925, Northbound Carriageway	Weaving Length (Birnam Junction to Station Access)	CD122: Geometric design of grade separated junctions, Clause 4.1	1 kilometre	0.62 kilometres
DEPC03	Ch. 3,070 to 3,440, Northbound Carriageway	Weaving Length (Station Access to Dunkeld Junction)	CD122: Geometric design of grade separated junctions, Clause 4.1	1 kilometre	0.37 kilometres
DEPC04	Ch. 4,690 to 5,100, Northbound Carriageway	Weaving Length (Dunkeld Junction to The Hermitage)	CD122: Geometric design of grade separated junctions, Clause 4.1	1 kilometre	0.41 kilometres
DEPC05	Ch. 5,450 to 6,440, Northbound Carriageway	Weaving Length (The Hermitage to Dalguise Junction)	CD122: Geometric design of grade separated junctions, Clause 4.1	1 kilometre	0.99 kilometres
DEPC06	Ch. 5,990 to 6,860, Northbound Carriageway, Lanes 1 & 2	SSD (On approach to and through Dalguise Junction)	CD109: Highway link design, Table 2.10, Clause 2.13	SSD = 295 metres	SSD (Lane 1) = 265 metres (1 step below) SSD (Lane 2) = 220 metres (1 step below)
DEPC07	Ch. 6,210 to 7,180, Southbound Carriageway, Lanes 1 & 2	SSD (On approach to and through Dalguise Junction)	CD109: Highway link design, Table 2.10, Clause 2.13	SSD = 295 metres	SSD (Lane 1) = 218 metres (1 step below) SSD (Lane 2) = 267 metres (1 step below)

Reference	Location & Chainage	Departure Type	DMRB Reference	Required Standard	Standard Provided
DEPC08	Ch. 7,870 to 7,910, Southbound Carriageway, Lane 2	SSD (On approach to and through Dalguise Junction)	CD109: Highway link design, Table 2.10, Clause 2.13	SSD = 295 metres	SSD (Lane 2) = 243 metres (1 step below)

5.8.16 DEPC01, DEPC05, DEPC06, DEPC07 and DEPC08 for Option ST2C are the same as DEPB03, DEPB02, DEPB04, DEPB05 and DEPB06 for Option ST2B. Option ST2C includes a further three Departures from requirements that are in relation to weaving length between junctions. DEPC02 relates to weaving length on the northbound carriageway between the proposed Birnam Junction and the left-in left-out junction proposed for maintenance access to Dunkeld & Birnam Station. DEPC03 relates to weaving length on the northbound carriageway between the proposed left-in left-out maintenance access at the station and Dunkeld Junction. It is noted that the left-in left-out junction is for maintenance and emergency access only and therefore anticipated usage will be low. DEPC04 is for weaving length between Dunkeld Junction and The Hermitage.

A9 Dual Carriageway, Option ST2D, Relaxations and Departures from Requirements

5.8.17 Option ST2D incorporates 14 Relaxations and six Departures from requirements, as detailed in Table 5.15 and 5.16.

Table 5.15: A9 Dual Carriageway, Option ST2D, Relaxations

Reference	Location & Chainage	Relaxation Type	DMRB Reference	Required Standard	Standard Provided
RLXD01	Ch. 2,610 to 2,780, Northbound & Southbound Carriageway	Horizontal Alignment	CD109: Highway link design, Table 2.10, Clause 4.5	R = 1,020 metres	R = 720 metres (1 step below)
RLXD02	Ch. 5,750 to 6,880, Northbound & Southbound Carriageway	Horizontal Alignment	CD109: Highway link design, Table 2.10, Clause 4.5	R = 1,020 metres	R = 726 metres (1 step below)
RLXD03	Ch. 0 to 830, Northbound Carriageway, Lane 2	SSD	CD109: Highway link design, Table 2.10, Clause 3.5	SSD = 295 metres	SSD (Lane 2) = 217 metres (1 step below)
RLXD04	Ch. 2,310 to 2,610, Northbound Carriageway, Lanes 1 & 2	SSD	CD109: Highway link design, Table 2.10, Clause 3.5	SSD = 295 metres	SSD (Lane 1) = 221 metres (1 step below) SSD (Lane 2) = 260 metres (1 step below)
RLXD05	Ch. 2,610 to 2,780, Northbound Carriageway, Lanes 1 & 2	Combination: Horizontal Alignment & SSD	CD109: Highway link design, Table 2.10, Clause 2.12	R = 1,020 metres SSD = 295 metres	R = 720 metres (1 step below) SSD (Lane 1) = 221 metres (1 step below) SSD (Lane 2) = 268 metres (1 step below)
RLXD06	Ch. 4,160 to 4,210, Northbound Carriageway, Lane 1	SSD	CD109: Highway link design, Table 2.10, Clause 3.5	SSD = 295 metres	SSD (Lane 1) = 281 metre (1 step below)

Reference	Location & Chainage	Relaxation Type	DMRB Reference	Required Standard	Standard Provided
RLXD07	Ch. 5,470 to 5,750, Northbound Carriageway, Lanes 1 & 2	SSD	CD109: Highway link design, Table 2.10, Clause 3.5	SSD = 295 metres	SSD (Lane 1) = 265 metres (1 step below) SSD (Lane 2) = 220 metres (1 step below)
RLXD08	Ch. 5,750 to 6,860, Northbound Carriageway, Lanes 1 & 2	Combination: Horizontal Alignment & SSD	CD109: Highway link design, Table 2.10, Clause 2.12	R = 1,020 metres SSD = 295 metres	R = 726 metres (1 step below) SSD (Lane 1) = 265 metres (1 step below) SSD (Lane 2) = 220 metres (1 step below)
RLXD09	Ch. 7,620 to 8,120, Northbound Carriageway, Lane 1	SSD	CD109: Highway link design, Table 2.10, Clause 3.5	SSD = 295 metres	SSD (Lane 1) = 236 metres (1 step below)
RLXD10	Ch. 250 to 1,090, Southbound Carriageway, Lane 1	SSD	CD109: Highway link design, Table 2.10, Clause 3.5	SSD = 295 metres	SSD (Lane 1) = 240 metres (1 step below)
RLXD11	Ch. 2,620 to 2,780, Southbound Carriageway, Lanes 1 & 2	Combination: Horizontal Alignment & SSD	CD109: Highway link design, Table 2.10, Clause 2.12	R = 1,020 metres SSD = 295 metres	R = 720 metres (1 step below) SSD (Lane 1) = 272 metres (1 step below) SSD (Lane 2) = 221 metres (1 step below)
RLXD12	Ch. 2,780 to 3,030, Southbound Carriageway, Lanes 1 & 2	SSD	CD109: Highway link design, Table 2.10, Clause 3.5	SSD = 295 metres	SSD (Lane 1) = 272 metres (1 step below) SSD (Lane 2) = 229 metres (1 step below)
RLXD13	Ch. 5,770 to 6,880, Southbound Carriageway, Lanes 1 & 2	Combination: Horizontal Alignment & SSD	CD109: Highway link design, Table 2.10, Clause 2.12	R = 1,020 metres SSD = 295 metres	R = 726 metres (1 step below) SSD (Lane 1) = 219 metres (1 step below) SSD (Lane 2) = 268 metres (1 step below)
RLXD14	Ch. 7,920 to 8,350 (end), Southbound Carriageway, Lane 2	SSD	CD109: Highway link design, Table 2.10, Clause 3.5	SSD = 295 metres	SSD (Lane 2) = 197 metres (2 steps below)

Table 5.16: A9 Dual Carriageway, Option ST2D, Departures from Requirements

Reference	Location & Chainage	Departure Type	DMRB Reference	Required Standard	Standard Provided
DEPD01	Ch. 2,260 to 2,300, Northbound Carriageway, Lanes 1 & 2	SSD (On approach to and through Birnam Junction)	CD109: Highway link design, Table 2.10, Clause 2.13	SSD = 295 metres	SSD (Lane 1) = 284 metres (1 step below) SSD (Lane 2) = 290 metres (1 step below)
DEPD02	Ch. 2,305 to 2,925, Northbound Carriageway	Weaving Length (Birnam Junction to Station Access)	CD122: Geometric design of grade separated junctions, Clause 4.1	1 kilometre	0.62 kilometres
DEPD03	Ch. 5,450 to 6,440, Northbound Carriageway	Weaving Length (The Hermitage to Dalguise Junction)	CD122: Geometric design of grade separated junctions, Clause 4.1	1 kilometre	0.99 kilometres
DEPD04	Ch. 5,990 to 6,860, Northbound Carriageway, Lanes 1 & 2	SSD (On approach to and through Dalguise Junction)	CD109: Highway link design, Table 2.10, Clause 2.13	SSD = 295 metres	SSD (Lane 1) = 265 metres (1 step below) SSD (Lane 2) = 220 metres (1 step below)
DEPD05	Ch. 6,210 to 7,180, Southbound Carriageway, Lanes 1 & 2	SSD (On approach to and through Dalguise Junction)	CD109: Highway link design, Table 2.10, Clause 2.13	SSD = 295 metres	SSD (Lane 1) = 218 metres (1 step below) SSD (Lane 2) = 263 metres (1 step below)
DEPD06	Ch. 7,870 to 7,910, Southbound Carriageway, Lane 2	SSD (On approach to and through Dalguise Junction)	CD109: Highway link design, Table 2.10, Clause 2.13	SSD = 295 metres	SSD (Lane 2) = 243 metres (1 step below)

5.8.18 The Departures from requirements noted for Option ST2D are the same as that included for Option ST2C.

Junction Relaxations and Departures from Requirements

5.8.19 Relaxations and Departures from requirements for the junctions included within the route options are included in Tables 5.17 to 5.24. It should be noted that for the purposes of the DMRB Stage 2 assessment, suitable Design Speeds, which the Relaxations and Departures from requirements have been evaluated from, have been assumed. Further assessment will be undertaken on the Design Speed of side roads that form part of the junctions as part of the DMRB Stage 3 assessment.

Option ST2A

5.8.20 The junctions associated with Option ST2A incorporate six Relaxations and 23 Departures from requirements, as detailed in Table 5.17 and 5.18.

Table 5.17: A9 Junctions, Relaxations, Option ST2A

Reference	Location & Chainage	Relaxation Type	DMRB Reference	Required Standard	Standard Provided
Murthly Junction					
No Relaxations					
Dunkeld Junction					
RLXJA01	Unclassified Road to Inver, Ch. 11 to Ch. 131	Horizontal Alignment	CD109: Highway link design, Table 2.10, Clause 4.5	R = 255 metres	R = 205 metres (1 step below)
RLXJA02	Unclassified Road to Inver, Ch. 50 to Ch. 70, Eastbound	SSD	CD109: Highway link design, Table 2.10, Clause 3.5	SSD = 90 metres	SSD = 75 metres (1 step below)
RLXJA03	Unclassified Road to Inver, Ch. 169, Westbound	SSD	CD109: Highway link design, Table 2.10, Clause 3.5	SSD = 90 metres	SSD = 82 metres (1 step below)
RLXJA04	Realigned A822 (Old Military Road), Ch. 25 to Ch. 85	Horizontal Alignment	CD109: Highway link design, Table 2.10, Clause 4.5	R = 255 metres	R = 180 metres (1 step below)
RLXJA05	Realigned A923, Ch. 130 to Ch. 160	Vertical Alignment	CD109: Highway link design, Table 2.10, Clauses 5.6 to 5.8, Table 5.7	K = 17 (crest)	K = 10 (crest) (1 step below)
The Hermitage Junction					
No Relaxations					
Dalguise Junction					
RLXJA06	Realigned B898, Ch. 420 to Ch. 570	Horizontal Alignment	CD109: Highway link design, Table 2.10, Clause 4.5	R = 255 metres	R = 180 metres (1 step below)

Table 5.18: A9 Junctions, Departures from Requirements, Option ST2A

Reference	Location & Chainage	Departure Type	DMRB Reference	Required Standard	Standard Provided
Murthly Junction					
DEPJA01	Right/Left Staggered Priority Junction (between the southbound diverge and southbound merge slip roads adjacent to the junction overbridge)	Stagger Distance	CD123: Geometric design of at-grade priority and signal-controlled junctions, Clause 2.23	50 metres	4.5 metres
DEPJA02	Right/Left Staggered Priority Junction (between the northbound diverge and northbound	Stagger Distance	CD123: Geometric design of at-grade priority and signal-controlled junctions,	50 metres	5 metres

Reference	Location & Chainage	Departure Type	DMRB Reference	Required Standard	Standard Provided
	merge slip roads adjacent to the junction overbridge)		Clause 2.23		
Dunkeld Junction					
DEPJA03	Realigned A822 (Old Military Road), Ch. 0 to Ch. 25	Horizontal Alignment	CD109: Highway link design, Table 2.10, Clause 4.5	R = 255 metres	R = 45 metres (4 steps below)
DEPJA04	Realigned A822 (Old Military Road), Ch. 85 to Ch. 122	Horizontal Alignment	CD109: Highway link design: Table 2.10 Clause 4.5	R = 255 metres	R = 50 metres (4 steps below)
DEPJA05	Unclassified Road to Inver	Horizontal Alignment	CD109: Highway link design: Table 2.10 Clause 4.5	R = 255 metres	R = 45 metres (4 steps below)
DEPJA06	Realigned A822 (Old Military Road)	Entry Path Radius	CD116: Geometric design of roundabouts: Clause 3.26	R = 100 metres	R = 256 metres
DEPJA07	Realigned A923, Ch. 20	Transition Length	CD109: Highway link design, Clause 4.12, Table 2.10	TL = 30.2 metres	TL = 0 metres
DEPJA08	Realigned A923, Ch. 64	Transition Length	CD109: Highway link design, Clause 4.12 Table 2.10	TL = 30.2 metres	TL = 0 metres
DEPJA09	Realigned A822 (Old Military Road), Ch. 25	Transition Length	CD109: Highway link design, Clause 4.12, Table 2.10	TL = 10.0 metres	TL = 0 metres
DEPJA10	Realigned A822 (Old Military Road), Ch. 86	Transition Length	CD109: Highway link design, Clause 4.12, Table 2.10	TL = 77.4 metres	TL = 0 metres
DEPJA11	Unclassified Road to Inver, Ch. 12	Transition Length	CD109: Highway link design, Clause 4.12, Table 2.10	TL = 37.6 metres	TL = 0 metres
DEPJA12	Unclassified Road to Inver, Ch. 131	Transition Length	CD109: Highway link design, Clause 4.12, Table 2.10	TL = 4.7 metres	TL = 0 metres
DEPJA13	Unclassified Road to Inver, Ch. 151	Transition Length	CD109: Highway link design, Clause 4.12, Table 2.10	TL = 12.8 metres	TL = 0 metres
DEPJA14	Unclassified Road to Inver, Ch. 80 to Ch. 130, Eastbound	SSD (on approach to junction)	CD116: Geometric design of roundabouts, Clause 3.39 CD109: Highway link design,	SSD = 90 metres	SSD = 30 metres (3 steps below)

Reference	Location & Chainage	Departure Type	DMRB Reference	Required Standard	Standard Provided
			Table 2.10		
DEPJA15	Unclassified Road to Inver, Ch. 0 to Ch. 80, Westbound	SSD	CD109: Highway link design, Table 2.10, Clause 3.5	SSD = 90 metres	SSD = 30 metres (3 steps below)
DEPJA16	Realigned A822 (Old Military Road), Ch. 0 to Ch. 10, Eastbound	Combination: Horizontal Alignment & SSD	CD109: Highway link design, Table 2.10, Clause 2.12	R = 255 metres SSD = 90 metres	R = 45 metres (4 steps below) SSD = 52 metres (2 steps below)
DEPJA17	Realigned A822 (Old Military Road), Ch. 0 to Ch. 122, Westbound	Combination: Horizontal Alignment & SSD	CD109: Highway link design, Table 2.10, Clause 2.12	R = 255 metres SSD = 90 metres	R = 45 metres (4 steps below) SSD = 61 metres (2 steps below)
DEPJA18	Realigned A923, Ch. 0 to Ch. 60, Westbound	Combination: Horizontal Alignment, Vertical Alignment & SSD	CD109: Highway link design, Table 2.10, Clause 2.12	R = 255 metres K = 13 (sag) SSD = 90 metres	R = 38 metres (4 steps below) K = 9 (sag) (1 step below) SSD = 56 metres (2 steps below)
DEPJA19	Realigned A923, Ch. 40 to Ch. 120, Eastbound	Combination: Horizontal Alignment, Vertical Alignment & SSD	CD109: Highway link design, Table 2.10, Clause 2.12	R = 255 metres K = 13 (sag) SSD = 90 metres	R = 38 metres (4 steps below) K= 9 (sag) (1 step below) SSD = 52 metres (2 steps below)
The Hermitage Junction					
No Departures from requirements					
Dalguise Junction					
DEPJA20	Northbound Diverge Slip Road, Ch. 0 to Ch. 170	SSD (from back of nose)	CD122: Geometric design of grade separated junctions, Clause 3.33, Figure 3.33b	SSD = 295 metres	SSD = 123 metres (3 steps below)
DEPJA21	Northbound Diverge Slip Road, Ch. 0 to Ch. 70	Near Straight Horizontal Alignment	CD122: Geometric design of grade separated junctions, Clause: 5.8	R = 1,020 metres	R = 735 metres (1 step below)
DEPJA22	Southbound Merge Slip Road, Ch. 0 to Ch. 85	Near Straight Horizontal Alignment	CD122: Geometric design of grade separated junctions, Clause: 5.8	R = 1,020 metres	R = 650 metres (2 steps below)
DEPJA23	Southbound Merge Slip Road	SSD	CD109: Highway link design, Table 2.10 CD122: Geometric design of grade	SSD = 295 metres	SSD = 161 metres (2 steps below)

Reference	Location & Chainage	Departure Type	DMRB Reference	Required Standard	Standard Provided
			separated junctions, Clause: 3.24		

Table Notes:

1) The transition length (TL) for each horizontal curve has been calculated in accordance with CD109: Highway link design, Clauses 4.15, 4.15.1 and 4.15.2.

Option ST2B

5.8.21 The junctions associated with Option ST2B incorporate six Relaxations and 22 Departures from requirements, as detailed in Table 5.19 and 5.20.

Table 5.19: A9 Junctions, Relaxations, Option ST2B

Reference	Location & Chainage	Relaxation Type	DMRB Reference	Required Standard	Standard Provided
Birnam Junction					
No Relaxations					
Dunkeld Junction					
RLXJB01	Unclassified Road to Inver, Ch. 11 to Ch. 131	Horizontal Alignment	CD109: Highway link design, Table 2.10, Clause 4.5	R = 255 metres	R = 205 metres (1 step below)
RLXJB02	Unclassified Road to Inver, Ch. 50 to Ch. 70, Eastbound	SSD	CD109: Highway link design, Table 2.10, Clause 3.5	SSD = 90 metres	SSD = 75 metres (1 step below)
RLXJB03	Unclassified Road to Inver, Ch. 169, Westbound	SSD	CD109: Highway link design, Table 2.10, Clause 3.5	SSD = 90 metres	SSD = 82 metres (1 step below)
RLXJB04	Realigned A822 (Old Military Road), Ch. 25 to Ch. 85	Horizontal Alignment	CD109: Highway link design, Table 2.10, Clause 4.5	R = 255 metres	R = 180 metres (1 step below)
RLXJB05	Realigned A923, Ch. 130 to Ch. 160	Vertical Alignment	CD109: Highway link design, Table 2.10, Clauses 5.6 to 5.11, Tables 5.7 & 5.9.	K = 17 (crest)	K = 10 (crest) (1 step below)
The Hermitage Junction					
No Relaxations					
Dalguise Junction					
RLXJB06	Realigned B898, Ch. 420 to Ch. 570	Horizontal Alignment	CD109: Highway link design, Table 2.10, Clause 4.5	R = 255 metres	R = 180 metres (1 step below)

Table 5.20: A9 Junctions, Departures from Requirements, Option ST2B

Reference	Location & Chainage	Departure Type	DMRB Reference	Required Standard	Standard Provided
Birnam Junction					
DEPJB01	Northbound Diverge Loop, Ch. 0 to Ch. 277	SSD (from back of nose)	CD109: Highway link design, Table 2.10 CD122: Geometric design of grade separated junctions, Clause 3.33, Figure 3.33b	SSD = 295 metres	SSD = 155 metres (3 steps below)
Dunkeld Junction					
DEPJB02	Realigned A822 (Old Military Road), Ch. 0 to Ch. 25	Horizontal Alignment	CD109: Highway link design, Table 2.10, Clause 4.5	R = 255 metres	R = 45 metres (4 steps below)
DEPJB03	Realigned A822 (Old Military Road), Ch. 85 to Ch. 122	Horizontal Alignment	CD109: Highway link design, Table 2.10, Clause 4.5	R = 255 metres	R = 50 metres (4 steps below)
DEPJB04	Unclassified Road to Inver	Horizontal Alignment	CD109: Highway link design, Table 2.10, Clause 4.5	R = 255 metres	R = 45 metres (4 steps below)
DEPJB05	Realigned A822 (Old Military Road)	Entry Path Radius	CD116: Geometric design of roundabouts, Clause 3.26	R = 100 metres	R = 256 metres
DEPJB06	Realigned A923, Ch. 20	Transition Length	CD109: Highway link design Clause 4.12, Table 2.10	TL = 30.2 metres	TL = 0 metres
DEPJB07	Realigned A923, Ch. 64	Transition Length	CD109: Highway link design, Clause 4.12, Table 2.10	TL = 30.2 metres	TL = 0 metres
DEPJB08	Realigned A822 (Old Military Road), Ch. 25	Transition Length	CD109: Highway link design, Clause 4.12, Table 2.10	TL = 10.0 metres	TL = 0 metres
DEPJB09	Realigned A822 (Old Military Road), Ch. 86	Transition Length	CD109: Highway link design, Clause 4.12, Table 2.10	TL = 77.4 metres	TL = 0 metres
DEPJB10	Unclassified Road to Inver, Ch. 12	Transition Length	CD109: Highway link design, Clause 4.12, Table 2.10	TL = 37.6 metres	TL = 0 metres
DEPJB11	Unclassified Road to Inver, Ch. 131	Transition Length	CD109: Highway link design, Clause 4.12, Table 2.10	TL = 4.7 metres	TL = 0 metres

Reference	Location & Chainage	Departure Type	DMRB Reference	Required Standard	Standard Provided
DEPJB12	Unclassified Road to Inver, Ch. 151	Transition Length	CD109: Highway link design, Clause 4.12, Table 2.10	TL = 12.8 metres	TL = 0 metres
DEPJB13	Unclassified Road to Inver, Ch. 80 to Ch. 130, Eastbound	SSD (on approach to junction)	CD116: Geometric design of roundabouts, Clause 3.39 CD109: Highway link design, Table 2.10	SSD = 90 metres	SSD = 30 metres (3 steps below)
DEPJB14	Unclassified Road to Inver, Ch. 0 to Ch. 80, Westbound	SSD	CD109: Highway link design, Table 2.10, Clause 3.5	SSD = 90 metres	SSD = 30 metres (3 steps below)
DEPJB15	Realigned A822 (Old Military Road), Ch. 0 to Ch. 10, Eastbound	Combination: Horizontal Alignment & SSD	CD109: Highway link design, Table 2.10, Clause 2.12	R = 255 metres SSD = 90 metres	R = 45 metres (4 steps below) SSD = 52 metres (2 steps below)
DEPJB16	Realigned A822 (Old Military Road), Ch. 0 to Ch. 122, Westbound	Combination: Horizontal Alignment & SSD	CD109: Highway link design, Table 2.10, Clause 2.12	R = 255 metres SSD = 90 metres	R = 45 metres (4 steps below) SSD = 61 metres (2 steps below)
DEPJB17	Realigned A923, Ch. 0 to Ch. 60, Westbound	Combination: Horizontal Alignment, Vertical Alignment & SSD	CD109: Highway link design, Table 2.10, Clause 2.12	R = 255 metres K = 13 (sag) SSD = 90 metres	R = 38 metres (4 steps below) K = 9 (sag) (1 step below) SSD = 56 metres (2 steps below)
DEPJB18	Realigned A923, Ch. 40 to Ch. 120, Eastbound	Combination: Horizontal Alignment, Vertical Alignment & SSD	CD109: Highway link design, Table 2.10, Clause 2.12	R = 255 metres K = 13 (sag) SSD = 90 metres	R = 38 metres (4 steps below) K= 9 (sag) (1 step below) SSD = 52 metres (2 steps below)
The Hermitage Junction					
No Departures from requirements					
Dalguise Junction					
DEPJB19	Northbound Diverge Slip Road, Ch. 0 to Ch. 170	SSD (from back of nose)	CD109: Highway link design, Table 2.10, Clause 3.5 CD122: Geometric design of grade separated junctions, Clause 3.33, Figure 3.33b	SSD = 295 metres	SSD = 123 metres (3 steps below)
DEPJB20	Northbound Diverge Slip Road,	Near Straight Horizontal Alignment	CD122: Geometric design of grade	R = 1,020 metres	R = 735 metres (1 step below)

Reference	Location & Chainage	Departure Type	DMRB Reference	Required Standard	Standard Provided
	Ch. 0 to Ch. 70		separated junctions, Clause: 5.8		
DEPJB21	Southbound Merge Slip Road, Ch. 0 to Ch. 85	Near Straight Horizontal Alignment	CD122: Geometric design of grade separated junctions, Clause: 5.8	R = 1,020 metres	R = 650 metres (2 steps below)
DEPJB22	Southbound Merge Slip Road	SSD	CD109: Highway link design, Table 2.10 CD122: Geometric design of grade separated junctions, Clause: 3.24	SSD = 295 metres	SSD = 161 metres (2 steps below)

Table Notes:

1) The transition length (TL) for each horizontal curve has been calculated in accordance with CD109: Highway link design, Clauses 4.15, 4.15.1 and 4.15.2.

Option ST2C

5.8.22 The junctions associated with Option ST2C incorporate three Relaxations and nine Departures from requirements, as detailed in Table 5.21 and 5.22.

Table 5.21: A9 Junctions, Relaxations, Option ST2C

Reference	Location & Chainage	Relaxation Type	DMRB Reference	Required Standard	Standard Provided
Birnam Junction					
No Relaxations					
Dunkeld & Birnam Station Access					
No Relaxations					
Dunkeld Junction					
RLXJC01	Realigned A822 (Old Military Road)/A923 Ch.80 to Ch. 190	Horizontal Alignment	CD109: Highway link design, Table 2.10, Clause 4.5	R = 255 metres	R = 180 metres (1 step below)
RLXJC02	Northbound Merge Slip Road, Ch.320 to Ch.375	Horizontal Alignment	CD109: Highway link design, Table 2.10, Clause 4.5	R = 360 metres	R = 180 metres (2 steps below)
The Hermitage Junction					
No Relaxations					
Dalguise Junction					
RLXJC03	Realigned B898, Ch. 420 to Ch. 570	Horizontal Alignment	CD109: Highway link design, Table 2.10, Clause 4.5	R = 255 metres	R = 180 metres (1 step below)

Table 5.22: A9 Junctions, Departures from Requirements, Option ST2C

Reference	Location & Chainage	Departure Type	DMRB Reference	Required Standard	Standard Provided
Birnam Junction					
DEPJC01	Northbound Diverge Loop, Ch. 0 to Ch. 277	SSD (from back of nose)	CD109: Highway link design, Table 2.10, Clause 3.5 CD122: Geometric design of grade separated junctions, Clause 3.33, Figure 3.33b	SSD = 295 metres	SSD = 155 metres (3 steps below)
Dunkeld & Birnam Station Access					
No Departures from requirements.					
Dunkeld Junction					
DEPJC02	Northbound Diverge Slip Road, Ch.0 to 140	SSD (from back of nose)	CD109: Highway link design, Table 2.10, Clause 3.5 CD122: Geometric design of grade separated junctions, Clause 3.33, Figure 3.33b	SSD = 295 metres	SSD = 171 metres (2 steps below)
DEPJC03	Southbound Diverge Slip Road, Ch.0 to 130	SSD	CD109: Highway link design: Table 2.10 CD122: Geometric design of grade separated junctions, Clause 3.33, Figure 3.33b	SSD = 295 metres	SSD = 258 metres (1 step below)
DEPJC04	Right/Left Staggered Priority Junction (between the Realigned A822 (Old Military Road)/A923 with the Southbound Diverge Slip Road and the Southbound Merge Slip Road)	Stagger Distance	CD123: Geometric design of at-grade priority and signal-controlled junctions, Clause 2.23	50 metres	30 metres
DEPJC05	Right/Left Staggered Priority Junction (between the Realigned A822 (Old Military Road)/A923 with the Northbound Diverge Slip Road	Stagger Distance	CD123: Geometric design of at-grade priority and signal-controlled junctions, Clause 2.23	50 metres	30 metres

Reference	Location & Chainage	Departure Type	DMRB Reference	Required Standard	Standard Provided
	and the road to Inver)				
The Hermitage Junction					
No Departures from requirements.					
Dalguise Junction					
DEPJC06	Northbound Diverge Slip Road, Ch. 0 to Ch. 170	SSD (from back of nose)	CD109: Highway link design, Table 2.10, Clause 3.5 CD122: Geometric design of grade separated junctions, Clause 3.33, Figure 3.33b	SSD = 295 metres	SSD = 123 metres (3 steps below)
DEPJC07	Northbound Diverge Slip Road, Ch. 0 to Ch. 70	Near Straight Horizontal Alignment	CD122: Geometric design of grade separated junctions, Clause: 5.8	R = 1,020 metres	R = 735 metres (1 step below)
DEPJC08	Southbound Merge Slip Road, Ch. 0 to Ch. 85	Near Straight Horizontal Alignment	CD122: Geometric design of grade separated junctions, Clause: 5.8	R = 1,020 metres	R = 650 metres (2 steps below)
DEPJC09	Southbound Merge Slip Road	SSD (from back of the nose)	CD109: Highway link design, Table 2.10 CD122: Geometric design of grade separated junctions, Clause: 3.24	SSD = 295 metres	SSD = 161 metres (2 steps below)

Option ST2D

5.8.23 The junctions associated with Option ST2D incorporate six Relaxations and 22 Departures from requirements, as detailed in Table 5.23 and 5.24.

Table 5.23: A9 Junctions, Relaxations, Option ST2D

Reference	Location & Chainage	Relaxation Type	DMRB Reference	Required Standard	Standard Provided
Birnam Junction					
No Relaxations					
Dunkeld & Birnam Station Access					
No Departures from requirements.					
Dunkeld Junction					
RLXJD01	Unclassified Road to Inver, Ch. 11 to Ch. 131	Horizontal Alignment	CD109: Highway link design, Table 2.10,	R = 255 metres	R = 205 metres (1 step below)

Reference	Location & Chainage	Relaxation Type	DMRB Reference	Required Standard	Standard Provided
			Clause 4.5		
RLXJD02	Unclassified Road to Inver, Ch. 50 to Ch. 70, Eastbound	SSD	CD109: Highway link design, Table 2.10, Clause 3.5	SSD = 90 metres	SSD = 75 metres (1 step below)
RLXJD03	Unclassified Road to Inver, Ch. 169, Westbound	SSD	CD109: Highway link design, Table 2.10, Clause 3.5	SSD = 90 metres	SSD = 82 metres (1 step below)
RLXJD04	Realigned A822 (Old Military Road), Ch. 25 to Ch. 85	Horizontal Alignment	CD109: Highway link design, Table 2.10, Clause 4.5	R = 255 metres	R = 180 metres (1 step below)
RLXJD05	Realigned A923, Ch. 130 to Ch. 160	Vertical Alignment	CD109: Highway link design, Table 2.10, Clauses 5.6 to 5.11, Tables 5.7 & 5.9	K = 17 (crest)	K = 10 (crest) (1 step below)
The Hermitage Junction					
No Relaxations					
Dalguise Junction					
RLXJD06	Realigned B898, Ch. 420 to Ch. 570	Horizontal Alignment	CD109: Highway link design, Table 2.10, Clause 4.5	R = 255 metres	R = 180 metres (1 step below)

Table 5.24: A9 Junctions, Departures from Requirements, Option ST2D

Reference	Location & Chainage	Departure Type	DMRB Reference	Required Standard	Standard Provided
Birnam Junction					
DEPJD01	Northbound Diverge Loop, Ch. 0 to Ch. 277	SSD (from back of nose)	CD109: Highway link design, Table 2.10 CD122: Geometric design of grade separated junctions, Clause 3.33, Figure 3.33b	SSD = 295 metres	SSD = 155 metres (3 steps below)
Dunkeld & Birnam Station Access					
No Departures from requirements.					
Dunkeld Junction					
DEPJD02	Realigned A822 (Old Military Road), Ch. 0 to Ch. 25	Horizontal Alignment	CD109: Highway link design, Table 2.10, Clause 4.5	R = 255 metres	R = 45 metres (4 steps below)
DEPJD03	Realigned A822 (Old Military Road), Ch. 85 to Ch. 122	Horizontal Alignment	CD109: Highway link design, Table 2.10, Clause 4.5	R = 255 metres	R = 50 metres (4 steps below)

Reference	Location & Chainage	Departure Type	DMRB Reference	Required Standard	Standard Provided
DEPJD04	Unclassified Road to Inver	Horizontal Alignment	CD109: Highway link design, Table 2.10, Clause 4.5	R = 255 metres	R = 45 metres (4 steps below)
DEPJD05	Realigned A822 (Old Military Road)	Entry Path Radius	CD116: Geometric design of roundabouts, Clause 3.26	R = 100 metres	R = 256 metres
DEPJD06	Realigned A923, Ch. 20	Transition Length	CD109: Highway link design, Clause 4.12, Table 2.10	TL = 30.2 metres	TL = 0 metres
DEPJD07	Realigned A923, Ch. 64	Transition Length	CD109: Highway link design, Clause 4.12, Table 2.10	TL = 30.2 metres	TL = 0 metres
DEPJD08	Realigned A822 (Old Military Road), Ch. 25	Transition Length	CD109: Highway link design, Clause 4.12, Table 2.10	TL = 10.0 metres	TL = 0 metres
DEPJD09	Realigned A822 (Old Military Road), Ch. 86	Transition Length	CD109: Highway link design, Clause 4.12, Table 2.10	TL = 77.4 metres	TL = 0 metres
DEPJD10	Unclassified Road to Inver, Ch. 12	Transition Length	CD109: Highway link design, Clause 4.12, Table 2.10	TL = 37.6 metres	TL = 0 metres
DEPJD11	Unclassified Road to Inver, Ch. 131	Transition Length	CD109: Highway link design, Clause 4.12, Table 2.10	TL = 4.7 metres	TL = 0 metres
DEPJD12	Unclassified Road to Inver, Ch. 151	Transition Length	CD109: Highway link design, Clause 4.12, Table 2.10	TL = 12.8 metres	TL = 0 metres
DEPJD13	Unclassified Road to Inver, Ch. 80 to Ch. 130, Eastbound	SSD (on approach to junction)	CD116: Geometric design of roundabouts, Clause 3.39 CD109: Highway link design, Table 2.10	SSD = 90 metres	SSD = 30 metres (3 steps below)
DEPJD14	Unclassified Road to Inver, Ch. 0 to Ch. 80, Westbound	SSD	CD109: Highway link design, Table 2.10, Clause 3.5	SSD = 90 metres	SSD = 30 metres (3 steps below)
DEPJD15	Realigned A822 (Old Military Road), Ch. 0 to Ch. 10, Eastbound	Combination: Horizontal Alignment & SSD	CD109: Highway link design, Table 2.10, Clause 2.12	R = 255 metres SSD = 90 metres	R = 45 metres (4 steps below) SSD = 52 metres (2 steps below)
DEPJD16	Realigned A822 (Old Military Road),	Combination: Horizontal Alignment & SSD	CD109: Highway link design, Table 2.10	R = 255 metres SSD = 90 metres	R = 45 metres (4 steps below)

Reference	Location & Chainage	Departure Type	DMRB Reference	Required Standard	Standard Provided
	Ch. 0 to Ch. 122, Westbound		Clause 2.12		SSD = 61 metres (2 steps below)
DEPJD17	Realigned A923, Ch. 0 to Ch. 60, Westbound	Combination: Horizontal Alignment, Vertical Alignment & SSD	CD109: Highway link design, Table 2.10, Clause 2.12	R = 255 metres K = 13 (sag) SSD = 90 metres	R = 38 metres (4 steps below) K = 9 (sag) (1 step below) SSD = 56 metres (2 steps below)
DEPJD18	Realigned A923, Ch. 40 to Ch. 120, Eastbound	Combination: Horizontal Alignment, Vertical Alignment & SSD	CD109: Highway link design, Table 2.10 Clause 2.12	R = 255 metres K = 13 (sag) SSD = 90 metres	R = 38 metres (4 steps below) K= 9 (sag) (1 step below) SSD = 52 metres (2 steps below)
The Hermitage Junction					
No Departures from requirements.					
Dalguise Junction					
DEPJD19	Northbound Diverge Slip Road, Ch. 0 to Ch. 170	SSD (from back of nose)	CD109: Highway link design: Table 2.10 CD122: Geometric Design of Grade Separated Junctions Clause 3.33 Figure 3.33b	SSD = 295 metres	SSD = 123 metres (3 steps below)
DEPJD20	Northbound Diverge Slip Road, Ch. 0 to Ch. 70	Near Straight Horizontal Alignment	CD122: Geometric Design of Grade Separated Junctions Clause: 5.8	R = 1,020 metres	R = 735 metres (1 step below)
DEPJD21	Southbound Merge Slip Road, Ch. 0 to Ch. 85	Near Straight Horizontal Alignment	CD122: Geometric Design of Grade Separated Junctions Clause: 5.8	R = 1,020 metres	R = 650 metres (2 steps below)
DEPJD22	Southbound Merge Slip Road	SSD	CD109: Highway link design: Table 2.10 CD122: Geometric Design of Grade Separated Junctions Clause: 3.24	SSD = 295 metres	SSD = 161 metres (1 step below)

Table Notes:

1) The transition length (TL) for each horizontal curve has been calculated in accordance with CD109: Highway link design, Clauses 4.15, 4.15.1 and 4.15.2.

Resolution of Relaxations and Departures from Requirements

5.8.24 The Relaxations and Departures from requirements have been discussed throughout the scheme development with Transport Scotland (Roads). Further assessment of the Relaxations and Departures from requirements (and Deviations from recommendations) will be undertaken as part of the DMRB Stage 3 assessment to eliminate or reduce where possible. Further assessment will also be undertaken on the junctions and side roads to evaluate and confirm suitable Design Speeds for design purposes.

5.8.25 Where Departures from requirements, Relaxations and Deviations from recommendations cannot be eliminated, suitable mitigation measures will be investigated, taking cognisance of relevant design standards and in consultation with key stakeholders.

5.9 Geotechnics and Earthworks

5.9.1 An assessment of the likely ground conditions affecting the various route options has been determined from the 1:10,560 and 1:50,000 British Geological Survey (BGS) maps. Reference has also been made during the study to the Preliminary Sources Study Reports (PSSR) prepared by AECOM in 2011. A detailed Ground Investigation (GI) was completed for the Pass of Birnam to Tay Crossing section of the A9 in February 2015 with additional exploratory holes undertaken in 2016. Further GI, consisting of four boreholes, was completed in May 2019, in the locality of Dunkeld & Birnam Station, with a full scope of scheme-wide supplementary GI completed in early 2020.

Superficial Geology

5.9.2 The PSSRs indicate that superficial deposits within the route corridor comprise Alluvium and River Terrace deposits overlying Glaciofluvial deposits and Glacial Till. The Alluvium, River Terrace and Glaciofluvial deposits consist predominantly of sand, gravel and silt along the valley margins. The Glacial Till comprises sandy gravelly clay. This information is supported by the published geological information.

5.9.3 From the southern extent of the scheme to Dunkeld Junction, Alluvial deposits cover the valley floor with Glaciofluvial deposits recorded on the periphery. Glacial Till is recorded on the gently sloping valley sides and is assumed to lie beneath the Alluvium and Glaciofluvial deposits throughout the proposed road alignment.

5.9.4 Between Dunkeld Junction and the River Tay crossing, the Alluvial deposits are located within a narrow band due to the restricted topography with Glaciofluvial deposits lining the valley margins.

5.9.5 Boreholes excavated to facilitate the construction of the current A9 are available to view on the BGS website. These show that the superficial deposits have been recorded at variable thicknesses, however they were typically between 10 metres and 30 metres thick. The borehole records indicate that locally, the superficial deposits can vary between 5 and 40 metres in thickness.

Solid Geology

5.9.6 The anticipated underlying bedrock geology beneath the proposed route options is provided in Table 5.25.

Table 5.25: Underlying Bedrock Geology

Route Options	Chainage (m)		Anticipated Solid Geology
	From	To	
Options ST2A, ST2B, ST2C and ST2D	0	850	Craighall Conglomerate Formation
	850	2,100	Birnam Slate and Grit Formation – Metasandstone and Metamudstone
	2,100	2,530	Birnam Slate and Grit Formation – Pelite
	2,530	4,440	Southern Highland Group – Psammite and Semipelite
	4,440	7,290	Ledi Grit Formation – Metasandstone
	7,290	8,350	Southern Highland Group – Psammite

5.9.7 The Highland Boundary Fault Zone (south of Ch. 800) forms the boundary between the Dalradian metasedimentary rocks and the Lower Devonian sedimentary and igneous rocks. This zone comprises several major north-east to south-west trending faults, which down-throw the solid strata to the south-east. The BGS states that the faulting has not been measured, although a fault was locally recorded at approximately 45° within the Birnam Slate and Grit Formation.

Mining and Quarrying

5.9.8 The anticipated geological strata along this section is of an age (Dalradian) that does not tend to be associated with any historic underground mining, i.e., there are no economic horizons of coal, fireclay or ironstone in this area. This is confirmed by a review of the Coal Authority Gazetteer, which confirms an absence of coal mining in the area. There is, however, mineral extraction beneath or close to the site area, including mining for lead. A Mineral Valuer's Report, included in the PSSRs, indicates historic mining for lead, copper and zinc may have taken place many years ago beneath a 1 kilometre section of the proposed road west of Dunkeld (Ch. 5,300 to Ch. 6,300). The report suggests it is possible that unrecorded workings exist at shallow depth (less than 30 metres depth) in this area.

5.9.9 A number of quarries and gravel pits have been noted along or in the vicinity of the road on historical maps. A summary of the identified quarries and gravel pits is presented in Table 5.26.

Table 5.26: Quarries and Gravel Pits

Designation	Approximate location	Approximate position of the existing A9	Comments
2 x Disused Quarries (including Birnam Quarry)	Ch. 1,600 to 2,200	South of Birnam, approximately 250 metres from the A9	Open cast slate mine. Now ceased to operate.
Disused Gravel Pit	Ch. 2,700 to 2,800	Immediately south of Birnam	Open cast gravel pit. Now ceased to operate.
Disused Quarry (Ladywell)	Ch. 3,750	Approximately 100 metres from the A9	Open cast metamorphic and igneous bedrock. Now ceased to operate.
Disused Quarry	Ch. 5,600	Approximately 350 metres from the existing A9 in the vicinity of the A822 (Old Military Road)	No record available of quarry type. Now ceased to operate.

5.9.10 The potential for quarries to be reopened has not been investigated at this stage and will require further environmental and engineering assessment. Notwithstanding this, the potential opportunity to obtain earthworks material or to deposit material should be recognised.

5.9.11 The Envirocheck Report, appended to the PSSRs, indicates possible natural or man-made cavities of unknown depth within 280 metres of the A9.

Other Man-Made Features

5.9.12 The proposed scheme comprises widening of the existing A9 and, as such, the ground conditions encountered will be significantly influenced by the existing earthworks, particularly embankments that have been formed as part of the previous construction.

5.9.13 The earthworks of the existing A9 are heavily influenced by the general topographic setting. The existing Pass of Birnam to Tay Crossing section of the A9 has generally been constructed on side long ground on the west side of the River Tay Valley. As such, the road is generally in an earthwork cutting slope on the northbound side and on embankment on the southbound side.

5.9.14 There are also sections of more conventional embankment where the A9 crosses low spots in the valley. These generally occur between Ch. 1,900 and 2,050, Ch. 2,950 and 3,200, Ch. 4,300 and 5,000 (where the existing A9 crosses the alluvial floodplain of the River Braan), Ch. 5,800 and 6,100 and Ch. 6,900 and 7,250.

5.9.15 There are also areas of significant embankment on the southbound side between Ch. 2,400 and 2,600, and Ch. 5,300 and 5,500.

5.9.16 The existing A9 crosses the River Tay between Ch. 7,500 and 7,600 and after the crossing the river valley is on the west of the carriageway. Therefore, the road is generally in an earthwork cutting slope on the southbound side and on embankment on the northbound side.

5.9.17 There is only one short section of existing low height embankment on the northbound side beyond the River Tay crossing. This is between Ch. 7,700 and 7,850.

Geomorphology

5.9.18 The River Tay occupies an ancient pre-glacial valley, which is incised into the metamorphic rocks of the area (Upper Dalradian), likely from the Cambrian Age. The recent glacial epoch resulted in a deepening of the River Tay Valley by ice flow. Valley sides are noted to be steeper towards the north, including rock slopes, and gentler in the broader valley towards the south. Within the valley floor, unconsolidated Alluvial deposits, including sands, gravels, cobbles and boulders are confirmed to exist. Glacial Till deposits are also likely to be present. Rockhead is variable and believed to be undulating within the study area.

Ground Conditions - General

5.9.19 A Detailed GI was undertaken by Soil Engineering between June 2014 and February 2015, designed and supervised by AECOM on behalf of Transport Scotland, to improve knowledge of the ground conditions along the route corridor. Details of the investigation have been outlined within the '*Ground Investigation Report (AECOM, 2016)*'.

5.9.20 The GI confirmed the ground conditions along the proposed route to be similar to published geological information. The Alluvium is generally encountered within the valleys of the River Tay and River Braan. The proposed route from Ch. 0 to 4,000 is underlain by Glaciofluvial deposits comprising sand, gravel with cobbles and boulders. The proposed route between Ch. 4,000 and 8,350 is underlain by Alluvium and River Terrace deposits. These deposits are granular in nature and comprise sand, silt, gravel and cobbles.

5.9.21 The investigation indicates that rockhead varies across the area. In the section between the southern scheme extent and Birnam Wood, rockhead was encountered at depths of between 7 metres and 23

metres and generally comprised conglomerates, basalt, tillite and unidentified metamorphic rocks. Between Birnam Wood and the River Tay crossing, rockhead was encountered from near surface to in excess of 55 metres and typically comprised schist, phyllite, psammite, pelite and gneiss, with basalt and slate also encountered locally.

5.9.22 A number of additional boreholes were undertaken to fill in gaps from the detailed GI. The results of this GI will inform the DMRB Stage 3 assessment.

5.9.23 In the locality of Dunkeld & Birnam Station, where the cut and cover tunnel and underpass structure would be constructed for Options ST2A and ST2B, ground conditions generally comprise River Terrace deposits, Glaciofluvial deposits and local deposits initially indicated to be Alluvium. All of these deposits are predominantly granular in nature comprising sand and gravel. River Terrace deposits are generally described as "*medium dense orangish brown slightly silty fine to coarse sand with gravels and cobbles*". Glaciofluvial deposits are generally described as "*dense gravelly cobbles and boulders with occasional sand bands*". Material described as Alluvium was also recorded in occasional boreholes and is described as "*very dense reddish brown fine to medium sand and angular to subangular fine to coarse gravel*".

5.9.24 Large boulders were recorded during the GI in approximately 20% of the boreholes, all in the vicinity of Dunkeld & Birnam Station. The drillers noted "*hard to dig*" conditions in this locality.

5.9.25 The investigation in the vicinity of the proposed cut and cover tunnel and underpass structure indicates that rockhead varies across this area and is generally described as "*medium strong to strong fine to medium grained schist*".

5.9.26 Groundwater monitoring was carried out in some of the boreholes and the monitoring readings were observed from October 2014 to April 2015. The highest groundwater level was recorded at 7.09 metres below ground level (bgl) (59.95 metres Above Ordnance Datum (AOD)) during February 2015 and the deepest reading was recorded at 21.43 metres bgl (44.6 metres AOD) during December 2014. The water levels recorded suggest that the proposed excavation for Options ST2A and ST2B is likely to be predominantly above the water level.

Ground Conditions and Ground Related Constraints

5.9.27 An assessment of the ground related constraints affecting the various route options has been undertaken using a variety of sources, including:

- Envirocheck Report (included in the PSSRs);
- Scottish Road Network Landslides Study (M.G. Winter et al, 2008);
- A9 Perth to Inverness Rock Slope Hazard Index Survey (Transport Research Laboratory TRL, A.J. Haber et al 1998);
- Detailed GI completed in February 2015;
- Advanced GI Birnam to Glen Garry completed in 2016; and
- Four boreholes completed in May 2019; and
- Scheme-wide supplementary GI completed in early 2020.

5.9.28 The ground related constraints for route options and junction options are summarised in Table 5.27 and presented on the drawings listed below that are included in Volume 2: Engineering Drawings.

- A9P02-JAC-HGT-Z_ZZZZZ_ZZ-FG-GE-0001;
- A9P02-JAC-HGT-Z_ZZZZZ_ZZ-FG-GE-0002;
- A9P02-JAC-HGT-Z_ZZZZZ_ZZ-FG-GE-0003;

- A9P02-JAC-HGT-Z_ZZZZZ_ZZ-FG-GE-0004;
- A9P02-JAC-HGT-Z_ZZZZZ_ZZ-FG-GE-0005;
- A9P02-JAC-HGT-Z_ZZZZZ_ZZ-FG-GE-0006; and
- A9P02-JAC-HGT-Z_ZZZZZ_ZZ-FG-GE-0007.

Table 5.27: Geotechnical Constraints

Approximate Chainage (m)	Anticipated Earthwork Maximum Height (m)		Constraint
	Embankment	Cutting	
450	Option ST2A - 1.2 (southbound))	Option ST2A - 1.1 (northbound)	Former Hospital (last noted in 1990)
	Option ST2B - 0.8 (southbound)	Option ST2B - 0.2 (northbound)	
	Option ST2C - 0.8 (southbound)	Option ST2C - 0.2 (northbound)	
	Option ST2D - 0.8 (southbound)	Option ST2D - 0.2 (northbound)	
2,100 to 2,200	Option ST2A - N/A	Option ST2A - 11.3 (southbound)	Sewage Works (1983) and Discharge Consent
	Option ST2B - 8.2 (southbound)	Option ST2B - 16.0 (southbound)	
	Option ST2C - 8.2 (southbound)	Option ST2C - 16.0 (southbound)	
	Option ST2D - 8.2 (southbound)	Option ST2D - 16.0 (southbound)	
2,470 to 2,480	Option ST2A - N/A	Option ST2A - 7.9 (northbound & southbound)	Gas Works (1886) & Garage (last noted in 1976)
	Option ST2B - 13.8 (southbound)	Option ST2B - 7.1 (northbound)	
	Option ST2C - 14.4 (southbound)	Option ST2C - 7.6 (northbound)	
	Option ST2D - 14.4 (southbound)	Option ST2D - 7.6 (northbound)	
2,610 to 2,710	Option ST2A - N/A	Option ST2A - 11.0 (southbound)	Gravel Pit (last noted in 1886)
	Option ST2B - 8.9 (southbound)	Option ST2B - 3.2 (northbound)	
	Option ST2C - 11.2 (southbound)	Option ST2C - N/A	
	Option ST2D - 11.2 (southbound)	Option ST2D - N/A	
3,300 to 3,460	Option ST2A - N/A	Option ST2A - 11.4 (northbound)	Dunkeld & Birnam Station, including sidings (last noted in 1867)
	Option ST2B - N/A	Option ST2B - 8.3 (southbound)	
	Option ST2C - 4.8 (southbound)	Option ST2C - 0.7 (northbound)	
	Option ST2D - 4.8 (southbound)	Option ST2D - 0.7 (northbound)	
3,700 to 3,800	Option ST2A - N/A	Option ST2A - 20.8 (northbound)	Quarry (last noted in 1967) Ladywell Landfill
	Option ST2B - N/A	Option ST2B - 11.7 (northbound)	
	Option ST2C - 3.3 (southbound)	Option ST2C - 6.4 (northbound)	
	Option ST2D - 0.3 (northbound)	Option ST2D - 8.9 (southbound)	
6,380 to 6,400	Option ST2A - 6.6 (southbound)	Option ST2A - 19.2 (northbound)	Tank (unspecified) (1983)
	Option ST2B - 6.6 (southbound)	Option ST2B - 19.2 (northbound)	
	Option ST2C - 6.6 (southbound)	Option ST2C - 19.2 (northbound)	
	Option ST2D - 6.6 (southbound)	Option ST2D - 19.2 (northbound)	
8,010	Option ST2A - N/A	Option ST2A - 0.7 (southbound)	Dunkeld Landslide (2004)
	Option ST2B - N/A	Option ST2B - 0.7 (southbound)	
	Option ST2C - N/A	Option ST2C - 0.7 (southbound)	
	Option ST2D - N/A	Option ST2D - 0.7 (southbound)	

(Source: Envirocheck Report)

5.9.29 From a review of the '*Scottish Road Network Landslides Study (M.G. Winter et al, 2008)*' two hazards have been identified, as detailed in Table 5.28. Both hazards are assigned hazard rankings of greater than 100. These will require further assessment as part of the DMRB Stage 3 assessment.

Table 5.28: Geotechnical Constraints/Landslide Hazards

Approximate Chainage (m)	Anticipated Earthwork Maximum Height (m)		Hazard Ranking / Comments on Hazard
	Embankment	Cutting	
2,100 to 2,900	Option ST2A - N/A	Option ST2A - 11.3 (southbound)	140 - Priority 2/ Potential hazards to west of road; hazards on hill, probably on open ground in forestry.
	Option ST2B - 8.2 (southbound)	Option ST2B - 16.0 (southbound)	
	Option ST2C - 8.2 (southbound)	Option ST2C - 16.0 (southbound)	
	Option ST2D - 8.2 (southbound)	Option ST2D - 16.0 (southbound)	
7,600 to 8,400	Option ST2A - 7.4 (southbound)	Option ST2A - 31.8 (southbound)	180 - Priority 1/ Potential hazards to east of road, as in the old A9; limited hazard potential highlighted, but the history of movement in the area north of the River Tay crossing, such as the August 2004 landslide caused by inadequate drainage, indicate that further assessment would be prudent. Hazards are more closely associated with localised geotechnical issues (cut slope stability management) than longer distance debris flow events.
	Option ST2B - 7.4 (southbound)	Option ST2B - 31.8 (southbound)	
	Option ST2C - 7.4 (southbound)	Option ST2C - 31.8 (southbound)	
	Option ST2D - 7.4 (southbound)	Option ST2D - 31.8 (southbound)	

(Source: Scottish Road Network Landslide Study, M.G.Winter et al, 2008)

Table Notes:

1) Scott Wilson (2011). A9 Pass of Birnam to Tay Crossing Preliminary Sources Study Report.

5.9.30 From a review of the '*A9 Perth to Inverness Rock Slope Hazard Index Survey (TRL, A.J. Haber et al 1998)*' a number of hazards have been identified on the rock slopes, as listed in Table 5.29. One location is classed as Category 2 (where slopes are to be reviewed in five years' time), whereas the other two locations are classed as Category 3 (where a detailed inspection on a priority basis is recommended). Only one location is classed as Category 1 where no further action is recommended. It should be noted that the Rock Slope Hazard Index is intended to act as a coarse sift using rapid, standardised field data collection.

Table 5.29: Geotechnical Constraints/Rock Slope Hazards

Route Options	Approximate Chainage (m)	Anticipated Earthwork Maximum Height (m)		Hazard Index/ Action Category
		Embankment	Cutting	
ST2A, ST2B, ST2C and ST2D	5,600	1.1	-	8.28 / Action Category 2
ST2A, ST2B, ST2C and ST2D	5,900	13.2	-	17.35 / Action Category 3
ST2A, ST2B, ST2C and ST2D	6,100	6.1	-	0.38 / Action Category 1
ST2A, ST2B, ST2C and ST2D	6,300	5.9	23.0	41.97 / Action Category 3
Action Category 1 - No further action recommended Action Category 2 - Slopes to be reviewed in 5 years Actions Category 3 - Detailed inspection recommended as a priority				

(Source: TRL A.J. Haber et al 1998)

5.9.31 Information included in Transport Scotland's Routine Maintenance Management System (RMMS) has been reviewed. The system shows that between 2013 and 2018, no relevant geotechnical related events occurred. It should be noted however, that the RMMS does not provide a severity rating or risk rating and therefore is limited with regards to geotechnical constraint identification. It will be considered further as part of the DMRB Stage 3 assessment.

5.9.32 The route options under consideration follow similar horizontal alignments. However, they differ vertically in the locality of Dunkeld & Birnam Station, with Options ST2A and ST2B lowered to form a cut and cover tunnel and underpass, and Options ST2C and ST2D generally at-grade. Encountered ground conditions will therefore have a significant influence on the construction of the options, which should be considered in the selection of a Preferred Route Option.

5.9.33 A further difference between the options, in terms of ground related constraints, is the Ladywell Landfill site that is located to the west of the Highland Main Line railway, north of Dunkeld & Birnam Station. The footprint of the proposed Birnam Glen Access Road, in Options ST2A and ST2B, is in close proximity to this site. The ground conditions, nature and extent of the waste deposited in the landfill are not known at this stage. There is a potential for contaminated ground to be encountered in this area that may require non-standard earthworks treatment. This may involve excavation and replacement of material or implementation of an engineered cap to retain the waste. The final form of remediation in this area will depend on the detailed proposals, which will be developed at a later stage.

Earthworks

5.9.34 For the purposes of the DMRB Stage 2 assessment, the earthwork slope angles assumed are detailed in Table 5.30.

Table 5.30: Geotechnical Slopes

Embankment or Cutting	Height	Gradient
Cutting (In Alluvial Slopes)	<5m	Not steeper than 27° or 1 metre vertical in 2 metres horizontal (1V in 2H)
Cutting (In Alluvial Slopes)	5m to 8m	Not steeper than 27° or 1 metre vertical in 2 metres horizontal (1V in 2H)
Cutting (In Alluvial Slopes)	>8m	Not steeper than 27° or 1 metre vertical in 2 metres horizontal (1V in 2H)
Cuttings (In River Terrace, Glaciofluvial and Glacial Till deposits)	<5m	Not steeper than 27° or 1 metre vertical in 2 metres horizontal (1V in 2H)
Cuttings (In River Terrace, Glaciofluvial and Glacial Till deposits)	5m to 10m	Not steeper than 27° or 1 metre vertical in 2 metres horizontal (1V in 2H)
Cuttings (In River Terrace, Glaciofluvial and Glacial Till deposits)	>10m	Not steeper than 27° or 1 metre vertical in 2 metres horizontal (1V in 2H)
Cuttings in Rock	-	Assuming 45° or 1 metre vertical in 1 metre horizontal (1V in 1H)
Embankment	<8m	Not steeper than 27° or 1 metre vertical in 2 metres horizontal (1V in 2H)
Embankment	>8m	Not steeper than 27° or 1 metre vertical in 2 metres horizontal (1V in 2H)

5.9.35 The above slopes are recommended from experience of the soil types anticipated and from the information available, while also considering adjacent constraints. The earthworks slopes will be re-assessed further during the DMRB Stage 3 assessment, considering relevant GI information.

5.9.36 Reinforced earthworks (e.g., reinforced earth embankments or soil nailed cutting slopes) have been proposed to avoid encroachment towards physical and environmental constraints where limited land is available or at locations where natural earthwork slopes cannot be accommodated for other reasons.

5.9.37 The majority of the site is expected to be underlain by granular material and as such settlement of embankments is largely expected to be immediate. Staged construction is considered to be satisfactory to allow settlement to occur during construction and basal reinforcement is not anticipated to be required for any of the alignments. This will require further consideration as part of the DMRB Stage 3 assessment and will be subject to a detailed review of the ground conditions encountered during the detailed GI.

5.9.38 Slope drainage will be required in all cut slopes, with crest and toe drainage as a minimum. Counterfort drainage may also be specified where the groundwater table is high or in alluvial cut slopes.

5.9.39 The inclusion of berms in cut slopes will be assessed by slope stability analysis during the DMRB Stage 3 assessment. Appropriate drainage will also be determined and designed at DMRB Stage 3.

5.9.40 Rock may be encountered within some cutting slopes and may also be encountered at the base of cuttings. Rock benches on new cutting slopes may be required at intervals and shall incorporate appropriate drainage (to be determined as part of the DMRB Stage 3 assessment). The need for in slope drainage and raking drains etc. shall be determined from the GI during the DMRB Stage 3 assessment.

Comparison of Route Options

5.9.41 A large proportion of the proposed earthworks are common to all options. Earthwork references for each option follow the nomenclature given below, followed by a sequential number.

- NB - Northbound;
- SB - Southbound;
- E - Embankment;
- C - Cutting; and
- NG - Earthworks that are near existing grade.

5.9.42 Options ST2A, ST2B, ST2C and ST2D follow the same horizontal alignment at the northern extent of the scheme beyond Ch. 5,000. However, the southern extent of the scheme varies both horizontally and vertically, albeit the horizontal variations are minimal.

5.9.43 The earthworks are common in all options after Ch. 5,000. As the A9 is on side long ground on the west side of the River Tay valley, earthwork cutting slopes are commonly on the northbound carriageway. One of these cutting slopes, on approach to Dalguise Junction (Ch. 6,140 to 6,480) has depth greater than 20 metres, assuming a slope of 27° (1 vertical: 2 horizontal). However, these slopes are located within rock and as existing rock faces are steeper, it is likely the angle of these slopes can be increased. This will be investigated as part of the DMRB Stage 3 assessment.

5.9.44 The highest embankment on the northbound side common to all options is approximately 10 metres high north of The Hermitage (Ch. 6,020). This embankment is expected to be founded on granular soils that is anticipated to provide a suitable foundation without the need for any basal reinforcement.

5.9.45 There is a cutting slope within the southbound earthworks, which extends to approximately 32 metres deep at the northern extent of the scheme (Ch. 7,870 to 8,141(end)) close to the tie-in with the following scheme.

5.9.46 Options ST2A and ST2B have a larger number of cutting slopes compared to Options ST2C and ST2D due to the lowering of the A9 in the locality of Dunkeld & Birnam Station. Option ST2C has a larger number of embankments, largely due to the A9 carriageway being raised to the north of the station to accommodate the grade separated junction at Dunkeld.

5.9.47 A summary of the earthwork slopes, and cut and fill volumes, for Options ST2A, ST2B, ST2C and ST2D is included in Tables 5.31 to 5.38.

Option ST2A

Table 5.31: Option ST2A Northbound Earthworks

Earthwork Reference	Chainage (m)		Maximum Height (m)	Cut Volume (m^3)	Fill Volume (m^3)
	From	To			
Embankment 1	0	805	7.4	1,981	8,192
Cutting 1	805	1,670	12.7	105,389	6,424
Embankment 2	1,670	1,850	4.1	1,829	4,234
Cutting 2	1,850	2,150	9.8	35,000	17
Cutting 3 (Cut and Cover Tunnel)	2,150	3,730	-	243,642	0
Cutting 4	3,730	4,038	19.6	47,108	687
Embankment 3	4,161	6,140	9.9	1,178	71,012
Cutting 5	6,140	6,480	23.4	74,583	684
Embankment 4	6,480	6,640	5.3	161	9,409
Cutting 6	6,640	6,930	4.6	49,553	10,212
Embankment 5	6,965	7,360	7.8	0	33,686
Cutting 7	7,360	8,421	-	1,748	535

Table 5.32: Option ST2A Southbound Earthworks

Earthwork Reference	Chainage (m)		Maximum Height (m)	Cut Volume (m^3)	Fill Volume (m^3)
	From	To			
Embankment 1	0	1,035	8.1	3,986	45,748
Cutting 1	1,035	2,150	11.3	98,882	190
Cutting 2 (Cut and Cover Tunnel)	2,150	3,730	-	277,654	0
Cutting 3	3,730	4,010	16.9	28,488	135
Near Grade 1	4,010	4,038	-	0	833
Embankment 2	4,161	4,986	9.4	7	33,448
Cutting 4	4,986	5,230	6.7	10,232	129
Embankment 3	5,230	5,480	13.4	4	55,985
Near Grade 2	5,480	5,730	-	74	2,003
Embankment 4	5,760	6,930	7.3	14,792	116,736
Embankment 5	6,965	7,417	6.4	637	18,328
River Tay Structure	7,417	7,723	-	-	-
Embankment 6	7,723	7,870	11.3	28	4,945

Earthwork Reference	Chainage (m)		Maximum Height (m)	Cut Volume (m^3)	Fill Volume (m^3)
	From	To			
Cutting 5	7,870	8,421	31.8	23,705	628

Option ST2B

Table 5.33: Option ST2B Northbound Earthworks

Earthwork Reference	Chainage (m)		Maximum Height (m)	Cut Volume (m^3)	Fill Volume (m^3)
	From	To			
Embankment 1	0	880	3.3	2,022	4,801
Murthly Estate Structure	880	890	-	-	-
Cutting 1	890	1,645	8.1	55,640	225
Embankment 2	1,645	2,150	9.3	0	43,451
Birnam Junction Structure	2,150	2,300	-	-	-
Embankment 3	2,300	2,745	7.3	170	19,068
Near Grade 1	2,745	2,860	-	994	54
Cutting 2 & Underpass Structure	2,860	4,000	15.7	90,037	493
Near Grade 2	4,000	4,038	-	0	947
Embankment 4	4,161	6,140	9.9	1,178	71,012
Cutting 3	6,140	6,480	23.4	74,583	684
Embankment 5	6,480	6,640	5.3	161	9,409
Cutting 4	6,640	6,930	4.6	49,553	10,212
Embankment 6	6,965	7,360	7.8	0	33,686
Near Grade 3	7,360	8,421	-	1,748	535

Table 5.34: Option ST2B Southbound Earthworks

Earthwork Reference	Chainage (m)		Max Height (m)	Cut Volume (m^3)	Fill Volume (m^3)
	From	To			
Embankment 1	0	750	8.1	965	11,755
Cutting 1	750	880	5.8	1,539	134
Murthly Estate Structure	880	890	-	-	-
Cutting 2	890	1,620	4.0	25,547	431
Embankment 2	1,620	1,840	1.6	127	4,843
Embankment 3	1,840	2,150	10.2	17,962	18,364
Birnam Junction Structure	2,150	2,300	-	-	-
Embankment 4	2,300	2,880	13.8	645	15,929
Cutting 3 & Underpass Structure	2,880	3,930	9.5	65,000	207

Earthwork Reference	Chainage (m)		Max Height (m)	Cut Volume (m^3)	Fill Volume (m^3)
	From	To			
Near Grade 1	3,930	4,038	-	1	1,980
Embankment 5	4,161	4,986	9.4	7	33,448
Cutting 4	4,986	5,230	6.7	10,232	129
Embankment 6	5,230	5,480	13.4	4	55,985
Near Grade 2	5,480	5,730	-	74	2,003
Embankment 7	5,760	6,930	7.3	14,792	116,736
Embankment 8	6,965	7,417	6.4	637	18,328
River Tay Structure	7,417	7,723	-	-	-
Embankment 9	7,723	7,870	11.3	28	4,945
Cutting 5	7,870	8,421	31.8	23,705	628

Option ST2C

Table 5.35: Option ST2C Northbound Earthworks

Earthwork Reference	Chainage (m)		Max Height (m)	Cut Volume (m^3)	Fill Volume (m^3)
	From	To			
Embankment 1	0	430	3.4	0	4,414
Near Grade 1	430	880	1.0	2,020	379
Murthly Estate Structure	880	890	-	-	-
Cutting 1	890	1,645	8.1	55,178	226
Embankment 2	1,645	2,160	9.4	6	42,683
Birnam Junction Structure	2,160	2,240	-	-	-
Embankment 3	2,240	3,350	7.7	18	41,384
Near Grade 2	3,350	3,450	-	233	606
Embankment 4	3,470	3,965	5.1	14,506	18,004
Dunkeld Junction Structure	3,965	4,030	-	-	-
Embankment 5	4,030	4,275	6.7	102	95,602
River Braan Structure	4,275	4,385	-	-	-
Embankment 6	4,385	6,140	12.4	0	122,704
Cutting 2	6,140	6,480	23.2	74,583	684
Embankment 7	6,480	6,640	5.3	161	9,409
Cutting 3	6,640	6,930	4.6	49,553	10,212
Embankment 8	6,965	7,360	7.8	0	33,686
Near Grade 3	7,360	8,421	-	1,748	535

Table 5.36: Option ST2C Southbound Earthworks

Earthwork Reference	Chainage (m)		Max Height (m)	Cut Volume (m^3)	Fill Volume (m^3)
	From	To			
Embankment 1	0	750	7.8	966	11,731
Near Grade 1	750	880	1.4	1,542	134
Murthly Estate Structure	880	890	-	-	-
Cutting 1	890	1,620	4.0	25,541	432
Embankment 2	1,620	1,840	1.6	124	4,844
Embankment 3	1,840	2,150	10.4	18,000	17,553
Birnam Junction Structure	2,150	2,300	-	-	-
Embankment 4	2,240	3,965	14.4	1,341	75,667
Dunkeld Junction Structure	3,965	4,030	-	-	-
Embankment 5	4,030	4,275	12.5	149	81,689
River Braan Structure	4,275	4,385	-	-	-
Embankment 6	4,385	4,940	9.7	0	83,100
Cutting 2	4,945	5,230	6.78	10,546	970
Embankment 7	5,230	5,480	13.4	4	55,985
Near Grade 2	5,480	5,760	-	74	2,002
Embankment 8	5,760	6,930	7.3	14,792	116,736
Embankment 9	6,965	7,417	6.4	637	18,328
River Tay Structure	7,417	7,723	-	-	-
Embankment 10	7,723	7,870	11.3	28	4,945
Cutting 3	7,870	8,421	31.8	23,705	628

Option ST2D

Table 5.37: Option ST2D Northbound Earthworks

Earthwork Reference	Chainage (m)		Max Height (m)	Cut Volume (m^3)	Fill Volume (m^3)
	From	To			
Embankment 1	0	430	3.5	0	5,384
Near Grade 1	430	880	0.9	1,881	509
Murthly Estate Structure	880	890	-	-	-
Cutting 1	890	1,645	8.1	55,195	226
Embankment 2	1,645	2,150	9.4	6	42,751
Birnam Junction Structure	2,150	2,300	-	-	-
Embankment 3	2,300	3,345	7.4	0	40,229
Near Grade 2	3,350	3,450	-	233	604
Cutting 2	3,475	3,925	4.1	21,674	313
Near Grade 3	3,925	4,038	-	716	1,705
Embankment 4	4,161	6,140	9.9	1,178	71,012
Cutting 3	6,140	6,480	23.4	74,583	684
Embankment 5	6,480	6,640	5.3	161	9,409
Cutting 4	6,640	6,930	4.6	49,553	10,212

Earthwork Reference	Chainage (m)		Max Height (m)	Cut Volume (m^3)	Fill Volume (m^3)
	From	To			
Embankment 6	6,965	7,360	7.8	0	33,686
Near Grade 4	7,360	8,421	-	1,748	535

Table 5.38: Option ST2D Southbound Earthworks

Earthwork Reference	Chainage (m)		Max Height (m)	Cut Volume (m^3)	Fill Volume (m^3)
	From	To			
Embankment 1	0	750	7.8	1,096	9,824
Cutting 1	750	880	1.4	1,580	132
Murthly Estate Structure	880	890	-	-	-
Cutting 2	890	1,620	4.0	25,556	430
Embankment 2	1,620	1,840	1.6	124	4,844
Embankment 3	1,840	2,150	10.4	18,000	17,553
Birnam Junction Structure	2,150	2,300	-	-	-
Embankment 4	2,300	4,038	13.7	19	35,671
Embankment 5	4,161	4,986	9.4	7	33,448
Cutting 3	4,986	5,230	6.7	10,232	129
Embankment 6	5,230	5,480	13.4	4	55,985
Near Grade 1	5,480	5,730	-	74	2,003
Embankment 7	5,760	6,930	7.3	14,792	116,736
Embankment 8	6,965	7,417	6.4	637	18,328
River Tay Structure	7,417	7,723	-	-	-
Embankment 9	7,723	7,870	11.3	28	4,945
Cutting 4	7,870	8,421	31.8	23,705	628

Junction Options - Earthworks

5.9.48 Grade separated junctions are proposed at Murthly/Birnam and Dalguise for all options. An at-grade elongated roundabout at Dunkeld is provided for Options ST2A, ST2B and ST2D, and a grade separated junction is provided for Option ST2C. The earthworks requirements at the junctions are detailed below.

Murthly Junction (Option ST2A)

5.9.49 The junction incorporates an overbridge structure and comprises:

- The northbound merge slip road is in cutting between Ch. 0 and 150, with a maximum depth of up to 6 metres. The slip road then transitions onto embankment beyond Ch. 150, up to 6 metres high;
- The northbound diverge slip road is generally at-grade before Ch. 100. Beyond Ch. 100, the slip road is on embankment up to 4.5 metres in height;
- The southbound merge slip road is on embankment throughout with a maximum height of up to 21 metres; and
- The southbound diverge slip road is in cutting, up to 3 metres high, between Ch. 0 and 135. It then transitions to embankment beyond Ch. 135, with a maximum height of up to 13 metres.

Birnam Junction, Options ST2B, ST2C and ST2D

5.9.50 The junction incorporates an underbridge structure and comprises:

- The realigned B867/Perth Road is in a cutting slope with a maximum depth up to 12.5 metres. Reinforced earthwork slopes are required between Ch. 75 and 360 to avoid encroachment towards the Highland Main Line railway where the side road is lower than existing ground levels to satisfy headroom clearance requirements at the underbridge structure;
- The northbound loop is proposed on an embankment with a maximum height of up to 10 metres; and
- The southbound merge slip road is on embankment between Ch. 0 and 135, with a maximum height of up to 10 metres. The southbound merge transitions into a cutting slope beyond Ch. 135 on the immediate approach to the priority junction with the realigned B867/Perth Road.

Dunkeld Junction (Options ST2A, ST2B and ST2D)

5.9.51 The junction incorporates an elongated at-grade roundabout and comprises:

- The realigned A923 is on embankment with a maximum height up to 4 metres between Ch. 50 and 170. A retaining wall structure, up to a maximum height of approximately 2 metres, is required between Ch. 70 and 115 to avoid encroachment towards the road that leads to Craigvinean Surgery and Dunkeld & Birnam Recreation Club;
- Beyond the tie-in point, which is the existing railway masonry arch bridge, the A822 (Old Military Road) is in cutting with a maximum depth of 10 metres; and
- Reinforced earthwork cutting slopes are required between Ch. 0 and 40 for the unclassified road to Inver to avoid encroachment towards the Highland Main Line railway. Between Ch. 40 and 170 the road is on embankment with a maximum height of up to 3 metres.

Dunkeld Junction (Option ST2C)

5.9.52 The junction is grade separated with an underbridge structure and comprises:

- The northbound merge slip road is on embankment with a maximum height of up to 17 metres to the north of the River Braan crossing. The northbound merge slip road crosses the River Braan on a structure between Ch. 110 and 130;
- The northbound diverge slip road is immediately adjacent to the Highland Main Line railway and is in cutting with a maximum depth of up to 9 metres;
- The southbound merge slip road is in cutting with a maximum depth of 14 metres in the locality of the war memorial. Adjacent to residential properties of King Duncan's Place and Telford Gardens the depth of cutting slope is approximately 6 metres. Three short lengths of retaining wall, up to 1.6 metres in height, are required to avoid encroachment towards residential properties;
- The southbound diverge slip road is on embankment between Ch. 0 and 600 up to 18 metres high. A retaining wall structure, up to approximately 14 metres maximum height, is proposed between Ch. 290 and 435 south of the River Braan to avoid encroachment towards Dunkeld & Birnam Recreation Club; and
- The unclassified road to Inver is in cutting alongside the Highland Main Line railway and has a priority junction with the northbound merge slip road at Ch. 100. A retaining wall structure or reinforced earthwork slope will be required.

Dalguise Junction (Options ST2A, ST2B, ST2C and ST2D)

5.9.53 The junction is grade separated with an underbridge structure and comprises:

- The northbound merge slip road is on embankment up to 7.5 metres high between Ch. 0 and 100, transitioning to a cutting slope between Ch. 200 and 390 that is up to approximately 6.5 metres deep;
- The northbound diverge slip road is in cutting with a maximum height of up to 24.5 metres. It is anticipated that rock is present at this location, therefore slopes may be steepened;
- The southbound merge slip road is on embankment with a maximum height up to 6.5 metres between Ch. 0 and Ch. 275. The slip road is in cutting between Ch. 275 and 370 with a maximum depth up to 2 metres; and
- The southbound diverge slip road is on embankment between Ch. 0 and Ch. 340 with a maximum height up to 6.5 metres. Beyond Ch. 340, the slip road crosses Inch Rail Underbridge and is therefore largely within the extent of the structure.

Reinforced Earthwork Slopes

5.9.54 A summary of the locations where reinforced earthwork slopes are anticipated for the route options under consideration are provided in Tables 5.39 to 5.42. Where the locations relate to side roads, this has been described in the location name. The reinforced earthwork slopes identified are locations where slopes steeper than 27° (1 vertical: 2 horizontal) are necessary.

Table 5.39: Summary of Option ST2A - Strengthened Earthworks

Earthworks/ Structure Wall	Chainage (m)		Length (m)	Average Height (m)	Slope (Steepened Earthworks only)	Cut/Fill
	From	To				
Steepened Earthworks - Realigned B867/Perth Road	2,150	2,180	30	9.2 (13.2 maximum)	1 in 1.5	Cut
Steepened Earthworks - A9 SB	3,730	3,820	90	15.1 (16.9 maximum)	1 in 1.3	Cut
Structural Wall – A9 NB	3,730	3,880	150	5.5 (9.3 maximum)	-	Cut
Structural Wall - Realigned A923 (Dunkeld Junction)	4,000	4,050	50	1.5 (2.0 maximum)	-	Fill
Steepened Earthworks - Roundabout (Dunkeld Junction)	4,110	4,125	15	3.9 (4.0 maximum)	1 in 1.7	Fill
Steepened Earthworks - unclassified road to Inver (Dunkeld Junction)	4,260	4,300	40	4.5 (5.2 maximum)	1 in 1	Cut
Steepened Earthworks - A9 SB	5,300	5,350	50	12.8 (13.2 maximum)	1 in 1.2	Fill
Structural Wall – A9 SB	5,850	6,060	210	11.9 (13.3 maximum)	-	Fill
Structural Wall – A9 SB	6,830	6,890	60	4.0 (4.9 maximum)	-	Fill
Structural Wall - SB Diverge (Dalguise Junction)	7,150	7,220	70	7.2 (7.9 maximum)	-	Fill

Table 5.40: Summary of Option ST2B - Strengthened Earthworks

Earthworks/ Structure Wall	Chainage (m)		Length (m)	Average Height (m)	Slope (Steepened Earthworks only)	Cut/Fill
	From	To				
Steepened Earthworks - Realigned B867/Perth Road (Birnam Junction)	2,000	2,210	210	5.0 (8.5 maximum)	1 in 1	Cut
Steepened Earthworks – A9 SB	2,450	2,840	390	7.7 (13.9 maximum)	1 in 1	Fill
Structural Wall - A9 SB	3,160	3,270	110	7.7 (8.3 maximum)	-	Cut
Structural Wall - A9 NB	3,160	3,270	110	6.1 (7.8 maximum)	-	Cut
Structural Wall - A9 SB	3,410	3,490	80	6.0 (8.2 maximum)	-	Cut
Structural Wall - A9 NB	3,410	3,490	80	5.7 (9.0 maximum)	-	Cut
Structural Wall - A9 SB	3,490	3,615	125	3.7 (6.1 maximum)	-	Cut
Structural Wall - A9 NB	3,490	3,840	350	6.0 (8.2 maximum)	-	Cut
Structural Wall - Realigned A923 (Dunkeld Junction)	4,000	4,040	40	1.5 (2.0 maximum)	-	Fill
Steepened Earthworks - Roundabout (Dunkeld Junction)	4,110	4,125	15	3.9 (4.0 maximum)	1 in 1.7	Fill
Steepened Earthworks - Unclassified Road to Inver (Dunkeld Junction)	4,260	4,300	40	4.5 (5.2 maximum)	1 in 1	Cut
Steepened Earthworks – A9 SB	5,300	5,350	50	12.8 (13.2 maximum)	1 in 1.2	Fill
Structural Wall - A9 SB	5,850	6,060	210	11.9 (13.3 maximum)	-	Fill
Structural Wall - A9 SB	6,830	6,890	60	4.0 (4.9 maximum)	-	Fill
Structural Wall - SB Diverge (Dalguise Junction)	7,150	7,220	70	7.2 (7.9 maximum)	-	Fill

Table 5.41: Summary of Option ST2C - Strengthened Earthworks

Earthworks/ Structure Wall	Chainage (m)		Length (m)	Average Height (m)	Slope (Steepened Earthworks only)	Cut/Fill
	From	To				
Steepened Earthworks – Realigned B867/Perth Road (Birnam Junction)	2,000	2,210	210	5.0 (8.5 maximum)	1 in 1	Cut

Earthworks/ Structure Wall	Chainage (m)		Length (m)	Average Height (m)	Slope (Steepened Earthworks only)	Cut/Fill
	From	To				
Steepened Earthworks - A9 SB	2,450	2,870	420	7.4 (14.5 maximum)	1 in 1	Fill
Structural Wall - SB Diverge (Dunkeld Junction)	4,170	4,320	150	10.7 (14.3 maximum)	-	Fill
Structural Wall - SB Merge (Dunkeld Junction)	3,660	3,700	40	0.9 (1.3 maximum)	-	Cut
Structural Wall - SB Merge (Dunkeld Junction)	3,790	3,810	20	1.0 (1.5 maximum)	-	Cut
Structural Wall - SB Merge (Dunkeld Junction)	3,860	3,900	40	0.8 (1.6 maximum)	-	Cut
Steepened Earthworks - Unclassified Road to Inver (Dunkeld Junction)	4,015	4,450	435	18.8 (26.5 maximum)	1 in 1	Cut
Steepened Earthworks - A9 SB	5,300	5,350	50	12.8 (13.2 maximum)	1 in 1.2	Fill
Structural Wall - A9 SB	5,850	6,060	210	11.9 (13.3 maximum)	-	Fill
Structural Wall - A9 SB	6,830	6,890	60	4.0 (4.9 maximum)	-	Fill
Structural Wall - SB Diverge (Dalguise Junction)	7,150	7,220	70	7.2 (7.9 maximum)	-	Fill

Table 5.42: Summary of Option ST2D - Strengthened Earthworks

Earthworks/ Structure Wall	Chainage (m)		Length (m)	Average Height (m)	Slope (Steepened Earthworks only)	Cut/Fill
	From	To				
Steepened Earthworks - Realigned B867/Perth Road (Birnam Junction)	2,000	2,210	210	5.0 (8.5 maximum)	1 in 1	Cut
Steepened Earthworks - A9 SB	2,450	2,870	420	7.4 (14.5 maximum)	1 in 1	Fill
Steepened Earthworks - A9 NB	3,500	3,845	345	7.7 (13.8 maximum)	1 in 1	Cut
Structural Wall - Realigned A923 (Dunkeld Junction)	4,000	4,040	40	1.5 (2.0 maximum)	-	Fill
Steepened Earthworks - Roundabout (Dunkeld Junction)	4,110	4,125	15	3.9 (4.0 maximum)	1 in 1.7	Fill
Steepened Earthworks - Unclassified Road to Inver (Dunkeld Junction)	4,260	4,300	40	4.5 (5.2 maximum)	1 in 1	Cut
Steepened Earthworks – A9 SB	5,300	5,350	50	12.8 (13.2 maximum)	1 in 1.2	Fill

Earthworks/ Structure Wall	Chainage (m)		Length (m)	Average Height (m)	Slope (Steepened Earthworks only)	Cut/Fill
	From	To				
Structural Wall - A9 SB	5,850	6,060	210	11.9 (13.3 maximum)	-	Fill
Structural Wall - A9 SB	6,830	6,890	60	4.0 (4.9 maximum)	-	Fill
Structural Wall - SB Diverge (Dalguise Junction)	7,150	7,220	70	7.2 (7.9 maximum)	-	Fill

Acceptability and Earthworks Balance

5.9.55 Based on the information obtained through GI for the scheme, it has been assumed that 90% of material excavated from cuttings (rock and soil) will be acceptable for re-use as general embankment fill (Class 1 or 2), with the remaining 10% deemed unacceptable and disposed off-site. It has been assumed that borrow pits will not be required and that any fill deficit will be imported. Table 5.43 details the earthwork cut and fill quantities for each route option.

Table 5.43: Table of Earthwork Cut / Fill Quantities

Route option	Topsoil Strip		Cut Material		Total Fill Required	Surplus + / Deficit -	Topsoil Disposal	Unacceptable Cut Material for Disposal	Total Disposal
	Total excavated	Total reused	Total excavated	Reused as fill (90%)					
ST2A	148,000	108,000	1,409,000	1,268,000	751,000	517,000	40,000	141,000	698,000
ST2B	143,000	100,000	1,012,000	911,000	700,000	211,000	43,000	102,000	356,000
ST2C	144,000	100,000	1,018,000	916,000	1,203,000	-287,000	44,000	102,000	146,000
ST2D	141,000	96,000	865,000	778,500	747,000	31,500	45,000	86,500	163,000

Table Notes:

1) Total disposal for Option ST2C is the addition of the remaining topsoil and unacceptable cut material (10%), due to material deficit.
2) Total waste for Options ST2A, ST2B and ST2D is the total excavated topsoil plus the total estimated cut, minus the total reused topsoil and total fill material required.
3) Topsoil disposal includes both acceptable and unacceptable topsoil to be disposed of off-site.
4) Surplus is acceptable material that is not required but could potentially be used off-site.

5.9.56 A more detailed acceptability and earthworks balance analysis will be undertaken as part of the DMRB Stage 3 assessment. The volume of acceptable material may be greater than that quoted due to the predominance of granular or rock materials in excavations.

Constructability

5.9.57 Constructability of the route options is considered in Chapter 5.13 (Constructability), however constructability issues in relation to geotechnics and earthworks are summarised below.

- Option ST2A, and to a lesser extent Option ST2B, are complex to construct with bored piles required to form the necessary retaining walls. Construction is further complicated by the physical and environmental constraints immediately alongside the A9, including the Highland Main Line railway and the Category A Listed station building. The significant plant required to erect the retaining walls and the requirement to maintain traffic on the A9 adds to the complexity;

- Option ST2C involves significant works to construct the elevated A9 and associated grade separated junction north of Dunkeld & Birnam Station. Temporary works would be required to ensure the A9 remains operational throughout the works;
- Option ST2A includes significant excavation of material resulting in a surplus of material. Options ST2B and ST2D also have a surplus of material, with Option ST2C in deficit and therefore requiring import; and
- Where reinforced earthwork solutions are required, it is anticipated that soil nails will be utilised. However, this will be considered in greater detail at future stages of design, particularly where strengthening work is required in close proximity to the Highland Main Line railway and the track support zone.

5.9.58 Additional issues to be considered for each of the route options at future stages of design are summarised below.

- Dewatering of excavations where ground water level is high, particularly in areas of soft/ alluvial deposits, may be required;
- Dense granular material with cobbles and boulders may affect the piling installation method;
- Rock blasting (if required) adjacent to the live A9 carriageway, Highland Main Line railway and residential properties will require risk assessment and safe working practice to minimise risk to road users, residents and the general public;
- Construction of reinforced earth embankments may require environmental mitigation measures;
- The length of geotextile reinforcement may necessitate full or partial removal of existing carriageway to install, which may require Traffic Management and due consideration to the safety of road users;
- If identified as part of the DMRB Stage 3 assessment, deposits of alluvium may result in additional measures (such as basal reinforcement beneath embankments) to prevent base failure during construction and may require additional measures in the temporary situation to allow construction access; and
- Outwith Ladywell Landfill site, contaminated land is not expected. However, it is possible that contaminated land may be encountered associated with the A9 and the various quarries and gravel pits in the locality.

5.10 Hydrology, Hydrogeology and Drainage

Hydrology

5.10.1 The effects of the four route options on the water environment are considered fully in Volume 1, Part 3 - Environmental Assessment, Chapter 10 (Road Drainage and the Water Environment). This section provides a summary of the engineering issues related to watercourse crossings and road drainage.

5.10.2 A preliminary assessment of hydrology has been undertaken for each route option. Following selection of a Preferred Route Option, a review of the drainage and flood risk strategy will be completed as part of the DMRB Stage 3 assessment.

5.10.3 The River Tay and associated floodplain dominate the hydrology of the study area. The River Braan is the only significant tributary within the Pass of Birnam to Tay Crossing project extents, joining the River Tay north of the proposed Dunkeld Junction.

Watercourses

5.10.4 A number of watercourses located within the project extents are affected by the proposed route options, including those listed in Table 5.44.

Table 5.44: Watercourses

Watercourse	Description
Inchewan Burn Ch. 3,450	Inchewan Burn flows from the south side of the River Tay Valley, with a small reservoir at its head. It falls through a steep valley before levelling and crossing below the Highland Main Line railway and A9 alongside Birnam Glen and flows into the River Tay. The burn has been subject to engineering works in the locality of the existing A9 in recent years to encourage fish to spawn.
River Braan Ch. 4,330	The River Braan meanders through the study area alongside The Hermitage and Inver. It flows into the River Tay immediately north of Dunkeld Junction with the A9 crossing the river on an underbridge. A footbridge crosses the river below the A9 structure. The A9 structure and earthworks associated with the road restrict the flow of the river during flood events. The existing bridge soffit is below the design flood level in the River Braan.
Inver Mill Lade Ch. 4,940	Inver Mill Lade is a minor watercourse that flows from the River Braan, underneath the A9 to join the River Tay in the locality of Inver.
River Tay Ch. 7,550	The River Tay is designated as an SAC. It is the largest watercourse in the vicinity of the scheme and is in close proximity and parallel to the A9 for much of the route. The A9 crosses the River Tay on an underbridge towards the northern extent of the scheme. This crossing does not impact on flows or river levels. The A923 crosses the river at Dunkeld, beyond the side road realignment that forms part of Dunkeld Junction. This structure causes a restriction to the flow during extreme flood events. The River Tay floodplain predominantly impacts areas towards the southern extent of the scheme. The Scottish Environment Protection Agency (SEPA) 0.5% Annual Exceedance Probability (AEP) (200-year) event flood mapping indicates that large areas of field and woodland to the south and east of Birnam are included within the floodplain. The floodplain also encroaches into low lying areas at Little Dunkeld and Inver. Between Inver and the River Tay crossing, the 0.5% AEP (200-year) flood levels on the River Tay are mostly contained closer to the river channel, apart from a short reach at Dalguise, where the floodplain abuts the Highland Main Line railway embankment.

5.10.5 There are a number of unnamed watercourses and drainage ditch networks that cross beneath the existing A9 in culverts. The approximate location of these unnamed watercourses and drainage ditch networks are shown in the figures listed below that are included in Volume 3: Environmental Figures.

- A9P02-JAC-EGN-Z_ZZZZZ_ZZ-RP-EN-0003_FIG10-1;
- A9P02-JAC-EGN-Z_ZZZZZ_ZZ-RP-EN-0003_FIG10-2;
- A9P02-JAC-EGN-Z_ZZZZZ_ZZ-RP-EN-0003_FIG10-3; and
- A9P02-JAC-EGN-Z_ZZZZZ_ZZ-RP-EN-0003_FIG10-4.

5.10.6 The location of minor culverts is shown on Drawings A9P02-JAC-GEN-X_ZZZZZ_ZZ-FG-RD-0001 and A9P02-JAC-GEN-X_ZZZZZ_ZZ-FG-RD-0002 included in Volume 2: Engineering Drawings.

5.10.7 Table 5.45 identifies the named watercourses affected by each route option and the proposed engineering treatment/impact as a result of the interface.

Table 5.45: Watercourse Crossings

Watercourse	Option ST2A	Option ST2B	Option ST2C	Option ST2D
Inchewan Burn Ch. 3,450	8 metre vertical drop structure and culvert to lower burn due to lowered A9 dual carriageway. Demolish existing A9 structure and construct new cut and cover tunnel at proposed level.	6 metre vertical drop structure and culvert to lower burn due to lowered A9 dual carriageway. Demolish existing A9 structure and construct new underpass at proposed level.	Demolish existing A9 structure and construct new structure at proposed level.	Demolish existing A9 structure and construct new structure at proposed level.
River Braan Ch. 4,330	Demolish existing A9 structure and construct new structure at proposed level. For Options ST2A, ST2B and ST2D, the structure will be approximately 3 metres higher than existing to account for flood levels. For Option ST2C, the structure is significantly higher, approximately 13 metres, and wider as it incorporates the slip roads that form part of the grade separated junction at Dunkeld.			

Watercourse	Option ST2A	Option ST2B	Option ST2C	Option ST2D
Inver Mill Lade Ch. 4,940	Extend/modify existing structure.			
River Tay Ch. 7,550	Retain existing structure for northbound carriageway and construct new structure for southbound carriageway at similar level.			

5.10.8 Options ST2C and ST2D have the same number of named watercourse crossings. Options ST2A and ST2B however, have an additional crossing, which is to accommodate the Birnam Glen Access Road crossing Inchewan Burn.

5.10.9 At the Inchewan Burn crossing, Options ST2C and ST2D are at a similar level. The crossing for Option ST2C is wider as the northbound diverge and southbound merge slip roads, associated with the grade separated junction at Dunkeld, are present. Options ST2A and ST2B require significant realignment of the burn within a drop structure and culvert to accommodate a lowered A9 dual carriageway. While both structures are similar, they are at varying depths, as noted in Table 5.45. At the River Braan, Options ST2A, ST2B and ST2D are approximately 3 metres higher than existing ground levels at the river crossing, to ensure the A9 dual carriageway is outwith designated flood levels. The structure is also wider to accommodate the dual carriageway. For Option ST2C however, the river crossing is approximately 13 metres higher than existing carriageway levels as it is in the locality of the grade separated junction at Dunkeld. The crossing is also significantly wider as the northbound merge and southbound diverge slip roads are included.

5.10.10 The Inver Mill Lade crossing is generally the same for all options, however it is slightly longer for Option ST2C as the A9 dual carriageway returns to existing ground levels following the grade separated junction at Dunkeld. At the River Tay crossing all options are identical, with a new structure proposed for the southbound carriageway. The structure will be at a similar level to the existing structure, which will be retained for the northbound carriageway, subject to a review of the structural integrity of the existing structure.

5.10.11 All route options will require one minor watercourse diversion at Dalguise, and Option ST2A will require an additional minor watercourse diversion at Birnam, as a result of the cut and cover tunnel.

5.10.12 The key differences between the mainline route options in terms of flood risk are:

- The greater loss of floodplain storage immediately north of the River Braan crossing as a result of the larger embankment footprint for Option ST2C;
- The residual flood risk due to the increased blockage risk at the drop structure and culvert arrangement proposed for the Inchewan Burn in Options ST2A and ST2B; and
- The residual flood risk to the A9 from blockage of the drainage systems serving the low points in the proposed cut and cover tunnel for Option ST2A and underpass for Option ST2B.

5.10.13 It is noted that the existing River Braan structure acts as a throttle, heightening flood levels within Inver. Provision of a new structure would remove this throttle, alleviating some of the impacts within Inver. However, other existing structures and the natural flood levels in the river, will still lead to flooding in the locality.

5.10.14 As noted above, there is a risk of blockage to the drop structure and culvert associated with Options ST2A and ST2B. However, under normal operation, the arrangement is not expected to alter flood risk. Although, it should be noted that works to the burn will have effects on geomorphology, biodiversity and fish passage.

5.10.15 Further assessment and consideration of mitigation, including the potential provision of compensatory floodplain storage to replace that lost to the scheme, will be identified as part of the DMRB Stage 3 assessment.

Hydrogeology

5.10.16 The alluvium and glaciofluvial deposits at the edge of the river valley are likely to be moderately to highly permeable and allow rapid infiltration and groundwater flow. The groundwater table is likely to be within 5 metres of the ground surface adjacent to the River Tay, with this depth increasing sharply away from the valley floor. Perched water tables may also be present above low permeability cohesive deposits such as alluvial clay and glacial till. Limited groundwater flow will be accommodated by sand and gravel bands within the till.

5.10.17 The metamorphic bedrock has low permeability, even allowing for weathering of the bedrock, therefore surface run-off will be rapid where outcrops are recorded. Any infiltration will be limited to discontinuities within the rock. The Craighall Conglomerate Formation is also indicated to be a barrier for any groundwater flow. Groundwater flow is likely to be controlled by the frequency and nature of discontinuities as the Dalradian rocks in particular have low permeability.

5.10.18 A water abstraction borehole was recorded 2 kilometres southeast of Birnam, drawing small amounts of water from igneous rock.

Drainage (Mainline & Junctions)

5.10.19 A preliminary drainage design has been undertaken to confirm that a technically feasible drainage solution exists for each route option, with due consideration of constraints such as topography, flood risk and whether the necessary technical standards (generally two levels of treatment in accordance with the SEA Strategic Environmental Principles) can be achieved. The developing drainage design will be assessed in further detail as part of the DMRB Stage 3 assessment. This will include a review of options to refine the position and type of treatment proposed, as well as further consultation with statutory consultees and liaison with any potentially affected landowners.

5.10.20 The preliminary drainage solutions for each of the route options vary between the southern extent of the scheme and The Hermitage Junction. This is due to the varying vertical alignments for each option through this area, the different junction arrangements at Murthly/Birnam and Dunkeld, and the inclusion of a cut and cover tunnel and underpass in Options ST2A and ST2B. As a result, the drainage design for each option will have differences through this section of the scheme that will influence the selection of a Preferred Route Option. The DMRB (TD 37/93: Scheme Assessment Reporting), identifies the need to highlight any unusual features of significant engineering difficulty associated with any of the options.

5.10.21 The drainage design for the A9 has been completed in accordance with relevant guidance notes and legislative documents related to trunk road drainage, including the '*Water Environment (Controlled Activities) (Scotland) Regulations 2011'*, the DMRB and the '*Construction Industry Research and Information Association (CIRIA) Guidelines (C753), the Sustainable Drainage Systems (SuDS) Manual*'. The design is also in accordance, where possible, with the principles of the 'A9 Dualling Programme, Environmental Design Guide, Chapter 3, Water and Flooding', which has been developed in collaboration with SEPA, Scottish Natural Heritage (now NatureScot), Historic Environment Scotland (HES) and the Cairngorms National Park Authority (CNPA). This design guide establishes a set of aims that all projects within the A9 Dualling Programme will seek to meet, ensuring commitment to an environmentally led design process.

5.10.22 The DMRB Stage 2 drainage designs were developed in accordance with relevant SEPA guidance, incorporating a 20% uplift for climate change. As part of the DMRB Stage 3 assessment, the drainage design for the Preferred Route Option will be refined, taking cognisance of SEPA's latest

recommendations on climate change allowance, as outlined in 'Climate change allowances for flood risk assessment in land use planning, Version 1' (Ref LUPS-CC1) (April 2019, or any subsequent updates).

5.10.23 Initial assessments indicate that the most appropriate SuDS components for the Pass of Birnam to Tay Crossing section of the A9, taking into account existing constraints and topography, are listed below. However, this will be subject to further assessment as part of the DMRB Stage 3 assessment.

- **Filter Drains and Detention Basins**: Where viable, two levels of treatment and attenuation will be provided by filter drains situated alongside the carriageway (in the verge and/or central reserve as appropriate), linking to a detention basin.

  Filter drains fit well beside roads, are cost effective and offer the first level of treatment by filtering out pollutants. Detention basins allow surface run-off to be stored, allowing low level pollutants, such as sediment, suspended soils and hydrocarbons to settle, and permit the controlled release of run-off into adjacent watercourses, thus providing attenuation and a second level of treatment. While basins can require significant land-take and are not suitable for steep sites, they are relatively simple to design and construct and have a high potential for ecological, aesthetic and amenity benefits. In addition, basins reduce the peak flow rate run-off and can cater for storm events.

  However, there are a number of site-specific issues that will prevent use of a filter drain and a detention basin at various locations along the route. At some points, there is insufficient level difference at outfall locations between the proposed carriageway and the receiving watercourse to allow a natural flow. Furthermore, many of the outfall locations are in close proximity to physical and environmental constraints that restrict the space available for provision of a detention basin. Detention basins also require regular maintenance to remove sediment and providing access in such a constrained site can be difficult.

- **Oversized Filter Drains**: An oversized filter drain could be utilised in discrete locations to provide a greater level of attenuation and treatment than a standard filter drain. Such a solution could be incorporated within the proposed carriageway cross-section, eliminating the requirement for further land-take. In addition, an oversized filter drain would not adversely impact the outfall level of the receiving watercourse and, due to relatively infrequent maintenance requirements, could be utilised within the central reserve.

- **Modular Trench Drain:** A modular trench drain is a system used to quickly intercept and collect surface run-off. Trench drains are generally channel-shaped with a grated cover flush with the surrounding road surface. Modular trench drains do not provide treatment but could convey surface run-off from a tunnel to sub-surface storage.

- **Dry Swales**: Dry swales can achieve two levels of treatment, as stated in the '*A9 Dualling Programme, Environmental Design Guide, Chapter 3, Water and Flooding (Appendix 3-1)*', where run-off is conveyed over the top surface by sheet flow. There is limited space alongside the proposed A9 dual carriageway, however there may be opportunities to locate an effective dry swale within the verge at some locations.

  Dry swales provide a greater level of attenuation than filter drains, however they do not normally deliver the necessary attenuation to replicate the natural drainage prior to development. As a result, they would need to be used alongside additional storage measures. For large dry swales, regular outfalls may be required to prevent flooding in extreme events, which could be achieved by incorporating open gratings at regular intervals. It should be noted that over-the-edge drainage to a swale cannot be achieved on kerbed side roads. Swales are also unsuitable for central reserve drainage due to maintenance requirements and access restrictions.

- **Geocellular/Modular Systems**: Attenuation could be provided by implementation of geocellular/modular storage systems. Such systems, which have a high void ratio, can be constructed below ground and used to control water discharge. The system can be used either

under trafficked or non-trafficked areas. However, they do not provide a form of treatment and maintenance of these systems to remove silt can be problematic.

- **Hydrodynamic Vortex Separator (HVS) Chambers:** The A9 Dualling Programme Environmental Design Principles suggests that where physical constraints prevent two levels of treatment from being achieved, a proprietary filtration/separation device to augment a single level of treatment may be considered.

  Implementation of an HVS chamber prior to an outfall would effectively remove sediment from run-off before discharging to receiving watercourses. The system may be suitable where there is insufficient space for a detention basin. Maintenance is similar to that for traditional gullies and can therefore be easily implemented into cyclic maintenance regimes.

- **Sump Storage Tank (with pump station)**: A sump storage tank is a below ground chamber that can collect surface run-off. Within a tunnel, a sump could be located at the low point of the road in order to collect all liquids that naturally flow to the lowest point of an alignment. Once a sump fills with liquid it is generally emptied by a vacuum tanker.

  A sump storage tank would incorporate an adjoining pump station, comprising duty and standby pumps. Sensors within the unit would activate the pumps once the level in the sump storage tank reaches an appropriate level. Run-off contained within the sump storage tank would be pumped out of the system for treatment and dispersal.

5.10.24 The indicative drainage arrangements for each route option contains a combination of the treatment and storage facilities detailed above. A summary of each option and the differential drainage components can be found in the sections below. Tables 5.46 to 5.49 provide an overview of the preliminary drainage design solutions in terms of carriageway catchments and outfall locations, which will be further developed as part of the DMRB Stage 3 assessment. The indicative outfall locations and any associated detention basins are shown on the drawings identified in Table 5.1.

5.10.25 It should be noted that while the indicative drainage designs currently incorporate detention basins, opportunities to incorporate retention ponds will be investigated as part of the DMRB Stage 3 assessment for the Preferred Route Option. Retention ponds are similar to detention basins, however they include a permanent pool of water to provide enhanced treatment properties.

Option ST2A Drainage Features

5.10.26 From its southern extent to the locality of the southern portal of the cut and cover tunnel, Option ST2A utilises filter drains and detention basins, which provide the necessary two levels of treatment. A detention basin is included in the locality of the proposed grade separated junction at Murthly on the east side of the A9, and a further two detention basins are proposed close to the southern tunnel portal, also on the east side, to attenuate and treat surface run-off from the A9 dual carriageway and realigned B867/Perth Road.

5.10.27 Surface run-off will be intercepted prior to entering the cut and cover tunnel where possible and an impermeable lining would be utilised on the tunnel roof and walls to prevent water ingress. The closed system within the cut and cover tunnel will utilise modular trenches, located at the edge of the carriageways, which will link to sump tanks that will collect any accidental spillages and water from fire suppression systems (both during routine testing and an emergency event). These sump tanks will be located below the running carriageway, at the low points within the tunnel. They will be monitored through the tunnel control building and emptied as required prior to being transported for treatment. The sump tanks would be emptied via a manhole within the tunnel carriageway. As such, one direction of the tunnel would need to be closed for this operation, utilising bi-directional traffic within the other half of the tunnel. Reduced speed limits would likely be put in place for safety reasons.

5.10.28 The sump tank within the cut and cover tunnel would be sized accordingly to account for flooding conditions. However, during flood events it is not envisaged that the closed system within the tunnel would experience a surge in run-off, largely as the tunnel is enclosed and adequate drainage is proposed outwith the tunnel, immediately adjacent to the tunnel portals. This will be considered further as part of the DMRB Stage 3 assessment if Option ST2A progresses as the Preferred Route Option. If further assessment identifies the need for additional measures during flood events, back-up pumps could be installed to pump collected run-off to adjacent detention basins or to the tunnel control building, where a storage tank would be required.

5.10.29 Between the northern extent of the cut and cover tunnel and the proposed Dunkeld Junction (approximate Ch. 3,730 to 4,038), run-off would be collected via filter drains, providing the first level of treatment. To provide attenuation for runoff within the 100 metre length immediately adjacent to the cut and cover tunnel (approximate Ch. 3,730 to 3,830), an oversized filter drain or geocellular/modular system could be used. In this instance, given the space constraints and as a geocellular/modular system would require greater excavation, an oversized filter drain is considered the most likely solution.

5.10.30 It is proposed that run-off within the 100 metre length immediately adjacent to the cut and cover tunnel (approximate Ch. 3,730 to 3,830) would be discharged from the oversized filter drain into an HVS, to treat pollutants. A carrier drain, linking to the HVS, will then carry run-off from the HVS through the tunnel, within the tunnel verge, to discharge into Inchewan Burn. The carrier drain is located within the tunnel as existing topography outwith the tunnel extents would result in the carrier drain being more than 10 metres below ground level, introducing access and maintenance complications. Furthermore, this would be at the rear of the bored piles that form the tunnel walls, with excavation likely to affect the structural integrity of the tunnel.

5.10.31 The discharge to Inchewan Burn would be fitted with a non-return valve. However, during flood events, there is a risk of back-up in the system, which has the potential to cause flooding within the tunnel. As such, to provide a greater volume of storage, the section of pipe closest to the Inchewan Burn outfall will be oversized. The system will also be linked to a second sump tank within the tunnel, underneath the carriageway. In the event of a flood and the system backing-up, excess run-off would be diverted to the second sump tank to prevent the tunnel flooding. Once full, the pumps within the sump storage tank will become operational, discharging the already treated run-off, directly to Inchewan Burn, downstream of the tunnel. This system will ensure that treated run-off is kept completely separate from run-off collected within the tunnel, which may contain contaminants.

5.10.32 The section of filter drain occupying the approximate 200 metre length immediately on approach to Dunkeld Junction (approximate Ch. 3,830 to 4,038) will outfall to the detention basin on the west of the A9, adjacent to the unclassified road to Inver, satisfying requirements for two levels of treatment. However, due to the existing topography and alignment of the proposed A9 dual carriageway, the connecting pipes will be approximately 5.5 metres below finished carriageway level. As such, this introduces complications for future maintenance.

5.10.33 North of the proposed Dunkeld Junction, filter drains and detention basins are utilised within Option ST2A, to attenuate and treat surface run-off. This provides the necessary two levels of treatment prior to discharging to adjacent watercourses. The section of proposed A9 immediately north of the Dunkeld Junction utilises a detention basin to the west of the A9, between the proposed dual carriageway and the realigned unclassified road to Inver. Further detention basins are located on the west of the A9 at Inver and north of The Hermitage. Detention basins are also located in the locality of the proposed Dalguise Junction, to the east of the proposed A9 dual carriageway and Highland Main Line railway, and to the immediate north of the River Tay crossing, on the west side of the A9. As noted previously, the drainage design, including the position of detention basins, will be reviewed in greater detail as part of the DMRB Stage 3 assessment.

5.10.34 A small detention basin is included in Option ST2A in the locality of the access road to properties on Birnam Glen, to the west of Dunkeld & Birnam Station. This basin is located between the access road and the Highland Main Line railway, outwith the boundary of the Ladywell Landfill site, and will attenuate and treat run-off from the access road.

5.10.35 While it is acknowledged that providing adequate drainage within and in close proximity to the cut and cover tunnel section for Option ST2A is complex, the above text identifies a system that would effectively drain the route. However, the maintenance requirements, as well as related cost and traffic management implications, associated with transporting run-off from the cut and cover tunnel section for treatment and dispersal does not represent good practice in terms of overall sustainability.

5.10.36 It should be noted that an indicative drainage design has not been developed for the area above the cut and cover tunnel at this stage. This will be considered further as part of the DMRB Stage 3 assessment if Option ST2A is taken forward as the Preferred Route Option. However, it is envisaged that any proposed drainage system would require a connection to the existing side road network.

5.10.37 A summary of the proposed drainage for Option ST2A is included in Table 5.46.

Table 5.46: Option ST2A - Drainage Catchments and Outfall Locations

Run	Section	Mainline Chainage (m)		Indicative SuDS Treatment & Attenuation Measures	Outfall
		Start	End		
A	Southern Extent of Scheme to Murthly Junction	0	800	Filter Drain & Detention Basin	River Tay
B	Murthly Junction to Southern Tunnel Portal	800	2,150	Filter Drain & Detention Basin	River Tay
C	Realigned Perth Road/B867 Side Road	-	-	Filter Drain & Detention Basin	River Tay
T1	Tunnelled section Southern Portal to Low Point	2,150	2,750	Modular Trench Drain & Sump Storage Tank (Internal Tunnel closed system) Runoff to be transported for treatment offsite[1]	To be confirmed[1]
T2	Tunnelled section Low Point to Northern Portal	2,750	3,730	Modular Trench Drain & Sump Storage Tank (Internal Tunnel closed system) Runoff to be transported for treatment offsite[1]	To be confirmed[1]
T3	Tunnel Northern Portal to Ch 3830	3,730	3,830	Oversized Filter Drain & HVS	Inchewan Burn
T4	Ch 3830 South of Dunkeld Roundabout Junction	3,830	4,038	Filter Drain & Detention Basin	River Braan
D	Birnam Glen Access Road	-	-	Filter Drain & Detention Basin	Inchewan Burn
E	Realigned A923	-	-	Filter Drain tie-in to Existing Drainage Network	Existing Drainage Network
F	Dunkeld Roundabout Junction to River Braan	4,038	4,300	Filter Drain & Detention Basin	River Braan
G	River Braan to North of Inver Rail Underbridge	4,300	5,830	Filter Drain & Detention Basin	Inver Mill Lade
H	North of Inver Rail Underbridge to Dalguise Junction	5,830	6,300	Filter Drain & Detention Basin	River Tay through Unnamed Watercourse 12A
I	Dalguise Junction to River Tay Crossing	6,300	7,380	Filter Drain & Detention Basin	River Tay

Run	Section	Mainline Chainage (m)		Indicative SuDS Treatment & Attenuation Measures	Outfall
		Start	End		
J	River Tay Crossing to Northern Extent of Scheme	7,390	8,330	Filter Drain & Detention Basin	River Tay

Table Notes:

1) This will be considered further as part of the DMRB Stage 3 assessment if Option ST2A progresses as the Preferred Route Option.

Option ST2B Drainage Features

5.10.38 Over the southern extent of Option ST2B, from the southern tie-in point to the proposed Birnam Junction, filter drains and detention basins are utilised to provide the appropriate level of attenuation and treatment prior to discharge into surrounding watercourses. Detention basins are located in the locality of the Murthly Castle Access Road, on the east side of the proposed A9, and alongside the realigned B867/Perth Road that forms part of Birnam Junction, also on the east side of the A9.

5.10.39 To the north of the proposed Birnam Junction, the A9 begins to lower, due to the underpass structure in the locality of Dunkeld & Birnam Station. Through this section, filter drains continue to be employed in the verges (and central reserve as appropriate) to intercept surface run-off and provide one level of treatment. However, as the A9 is lower than adjacent ground levels and due to the constrained nature of the site, with residential and commercial properties on the east and the Highland Main Line railway and Dunkeld & Birnam Station to the west, detention basins are not considered appropriate. To further treat surface run-off, it is proposed to utilise an HVS, which would be in the locality of the low point towards the northern extent of the underpass, immediately south of Inchewan Burn. A geocellular/modular storage system would be required beneath the road at this location to store run-off and control discharge into Inchewan Burn. This outfall would be fitted with a non-return valve to prevent backwards flow from the burn. It should be noted that the geocellular/modular system below the carriageway requires to be maintained regularly, likely once or twice each year. As such, one direction of the carriageway would need to be closed to undertake maintenance, using bi-directional traffic on the other carriageway. Reduced speed limits would likely be put in place for safety reasons.

5.10.40 A similar solution, utilising filter drains, HVS and geocellular/modular storage would be utilised for the section of proposed A9 dual carriageway between the Inchewan Burn and proposed Dunkeld Junction. Between Dunkeld Junction and the River Braan, filter drains and detention basins are included in Option ST2B, providing the necessary two levels of treatment.

5.10.41 North of Dunkeld Junction, the proposed A9 is largely at existing carriageway levels. While there are a number of adjacent constraints, which dictate where detention basins can be placed, it is not as constrained as the section to the south. As detailed for Option ST2A, Option ST2B utilises filter drains and detention basins to attenuate and treat surface run-off, achieving the desired two levels of treatment. The locations of the detention basins to the north of Dunkeld Junction are the same as that detailed for Option ST2A.

5.10.42 As with Option ST2A, Option ST2B includes a small detention basin in the locality of the access road to properties on Birnam Glen, to the west of Dunkeld & Birnam Station. This basin is located between the access road and the Highland Main Line railway, outwith the boundary of the Ladywell Landfill, and will attenuate and treat run-off from the access road.

5.10.43 It should be noted that an indicative drainage design has not been developed for the area above the underpass structure at this stage. This will be considered further as part of the DMRB Stage 3 assessment if Option ST2B is taken forward as the Preferred Route Option. However, it is envisaged that any proposed drainage system would require a connection to the existing side road network.

5.10.44 A summary of the proposed drainage for Option ST2B is included in Table 5.47.

Table 5.47: Option ST2B - Drainage Catchments and Outfall Locations

Run	Section	Chainage (m)		Indicative SuDS Treatment & Attenuation Measures	Outfall
		Start	End		
A	Southern Extent of Scheme to Murthly Estate Underbridge	0	860	Filter Drain & Detention Basin	River Tay
B	Murthly Estate Underbridge to North of Birnam Junction	860	2,550	Filter Drain & Detention Basin	River Tay
C	North of Birnam Junction to Inchewan Burn	2,550	3,490	Filter Drain, HVS & Geocellular/Modular System	Inchewan Burn
D	Birnam Glen Access Road	-	-	Filter Drain & Detention Basin	Inchewan Burn
E	Inchewan Burn to Dunkeld Roundabout Junction	3,490	3,900	Filter Drain, HVS & Geocellular/Modular System	Inchewan Burn
F	Dunkeld Roundabout Junction to River Braan	3,900	4,300	Filter Drain & Detention Basin	River Braan
G	Realigned A923	-	-	Filter Drain tie-in to Existing Drainage Network	Existing Drainage Network
H	River Braan to North of Inver Rail Underbridge	4,300	5,830	Filter Drain & Detention Basin	Inver Mill Lade
I	North of Inver Rail Underbridge to Dalguise Junction	5,830	6,300	Filter Drain & Detention Basin	River Tay through Unnamed Watercourse 12A
J	Dalguise Junction to River Tay crossing	6,300	7,380	Filter Drain & Detention Basin	River Tay
K	River Tay crossing to Northern Extent of Scheme	7,380	8,330	Filter Drain & Detention Basin	River Tay

Option ST2C Drainage Features

5.10.45 Option ST2C is generally at-grade throughout, apart from the section to the north of Dunkeld & Birnam Station that is raised to accommodate Dunkeld Junction, which is grade separated. As such, filter drains and detention basins are proposed throughout Option ST2C. However, in the locality of Dunkeld Junction a geocellular/modular system is required to attenuate run-off from sections of the southbound slip roads and realigned A923/A822 (Old Military Road) prior to discharge, largely as insufficient space exists for detention basins.

5.10.46 At the southern extent of the scheme, detention basins are proposed in the locality of the Murthly Castle Access Road, on the east side of the proposed A9, and alongside the realigned B867/Perth Road that forms part of the Birnam Junction, also to the east of the A9.

5.10.47 North of Birnam Junction, a detention basin is proposed on the east side of the A9, adjacent to Gladstone Terrace and the proposed station car park. A further detention basin is proposed on the north side of the Inchewan Burn in the locality of residential properties of Stell Park Road. Similarly, to Options ST2A and ST2B, a detention basin is included in Option ST2C on the immediate west of the A9, alongside the unclassified road to Inver. It should be noted that this basin is larger for Option ST2C due to the increased catchment area from the southbound slip roads, realigned A923/A822 (Old Military Road) and Unclassified Road to Inver. As noted above, runoff from part of Dunkeld Junction is required to outfall to a geocellular/modular system due to space constraints at the junction. It is proposed that the geocellular/modular system would connect to the existing drainage network on the A923.

5.10.48 To the north of the River Braan crossing, detention basins are proposed at Inver, north of The Hermitage, at Dalguise Junction and immediately north of the River Tay crossing, as detailed for Options ST2A and ST2B.

5.10.49 Option ST2C includes a Network Rail maintenance access track to Dunkeld & Birnam Station, as well as a new station car park on the site of the existing Birnam Industrial Estate. Filter drains would be used for the maintenance access track, and permeable trench drains or permeable paving would be utilised within the station car park. The drainage system would tie-in to the existing side road drainage network on Station Road. It is noted that an alternative solution, whereby runoff from the station car park is discharged to the Inchewan Burn, could be investigated should the local authority (PKC) identify any issues. Should Option ST2C be taken forward as the Preferred Route Option, these options will be considered in greater detail as part of the DMRB Stage 3 assessment, in consultation with PKC.

5.10.50 A summary of the proposed drainage for Option ST2C is included in Table 5.48.

Table 5.48: Option ST2C - Drainage Catchments and Outfall Locations

Run	Section	Chainage (m)		Indicative SuDS Treatment & Attenuation Measures	Outfall
		Start	End		
A	Southern Extent of Scheme to Murthly Estate Underbridge	0	880	Filter Drain & Detention Basin	River Tay
B	Murthly Estate Underbridge to North of Birnam Junction	880	2,570	Filter Drain & Detention Basin	River Tay
C	North of Birnam Junction to Dunkeld & Birnam Station Car Park	2,570	3,280	Filter Drain & Detention Basin	Inchewan Burn
C/D	Dunkeld & Birnam Station Car Park to North of Inchewan Burn	3,280	3,550	Filter Drain & Detention Basin	Inchewan Burn
D	Dunkeld Junction (Southbound Slip Roads and Realigned A923/A822 (Old Military Road))	N/A	N/A	Filter Drain, HVS & Geocellular/Modular System	Existing Drainage Network
E	North of Inchewan Burn to River Braan, including Dunkeld Junction	3,550	4,300	Filter Drain & Detention Basin	River Braan
F	River Braan to North of Inver Rail Underbridge	4,300	5,830	Filter Drain & Detention Basin	Inver Mill Lade
G	North of Inver Rail Underbridge to Dalguise Junction	5,830	6,300	Filter Drain & Detention Basin	River Tay through Unnamed Watercourse 12A
H	Dalguise Junction to River Tay Crossing	6,300	7,380	Filter Drain & Detention Basin	River Tay
I	River Tay Crossing to Northern Extent of Scheme	7,380	8,330	Filter Drain & Detention Basin	River Tay
J	Station Car Park and Maintenance Access to Dunkeld & Birnam Station	N/A	N/A	Filter Drains and Permeable Trench Drains/Permeable Paving	Existing Drainage Network

Option ST2D Drainage Features

5.10.51 As Option ST2D is generally at-grade, similar to Option ST2C, filter drains and detention basins are proposed throughout. Detention basins are proposed in the locality of Murthly Castle Access Road, alongside the realigned B867/Perth Road that forms part of the Birnam Junction, in the locality of the proposed station car park, alongside the unclassified road to Inver, at Inver, to the north of The Hermitage, in the locality of Dalguise Junction and to the north of the River Tay crossing.

5.10.52 Option ST2D also includes a proposed drainage system for the maintenance access to Dunkeld & Birnam Station and proposed station car park. This would be the same as that detailed for Option ST2C.

5.10.53 A summary of the proposed drainage for Option ST2D is included in Table 5.49.

Table 5.49: Option ST2D - Drainage Catchments and Outfall Locations

Run	Section	Chainage (m)		Indicative SuDS Treatment & Attenuation Measures	Outfall
		Start	End		
A	Southern Extent of Scheme to Murthly Estate Underbridge	0	860	Filter Drain & Detention Basin	River Tay
B	Murthly Estate Underbridge to North of Birnam Junction	860	2,650	Filter Drain & Detention Basin	River Tay
C	North of Birnam Junction to Inchewan Burn	2,650	3,440	Filter Drain & Detention Basin	Inchewan Burn
D	Inchewan Burn to River Braan	3,440	4,300	Filter Drain & Detention Basin	River Braan
E	Realigned A923	-	-	Filter Drain tie-in to Existing Drainage Network	Existing Drainage Network
F	River Braan to North of Inver Rail Underbridge	4,300	5,830	Filter Drain & Detention Basin	Inver Mill Lade
G	North of Inver Rail Underbridge to Dalguise Junction	5,830	6,300	Filter Drain & Detention Basin	River Tay through Unnamed Watercourse 12A
H	Dalguise Junction to River Tay crossing	6,300	7,380	Filter Drain & Detention Basin	River Tay
I	River Tay crossing to Northern Extent of Scheme	7,380	8,330	Filter Drain & Detention Basin	River Tay
J	Station Car Park and Maintenance Access to Dunkeld & Birnam Station	N/A	N/A	Filter Drains and Permeable Trench Drains/Permeable Paving	Existing Drainage Network

Drainage (Side Roads)

5.10.54 As detailed above, the scheme interfaces with the existing side road network at a number of locations, including at Murthly/Birnam, Dunkeld and Dalguise Junctions, where side roads will be realigned as part of the works. The realigned side roads will form part of the overall junction arrangements and connect to the proposed A9 drainage systems as outlined. However, at Dunkeld & Birnam Station car park, and Dunkeld Junction, it is likely that drainage infrastructure would connect to the existing side road network.

5.10.55 The proposals outlined above are indicative and will be subject to further discussions with the relevant stakeholders. As part of the DMRB Stage 3 assessment, the drainage design for the Preferred Route Option will be refined and alternative proposals may be identified. These proposals may include kerbs, gullies and filter drains.

5.10.56 Where a kerb and footway are proposed, it is likely traditional gullies will be employed to collect surface run-off. To facilitate a level of treatment, run-off could be discharged into an adjacent filter drain within the verge, where water will percolate through filter medium before entering a carrier drain. It should be noted that the limited depth between pipes is likely to restrict the effective filtration, and maintenance access is an issue.

5.10.57 These methods will require further discussion with PKC to determine their acceptability, given the more onerous maintenance requirements associated with these systems.

Drainage Departures from Requirements

5.10.58 The indicative drainage designs have been developed in accordance with the DMRB, including the documents listed below.

- CG 501: Design of highway drainage systems;
- CD 523: Determination of pipe roughness and assessment of sediment deposition to aid pipeline design;
- CD 524: Edge of pavement details;
- CD 525: Design of combined surface and sub-surface drains and management of stone scatter;
- CD 528: Vortex separators for use with road drainage systems;
- CD 529: Design of outfall and culvert details;
- CD 531: Reservoir pavements for drainage attenuation;
- CD 532: Vegetated drainage systems for highway runoff;
- CD 533: Determination of pipe and bedding combinations for drainage works; and
- CD 534: Chamber tops and gully tops for road drainage and services.

5.10.59 To reduce impacts on adjacent environmental and physical constraints, and to lessen construction complexity and costs, Departures from requirements can be incorporated into the drainage design. Departures from requirements cover a range of drainage parameters, including drainage connections, SuDS design, diameter of filter drains, and design of outfall and culvert details. Any Departure from requirements applied to the design must consider the safety aspects on the reduced standard and provide suitable justification.

5.10.60 Based on the preliminary drainage design that has been undertaken at this stage, no Departures from requirements have been identified. However, further development of the drainage design will be completed as part of the DMRB Stage 3 assessment with the aim of eliminating or reducing any variation from the recommendations or requirements of the DMRB. This will be completed in consultation with the Overseeing Organisation (Transport Scotland, Roads).

5.11 Structures

5.11.1 This section provides a general overview of the requirements for structures for the Pass of Birnam to Tay Crossing project. While many of the structures are located in the same locations for the route options, the specific structure configurations vary to accommodate the particular requirements of the differing alignments at each site.

5.11.2 With the exception of the junction locations, the structures are described from south to north, with the separate route options discussed within the text for each structure. Outline details of potential structural solutions are provided in each case. Solutions will be further developed as part of the DMRB Stage 3 assessment following selection of a Preferred Route Option and enhanced details will be provided at that stage. All structural solutions described comply with the DMRB and it is not envisaged that any Departures from requirements will be required at this stage.

5.11.3 The proposals below are based on adopting concrete construction, either cast in-situ or precast, where spans permit, as this is generally the most cost-effective type of construction. However, where larger spans cannot be avoided, steel concrete composite construction is proposed.

5.11.4 Wherever possible, integral construction has been proposed to minimise long-term maintenance requirements and costs where the overall length of the structure does not exceed 60 metres and the

skew does not exceed 30°. In cases where integral construction is not appropriate, bearings and movement joints will be provided in conjunction with abutment inspection galleries.

5.11.5 The proposed locations of the structures described below are shown on the drawings listed below, which are included in Volume 2: Engineering Drawings.

- A9P02-JAC-SGN-A_MLZZZ_ZZ-FG-ST-0001;
- A9P02-JAC-SGN-A_MLZZZ_ZZ-FG-ST-0002;
- A9P02-JAC-SGN-B_MLZZZ_ZZ-FG-ST-0001;
- A9P02-JAC-SGN-B_MLZZZ_ZZ-FG-ST-0002;
- A9P02-JAC-SGN-C_MLZZZ_ZZ-FG-ST-0001;
- A9P02-JAC-SGN-C_MLZZZ_ZZ-FG-ST-0002;
- A9P02-JAC-SGN-D_MLZZZ_ZZ-FG-ST-0001; and
- A9P02-JAC-SGN-D_MLZZZ_ZZ-FG-ST-0002.

Underbridges

5.11.6 In the context of the A9 Dualling Programme, underbridges are structures which allow the A9 dual carriageway to cross over a road, railway or watercourse. It is proposed that the carriageway width, including hardstrips, will be continued over decks of underbridges. In addition, verges and central reserves of the A9 carriageway will be continued with no reduction of width, in accordance with the DMRB (CD127: Cross-sections and headrooms). The carriageway width, hardstrips, where provided, and verges of local roads will be continued through underbridges.

Overbridges

5.11.7 In the context of the A9 Dualling Programme, overbridges are structures which allow the A9 dual carriageway to cross underneath a road or railway. The carriageway width and, where provided, hard strips of local roads will be continued over the decks of overbridges. In addition, the verges of local roads carried by overbridges, and the verge and central reserve of the A9 beneath overbridges, will be continued through the structure. This is in accordance with the DMRB (CD127: Cross-sections and headrooms).

General

5.11.8 At certain locations, it may be necessary to widen, lengthen or increase the span of structures to accommodate forward visibility requirements. This will be more likely where road alignments are curved or where structures are located in the vicinity of junctions. Widening would be accommodated by increasing the width of the verge and central reserve as appropriate.

5.11.9 All route options require the extension, replacement or demolition of six existing bridges. In addition, up to six new structures will be required across the route options to facilitate access and accommodate grade separated junctions. These are described below.

<u>Murthly Junction Overbridge (Option ST2A)</u>

5.11.10 This structure will carry Murthly Estate Access Track, which forms part of the grade separated junction, over the A9 dual carriageway. It will be a three-span structure with a central span approximately 27 metres long and side spans approximately 11.5 metres long. The width of the deck will be approximately 15 metres. There is no skew.

5.11.11 This route option is based on widening the existing carriageway on both sides at this location.

5.11.12 The new structure will be continuous over the piers and integral at the abutments. The deck will comprise precast prestressed concrete beams composite with an in-situ reinforced concrete slab. The substructure will be reinforced concrete bank seat abutments and piers comprising circular reinforced concrete columns. It is likely that the new structure will be able to adopt spread footings.

Murthly Estate Underbridge (Options ST2B, ST2C and ST2D)

5.11.13 This new structure will carry the A9 dual carriageway over a new road providing access to Murthly Estate. It will be a single span structure with a clear square span of approximately 9 metres and no skew. The structure width will be approximately 27 metres.

5.11.14 Options ST2B, ST2C and ST2D are identical at this location and are based on widening the existing carriageway on both sides.

5.11.15 The new structure will be integral. The dual carriageway alignment remains at existing carriageway level and the access road is in cutting below. The structure will comprise precast concrete arch units on concrete abutments. It is likely that the new structure will be able to adopt spread footings. Stone masonry cladding will be applied to the exposed concrete surfaces to improve the structure's aesthetics.

Birnam Junction Underbridge (Options ST2B, ST2C and ST2D)

5.11.16 This structure will carry the A9 dual carriageway over the realigned B867/Perth Road. The cross-section of the dual carriageway tapers over the length of the structure to accommodate the northbound merge slip road. It will be a skewed three-span structure with the skew varying from approximately 54.8° to 57°. The skewed central span length varies from approximately 31 metres to 32.5 metres and the side span lengths vary from approximately 19 metres to 21 metres. The square width of the deck varies between approximately 29 metres and 31 metres.

5.11.17 This route option is based on widening the existing carriageway to the southbound side.

5.11.18 The new structure will be continuous over the piers and simply supported at the abutments, as the skew is in excess of 30°. The deck will comprise precast prestressed concrete beams composite with an in-situ reinforced concrete slab. The substructure will be reinforced concrete bank seat abutments and piers comprising circular reinforced concrete columns. It is likely that the new structure will be able to adopt spread footings. Abutment galleries will be provided to allow the future inspection and maintenance of bearings and expansion joints.

Cut and Cover Tunnel (Option ST2A)

5.11.19 The cut and cover tunnel will allow the reconnection of Dunkeld & Birnam Station with Station Road by placing the A9 dual carriageway in a twin-box tunnel. It will be a two-span structure comprising three lines of bored pile walls, including an intermediate pier within the central reserve. The structure will have clear spans of approximately 10.7 metres and 13.1 metres. Headroom of 7.95 metres will be provided in each tunnel box to provide the 6.45 metres minimum traffic headroom and sufficient space for Mechanical and Electrical equipment, which includes ventilation. A separate concrete portal will be constructed in the southbound tunnel box to provide an emergency pedestrian escape route. The emergency tunnel will be 1.8 metres wide and 5.85 metres high, with regularly spaced openings into both tunnel boxes. The total length of the structure will be approximately 1.5 kilometres.

5.11.20 This route option is based on widening the existing carriageway on the northbound side at this location and lowering the alignment by approximately 10 metres.

5.11.21 The structure will be integral. The finished ground level over the top of the structure will remain at existing carriageway level and the new dual carriageway will pass through twin boxes below. Cover

level between the ground surface and the slab deck will vary, however it will likely be approximately 0.5 metres. It is assumed that topsoil and free draining material would be positioned on the slab deck to facilitate vegetation growth, however as the depth of material is limited, vegetation would be restricted to that with shallow rooting depths to protect the structure.

5.11.22 With the exception of a short section over the Inchewan Burn, the tunnel will be constructed using top-down techniques. The slab deck will comprise precast prestressed concrete beams composite with in-situ concrete infill to minimise construction time. The substructure will be formed by concrete-faced contiguous bored piles walls. The piles will have a diameter of 1.2 metres and a length of approximately 9 metres above finished road level. The overall depth of the piles below road level will be confirmed at a later stage. Infill concrete will be placed between the bored piles and a 0.45 metres thick reinforced concrete facing applied to each pile wall. A 1 metre thick slab will form the base of each box, propping the pile walls below carriageway level.

5.11.23 To allow realignment of the Inchewan Burn, a section of the tunnel, at approximate Ch. 3,450, will be constructed in-situ as twin reinforced concrete boxes using bottom-up techniques. The deck will comprise precast prestressed concrete beams with in-situ concrete infill, as in other sections of the tunnel, while the base slab will be 1 metre thick, except locally over the culvert where it will be 0.6 metres thick.

5.11.24 The tunnel will be constructed in four distinct sections. Construction of the section adjacent to the existing station building will follow an alternative construction phasing due to the additional complexity within this location. A 50 metre span temporary bridge will be required as an off-line diversion for the existing A9 single carriageway during demolition of the existing Birnam Glen Underbridge, installation of the Inchewan Burn Culvert and construction of the bottom-up tunnel segment.

A9 Dual Carriageway Underpass (Option ST2B)

5.11.25 This structure will allow the reconnection of Dunkeld & Birnam Station with Station Road by placing the A9 dual carriageway in an underpass adjacent to the station. It will be a two-span structure comprising three lines of bored pile walls, including an intermediate pier within the central reserve. The structure will create space for a new station access route and station car park. Each span will be approximately 14 metres long and the underpass will be approximately 150 metres wide.

5.11.26 This route option is based on widening the existing carriageway on the northbound side.

5.11.27 The new structure will be integral and continuous over the pier. The new access road alignment and car park remain at existing carriageway level and the new dual carriageway is in the underpass below, allowing the structure to be constructed using top-down techniques. The slab deck will comprise precast prestressed concrete beams with in-situ concrete infill to minimise construction time. Substructures will be formed of contiguous bored pile walls with an in-situ concrete facing.

Pedestrian Underpass (Options ST2C and ST2D)

5.11.28 This structure will carry the A9 dual carriageway over a pedestrian access from the new station car park and entrance plaza area to Dunkeld & Birnam Station. The underpass will be a single span structure with a clear square span of 5 metres, no skew and headroom of 3 metres. The length of the underpass will be approximately 28 metres.

5.11.29 The underpass will comprise precast concrete box sections to minimise construction time. It will extend from the car park and entrance plaza, passing beneath the A9 carriageway, to Platform 1 (southbound), alongside the station building.

Birnam Glen and Inchewan Burn Underbridge (Option ST2C and Option ST2D)

5.11.30 This structure will carry the A9 dual carriageway over Birnam Glen and Inchewan Burn, which is a tributary of the River Tay. To maintain the headroom provision above Birnam Glen at a clearance similar to the adjacent railway bridge, the complete replacement of the existing A9 structure will be required. The new bridge will be a two-span structure with a width of approximately 27 metres and a skew angle of approximately 5°. The clear span over Birnam Glen will be approximately 7 metres long and the span over the burn will be approximately 18 metres long.

5.11.31 This route option is based on widening the existing carriageway to the northbound side.

5.11.32 The structure will be integral and continuous over the central pier. The deck over Birnam Glen will comprise precast prestressed concrete beams with in-situ concrete infill, whereas the deck over the burn will comprise precast prestressed concrete beams with an in-situ slab above. The substructure will comprise ¾ height reinforced concrete abutments and a reinforced concrete leaf pier. It is likely that the new structure will be able to adopt spread footings.

Inchewan Burn Culvert (Option ST2A)

5.11.33 This new structure will carry the Inchewan Burn, which is a tributary of the River Tay, below the new cut and cover tunnel. It will be a single span box culvert structure with a clear square span of approximately 2.5 metres and an internal clear height of approximately 1.5 metres. The length of the culvert will be approximately 55 metres.

5.11.34 The structure will comprise precast concrete units and it will have a vertical drop structure approximately 8 metres high at the upstream end to achieve the level change needed to pass beneath the lowered A9 dual carriageway.

Inchewan Burn Culvert (Option ST2B)

5.11.35 This new structure will carry the A9 dual carriageway over the Inchewan Burn. It will be positioned immediately north of the A9 Dual Carriageway Underpass (Option ST2B) and will be a single span box culvert structure with a clear square span of approximately 2.5 metres and an internal clear height of approximately 1.5 metres. The length of the culvert will be approximately 35 metres.

5.11.36 This route option is based on widening the existing carriageway on the northbound side.

5.11.37 The structure will comprise precast concrete units and it will have a vertical drop structure approximately 6 metres high at the upstream end to achieve the level change needed to pass beneath the lowered carriageway.

Birnam Glen Access Bridge (Option ST2A and ST2B)

5.11.38 This structure will carry the new Birnam Glen Access Road over Birnam Glen and Inchewan Burn to access residential properties to the west of Dunkeld & Birnam Station. The new bridge will be a single span structure with a clear square span of approximately 30 metres and a width of approximately 11.5 metres. There is no skew.

5.11.39 The structure will be integral. The deck will comprise precast prestressed concrete beams with an in-situ slab above. The substructure will be reinforced concrete bank seat abutments. It is likely that the new structure will be able to adopt spread footings.

Dunkeld Junction Underbridge (Option ST2C)

5.11.40 This structure will carry the A9 dual carriageway over the realigned A923/A822 (Old Military Road). It will be a three-span integral structure with a central skew span length of approximately 25 metres and

side spans approximately 15-metres-long (skewed). The square width of the deck is approximately 32.5 metres, and the skew angle of the structure is approximately 23°.

5.11.41 This route option is based on widening the existing carriageway towards the northbound side.

5.11.42 The new structure will be continuous over the piers. The deck will comprise precast prestressed concrete beams with an in-situ concrete slab above. The substructure will be reinforced concrete bank seat abutments and piers comprising circular reinforced concrete columns. It is likely that the new structure will be able to adopt spread footings.

River Braan Underbridge (Options ST2A, ST2B and ST2D)

5.11.43 This structure will carry the A9 dual carriageway over the River Braan, which is a tributary of the River Tay and forms part of the River Tay SAC. The existing structure lies below the 1 in 200 year flood level, meaning that it cannot be retained, and a new structure is required for each route option.

5.11.44 The new alignment raises the mainline approximately 3 metres above the existing A9 carriageway at the river crossing. The new structure will be a single span integral bridge with a clear square span of approximately 41 metres and no skew. The width of the new bridge will be approximately 30 metres.

5.11.45 These route options are based on widening the existing carriageway on the northbound side.

5.11.46 The structure will have a composite deck of five braced pairs of steel plate girders with a transversely spanning reinforced concrete slab. The substructure will be reinforced concrete bank seat abutments. It is likely that the new structure will be able to adopt spread footings.

River Braan Underbridge (Option ST2C)

5.11.47 This structure will carry the A9 dual carriageway over the River Braan, which is a tributary of the River Tay and forms part of the River Tay SAC.

5.11.48 This route option is based on widening the existing carriageway on the northbound side. The proximity of the Dunkeld Junction means that it incorporates slip roads which also cross the River Braan as part of the A9 structure.

5.11.49 This alignment option is based on a raised mainline approximately 13 metres above the existing A9 carriageway at the river crossing. The new structure will be a three-span bridge, with separate decks for the northbound merge slip road, the A9 carriageway and the southbound diverge slip road. The decks have spans of approximately 30.5 metres, 44.5 metres and 30.5 metres, with skews ranging from approximately 0° to 6°. The widths of the decks are approximately 13.5 metres, 33.5 metres and 14.5 metres.

5.11.50 The new structure will be simply supported at the abutments and continuous over the piers. The steel composite decks will comprise two braced pairs of steel plate girders for each of the slip roads and five braced pairs of steel plate girders for the mainline, with a transversely spanning reinforced concrete deck in all cases. Substructures will be reinforced concrete bank seat abutments with discrete intermediate piers for each pair of steel beams. Abutment galleries will be provided to allow the future inspection and maintenance of the bearings and expansion joints. It is likely that the new structure will be able to adopt spread footings.

Inver Mill Lade Culvert (Options ST2A, ST2B, ST2C and ST2D)

5.11.51 This structure will carry the A9 dual carriageway over the Inver Mill Lade watercourse. For all alignment options this will be a single span buried structure with a clear square span of approximately 3.5 metres and nominal internal height of approximately 2 metres. The length of the culvert extension measured

along the watercourse will be approximately 12 metres for Options ST2A, ST2B and ST2D and 10 metres for Option ST2C.

5.11.52 All route options are similar at this location and are based on widening the existing carriageway to the southbound side. The proposed road alignment at this location extends beyond the plan extent of the existing structure on one side only (the north side) and as such extension of the existing structure is likely.

5.11.53 The extended structure will be of precast concrete portal construction and square to the existing culvert. The extension will be supported on piled footings and scour protection aprons are likely to be required, topped with natural gravel to reinstate the watercourse.

Inver Rail Underbridge (Options ST2A, ST2B, ST2C and ST2D)

5.11.54 This structure will carry the A9 dual carriageway over the single track Highland Main Line railway. For all alignment options the new bridge will be a single span structure with a clear square span of approximately 7.5 metres, a clear skew span of approximately 9.1 metres and a skew angle of approximately 35°. The A9 and the railway cross at an angle of approximately 64°. The length of deck extension will be approximately 65 metres.

5.11.55 All route options are identical at this location and are based on widening the existing carriageway to the southbound side. The proposed road alignment at this location extends beyond the plan extent of the existing structure on the north side only and as such, extension of the existing structure is likely. Although this will require a diagonal joint beneath the central reserve, the size of the existing structure and the associated railway interface means complete replacement is unlikely.

5.11.56 The extension will be simply supported, and the slab deck will comprise precast prestressed concrete beams with in-situ concrete infill to minimise construction time and hence railway possessions. Substructures will be full height reinforced abutments. It is likely that piled footings will be required.

Dalguise Junction Underbridge (Options ST2A, ST2B, ST2C and ST2D)

5.11.57 This new structure will carry the A9 dual carriageway and northbound merge slip road over the realigned B898. The bridge curves in plan and the span increases to the western end of the bridge to follow the curvature of the road and allow for a junction with the northbound merge and diverge slip roads. For all alignment options, the new bridge will be a single span structure with a square span varying from approximately 15.5 metres to 20 metres, a skew span varying from approximately 18 metres to 23.5 metres and a skew angle of approximately 30°. The overall length of the proposed structure will be approximately 130 metres.

5.11.58 The structure will be integral. The dual carriageway alignment remains close to existing carriageway level and the realigned B898 is in cutting below, such that the slightly off-line alignment allows the structure to be constructed using top-down techniques. The deck will comprise precast prestressed concrete beams with an in-situ reinforced concrete slab above. Substructures will be formed of contiguous bored pile walls with an in-situ concrete facing. The overall depth of the piles will be confirmed at a later stage of the project.

Inch Rail Underbridge (Options ST2A, ST2B, ST2C and ST2D)

5.11.59 This structure will carry the A9 dual carriageway over the single track Highland Main Line railway. For all alignment options the new bridge will be a square single span crossing structure with a clear span of approximately 9.8 metres. The A9 and the railway cross at an angle of approximately 70°. The length of deck extension will be approximately 63.5 metres.

5.11.60 All route options are identical at this location and are based on widening the existing carriageway to the southbound side. The proposed road alignment at this location extends beyond the plan extent of the existing structure on the east side only and as such, extension of the existing structure is likely. Although this will require a joint beneath the carriageway, the size of the existing structure and the associated railway interface means complete replacement is unlikely.

5.11.61 The extension will be integral, and the slab deck will comprise precast prestressed concrete beams with in-situ concrete infill to minimise construction time and hence railway possessions. Substructures will be full height reinforced concrete abutments. It is likely that piled footings will be required.

River Tay Underbridge (Options ST2A, ST2B, ST2C and ST2D)

5.11.62 This structure will carry the A9 dual carriageway over the River Tay, a Core Path on the southern bank, and a Core Path and NCN Route 77 on the northern bank. The watercourse and areas of the adjacent bank are within the River Tay SAC.

5.11.63 All route options are identical at this location and are based on widening the existing carriageway to the southbound side.

5.11.64 The alignment options utilise the existing structure to carry the northbound carriageway and a new structure will be constructed to accommodate the southbound carriageway. Retaining the existing structure provides a cost-efficient solution, whilst reducing potential construction impacts on the River Tay SAC. However, the suitability of the existing structure will be assessed as part of the DMRB Stage 3 assessment, prior to confirming that the structure can be retained.

5.11.65 The new structure will be a three-span square structure, with a central span of 135 metres and side spans of 85 metres. The superstructure for the new deck will adopt twin continuous steel box girders of uniform depth, with a composite reinforced concrete slab deck. The intermediate supports are likely to be twin circular columns on piled footings. The abutments will be reinforced concrete bank seats on piled footings. The bridge deck tapers over the length of the south span to accommodate the Dalguise Junction southbound diverge slip road.

5.11.66 Traffic flow can be maintained over the existing bridge during construction of the new structure. The two decks will likely be structurally separate.

5.12 Public Utilities

Introduction

5.12.1 This section identifies the existing utility apparatus within the A9 corridor, based on information provided by each supplier. Existing public utility infrastructure within the A9 corridor is shown on the drawings listed below that are included in Volume 2: Engineering Drawings.

- A9P02-JAC-VUT-X_ZZZZZ_ZZ-FG-RD-0001; and
- A9P02-JAC-VUT-X_ZZZZZ_ZZ-FG-RD-0002.

5.12.2 The total number of utility interfaces for each route option has been identified and is presented to provide an indication of the potential impact of the four route options on the existing public utility infrastructure. Utility diversions at the interface locations identified have not been designed, however this will be undertaken as part of the DMRB Stage 3 assessment.

5.12.3 The plan and profile drawings listed in Table 5.1 show the interaction between the utility apparatus and the route options.

Telecommunications

Network

5.12.4 British Telecommunications (BT) Openreach has utility apparatus within the existing A9 corridor. There is an existing BT Openreach underground cable that generally follows the alignment of the existing A9. To the south of the existing Birnam Junction, an underground cable is on the immediate west of the existing A9 and between Birnam and Dunkeld Junctions an underground cable is on the immediate east. North of the existing Dunkeld Junction, underground cables are located on both the east and west sides of the A9 and while there are short sections where the cables are located only to the east, this generally continues to the River Tay crossing. North of the River Tay crossing, there is an underground cable to the immediate east side of the A9. There are additional underground and overhead BT Openreach cables throughout the locality that serve the adjacent communities, the majority of which link to the underground cables alongside the A9.

5.12.5 In addition to the BT Openreach infrastructure, there is an O_2/Three mobile mast located immediately south of the River Tay crossing on the east side of the A9, opposite the existing priority junction with the B898. A further mast, owned by Arqiva is located south of the existing priority junction with the B898, on the west side of the road.

5.12.6 At the northern extent of the scheme, immediately north of the Inch Rail Underbridge, there is a Global System for Mobile Communications - Railway (GSM-R), which is located immediately adjacent to the Highland Main Line railway. This system delivers secure communications between drivers and signallers and is essential for the safe operation of the rail network. The GSM-R is within Network Rail owned land and will not be impacted by the works.

Impacts

5.12.7 Table 5.50 summarises the number of interfaces with telecommunications infrastructure for each route option.

Table 5.50: Number of Interfaces with Telecommunications Infrastructure

Route Option	Impacts on BT Openreach Underground Network	Impacts on BT Openreach Overhead Network	Impacts on Mobile Network Infrastructure	Total
ST2A	13	11	1	25
ST2B	12	12	1	25
ST2C	10	12	1	23
ST2D	10	12	1	23

5.12.8 As shown in Table 5.51, the number of impacts are broadly similar for all four options. Options ST2A and ST2B include additional impacts as a result of the new Birnam Glen Access Road, that provides access to properties to the west of Dunkeld & Birnam Station.

5.12.9 The impacts for each option vary in length and significance. The impacts for Options ST2A and ST2B, due to the lowered A9 dual carriageway and implementation of bored piled walls, will be significant and may require extensive temporary diversions during construction. For Options ST2A and ST2B, it is anticipated that the utility apparatus would be incorporated within the top of the cut and cover tunnel and underpass respectively, however this is subject to further design work and discussions with relevant stakeholders. Options ST2C and ST2D are generally at-grade and therefore, although temporary diversions will be necessary during construction, they would not be significant. Option ST2C is raised north of Dunkeld & Birnam Station, and the telecommunications infrastructure would need to be incorporated within the new carriageway.

5.12.10 The O_2/Three mobile mast is immediately adjacent to the proposed southbound carriageway and therefore will likely require to be repositioned as a result of the works. Furthermore, access to the mast is currently direct from the A9 and as a result of A9 dualling, direct accesses will be closed.

5.12.11 The mast owned by Arqiva is approximately 10 metres from the proposed design and therefore is unlikely to be directly impacted. Access, which is currently direct from the A9, will however be altered.

Gas

Network

5.12.12 Underground Scottish Gas Networks (SGN) apparatus is located within the A9 corridor over the extents of the scheme. The most significant element of SGN infrastructure is a local high pressure main, which crosses the A9 towards the southern extent of the scheme and then runs adjacent to the existing A9 for a short length on its west side (approximate Ch. 1,300 to 1,800). The high pressure main crosses the A9 for a second time and circumnavigates Birnam and Little Dunkeld, positioned on the west bank of the River Tay. The high pressure main crosses the River Braan close to its confluence with the River Tay and continues immediately alongside the River Tay until the River Tay crossing. At the crossing, the high pressure main crosses beneath the structure and continues north, following the path of the Highland Main Line railway towards Dalguise.

5.12.13 A number of low pressure mains serve the surrounding communities. One of the low pressure mains crosses the existing A9 at Birnam Glen, in the vicinity of Dunkeld & Birnam Station. This low pressure main serves the residential properties to the west of the station.

5.12.14 A Pipeline Consultation Zone is designated through the scheme along the alignment of the local high-pressure gas main and is covered by local planning policy EP4. The extents of the Pipeline Consultation Zone are shown in Volume 3: Environmental Figures (Figures 8.5 a-d).

Impacts

5.12.15 Table 5.51 summarises the number of interfaces with SGN infrastructure for each route option.

Table 5.51: Number of Interfaces with SGN Infrastructure

Route Option	Impacts on Local High Pressure Main	Impacts on Low Pressure Main	Total
ST2A	3	2	5
ST2B	3	2	5
ST2C	3	2	5
ST2D	3	2	5

5.12.16 As shown in Table 5.51, the number of conflicts with SGN infrastructure is common for all options. At the southern extent of the scheme, where the local high pressure main crosses the A9 twice, suitable diversions will be required. It is not expected that this will be a significant issue, although it is noted that Option ST2A is lower than Options ST2B, ST2C and ST2D as it is on approach to the southern portal of the cut and cover tunnel.

5.12.17 Options ST2A and ST2B are lowered in the vicinity of Dunkeld & Birnam Station, therefore they will have a significant impact on the crossing point of the low pressure main at Birnam Glen. Temporary measures will be required during construction, particularly as the bored piled walls for the cut and cover tunnel and underpass are formed and works undertaken to lower the adjacent Inchewan Burn. Post construction, the low pressure main may be incorporated within the top of the cut and cover tunnel and underpass, however this is subject to further design work and discussions with relevant

stakeholders. Options ST2C and ST2D are generally at grade and therefore, although temporary measures will be necessary during construction, impacts would not be significant.

5.12.18 As noted in Paragraph 5.12.12, the existing local high pressure main is located in close proximity to the River Tay. Following discussions, SGN has noted concerns regarding erosion of the riverbank and the possible implications on the high pressure main. It is therefore likely that SGN will undertake diversions in the near future that will be considered as part of the DMRB Stage 3 assessment.

Electricity

Network

5.12.19 The Scottish and Southern Energy (SSE) distribution network covers large sections of the project extents, providing electricity to Birnam, Little Dunkeld, Dunkeld and Inver. Between the southern extent of the scheme and the River Braan crossing, the majority of infrastructure is more remote from the A9, however there are isolated locations where SSE infrastructure crosses the A9. To the immediate north of the existing access to Murthly Castle, a high voltage overhead cable crosses the A9 and, in a similar location, an underground cable traverses the existing road. There are further underground crossings to the south of Dunkeld & Birnam Station, at Birnam Glen/Inchewan Burn and immediately south of the River Braan crossing.

5.12.20 In the locality of Inver, a high voltage underground cable crosses the A9 and is on the immediate west of the road before crossing close to The Hermitage. Existing high voltage overhead cables are located on the east of the A9 north of Inver for a short length, before crossing the River Tay. A further length of high voltage overhead cable is on the east side of the A9 on approach to the River Tay crossing. Immediately south of the river crossing the overhead cable crosses the A9. At this location, high voltage underground cables also cross the A9.

Impacts

5.12.21 Table 5.52 summarises the number of interfaces with the SSE distribution infrastructure for each route option.

Table 5.52: Number of Interfaces with SSE Electricity Distribution Network

Route Option	Impacts on High Voltage Overhead Cable	Impacts on High Voltage Underground Cable	Impacts on Low Voltage Overhead Cable	Impacts on Low Voltage Underground Cable	Impacts on Pipeline	Total
ST2A	6	12	7	33	0	58
ST2B	6	12	7	33	0	58
ST2C	6	11	3	29	0	49
ST2D	5	11	3	28	0	47

5.12.22 At the northern extent of the scheme, north of the River Braan crossing, the impacts on SSE infrastructure will be generally consistent for all options. Existing high voltage underground cables and high voltage overhead cables in the locality of Inver and The Hermitage would need to be diverted to accommodate the scheme. Diversions may also be required in the locality of the River Tay crossing as a result of the scheme.

5.12.23 In the locality of the existing access to Murthly Castle, all options impact SSE infrastructure. Impacts are more significant for Option ST2A, which incorporates a grade separated junction in this area, further impacting adjacent high voltage overhead cables. All options also impact crossing points to the south of Dunkeld & Birnam Station and at Birnam Glen/Inchewan Burn. These impacts will be significant for Options ST2A and ST2B, which involve lowering the A9. Electrical infrastructure will

therefore need to be diverted or placed within the top of the cut and cover tunnel and underpass structures. However, this is subject to further design work and discussions with relevant stakeholders.

Water Supply and Sewerage

Network

5.12.24 Scottish Water apparatus is present within the project extents, focussed within residential areas within Birnam, Little Dunkeld and Inver. An existing combined water main crosses the existing A9 at the location of the existing left/right staggered priority junction with the B867 and Perth Road, with a further crossing at Dunkeld & Birnam Station, following the alignment of Birnam Glen. An existing combined sewer outfall also crosses the A9 in the locality of the station, following the alignment of the combined water main. An existing water main and combined sewer outfall cross the existing A9 in the locality of the existing right/left staggered priority junction with the A923 and A822 (Old Military Road).

Impacts

5.12.25 Table 5.53 summarises the number of interfaces with Scottish Water infrastructure for each route option.

Table 5.53: Number of Interfaces with Scottish Water, Water Supply Infrastructure

Route Option	Impacts on Water Mains	Impacts on Combined Sewage Outfalls	Impacts on Rising Mains	Total
ST2A	5	5	0	10
ST2B	5	5	0	10
ST2C	5	5	0	10
ST2D	5	5	0	10

5.12.26 All options will impact the water supply and sewerage apparatus in the locality of the existing junctions. For Options ST2B, ST2C and ST2D, the apparatus in the locality of the existing Birnam Junction will be impacted with diversions likely. Option ST2A is lowered in this locality due to the cut and cover tunnel, with the southern portal in close proximity to the crossing point of the existing water main. As such, diversions may be more significant, albeit infrastructure could be included adjacent to the proposed realigned B867/Perth Road across the tunnel.

5.12.27 All options will impact the existing infrastructure at the existing Dunkeld Junction. Options ST2A, ST2B and ST2D are largely at-grade in this locality and Option ST2C is elevated. It is not anticipated that diversions will be significantly complex, however this will be considered as part of the DMRB Stage 3 assessment.

5.12.28 In the locality of Dunkeld & Birnam Station, Options ST2C and ST2D are largely at-grade, therefore, although temporary measures will be necessary during construction, impacts would not be significant. Options ST2A and ST2B however, are lowered, with significant construction works in the locality to form the cut and cover tunnel and the underpass respectively. As such, considerable temporary and permanent diversions will be required. Water supply and sewerage apparatus may be placed within the top of the cut and cover tunnel and underpass structure, however this is subject to further design work and discussions with relevant stakeholders.

5.13 Constructability

Introduction

5.13.1 The route options under consideration as part of the DMRB Stage 2 assessment involve significant construction works within a constrained corridor, impacting adjacent physical and environmental constraints, including the Highland Main Line railway, Dunkeld & Birnam Station and the Category A Listed station building, Birnam Industrial Estate, residential properties and adjacent watercourses. Given that these constraints will significantly impact later stages of design and assessment, the constructability of each route option has been assessed in greater detail than is normal as part of the DMRB Stage 2 assessment. As such, the constructability of each route option will inform the identification of the Preferred Route Option.

5.13.2 It should be noted that at this stage in the route selection process, the focus is on a likely construction scenario for the purposes of assessing the potential impacts. However, exact construction methods would be identified by the successful Contractor, allowing them to use their experience to identify any innovative methods that may lessen complexity and reduce associated impacts, costs and construction time.

5.13.3 In terms of constructability, the key variances between route options will be in the construction of the route between the existing Birnam and Dunkeld junctions. As such, the primary focus of the review has been on the constructability of this section, which covers the cut and cover tunnel in Option ST2A, underpass structure in Option ST2B, grade separated junction at Dunkeld in Option ST2C, and pedestrian underpass in Options ST2C and ST2D.

5.13.4 The construction techniques considered have been developed taking due cognisance of existing constraints, including the adjacent topography, land-use and groundwater conditions. Key constraints that have influenced the proposed design are noted below.

- Transport Scotland's aspiration to maintain two-way traffic on the A9 throughout construction;
- The close proximity of physical constraints, including residential and commercial properties, the Highland Main Line railway and Dunkeld & Birnam Station, which limits the space available to undertake construction works;
- The impact on environmental constraints, mainly Inchewan Burn; and
- The findings of detailed and supplementary GI (see Chapter 5.9 (Geotechnics and Earthworks)).

Option ST2A (Community's Preferred Route Option)

Tunnel Construction Techniques Considered

5.13.5 Three construction techniques were initially considered for constructing the 1.5 kilometre cut and cover tunnel, which are summarised below. It is noted that the consideration of possible options was undertaken in consultation with relevant guidance and standards, with specialist advice from professionally qualified staff highly experienced in tunnel construction. Other tunnelling techniques, such as the New Austrian Tunnelling Method (NATM), are unsuitable, largely due to the ground conditions in the locality.

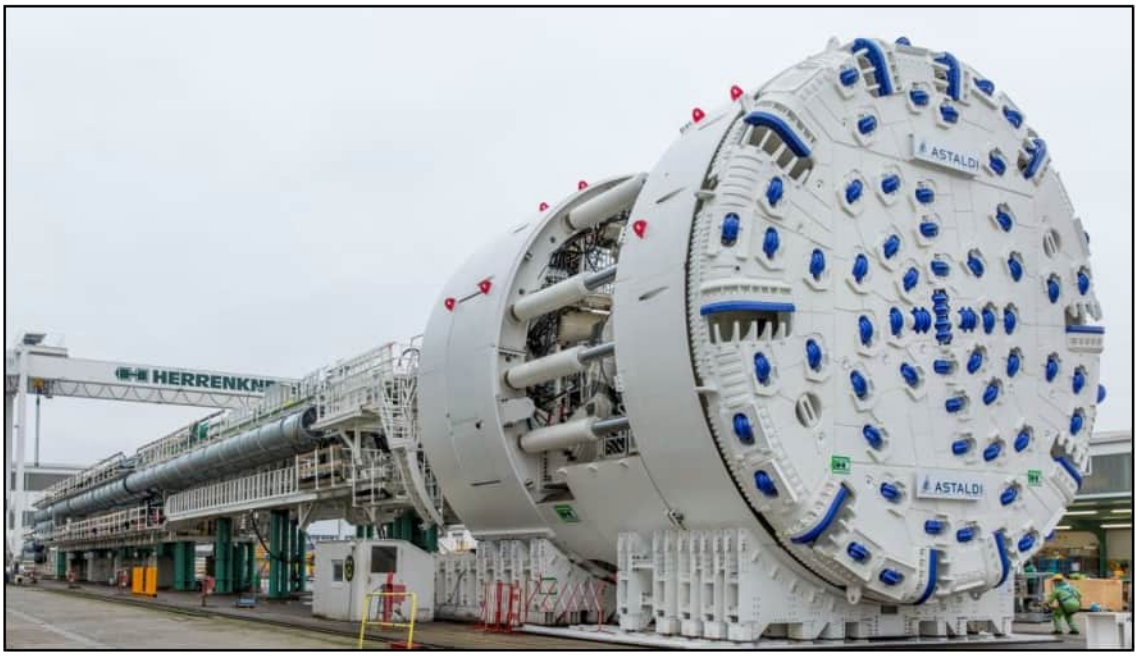
- Tunnel Boring Machine (TBM) - A below ground excavation approach, where a machine is used to excavate tunnels, generally with a circular cross-section and at depth.
- Cut and Cover, Bottom-Up Construction - Involves the construction of a structural box, formed in an open temporary excavation. The tunnel box structure is constructed in the excavation and then backfilled.

- Cut and Cover, Top-Down Construction (formation of permanent retaining walls below ground)
  - Where construction space is limited, permanent retaining walls can be installed to limit the extent of the excavation and form the tunnel walls. Once retaining walls are complete, material is excavated between the walls to form the tunnel.

TBM

5.13.6 To accommodate the proposed A9 dual carriageway, two adjacent tunnels, formed with a TBM, shown in Figure 5.4, would be required. One tunnel would accommodate the northbound carriageway and one the southbound carriageway, with both likely to be approximately 14 metres in diameter. A separate, smaller tunnel, likely approximately 6 metres in diameter, would also be required to facilitate emergency evacuation from the tunnel. This tunnel would be connected to the two larger tunnels at regular intervals. As effectively three bored tunnels would be required, the width of the tunnelled zone would be significant, likely resulting in works outwith the existing A9 corridor, beneath adjacent constraints, including residential properties and the Highland Main Line railway.

Figure 5.4: TBM (8 metres diameter)



5.13.7 To maintain the structural integrity of the tunnel, adequate clearance is required above the soffit level to the ground level above. At Inchewan Burn, which generally sits in a deep valley, the clearance required is approximately 20 metres, based on the GI information available. Maintaining this depth and providing a roundabout junction generally at-grade at Dunkeld, with suitable connections to the A923, A822 (Old Military Road) and A9 (north and south), and considering other constraints, including the Highland Main Line railway, the River Braan and its floodplain and existing topography, is unlikely to be viable. The assessment undertaken suggests that due to the depth required for the TBM, the northern portal of the tunnel would be approximately 100 to 150 metres from the junction. UK design standards dictate that junctions should not be provided within or in close proximity to tunnels due to the increased accident risk and restricted access for the attendance of emergency services. For reference, for a 70 mph speed limit, a distance of approximately 450 metres is defined as the immediate approach to a junction. For a 60 mph speed limit, the immediate approach to a junction is approximately 320 metres and for a 50 mph speed limit it is approximately 240 metres.

5.13.8 The omission of a junction at Dunkeld has significant traffic implications through Birnam, with a potential increase of approximately 4,000 vehicles per day likely on Perth Road. However, if the existing A9 remained operational above the tunnel as a local road, future traffic flows on Perth Road

would be similar to existing. For reference, the existing Annual Average Daily Traffic (AADT) flows on Perth Road vary between approximately 1,300 (at the southern extent) and 2,600 (at the northern extent).

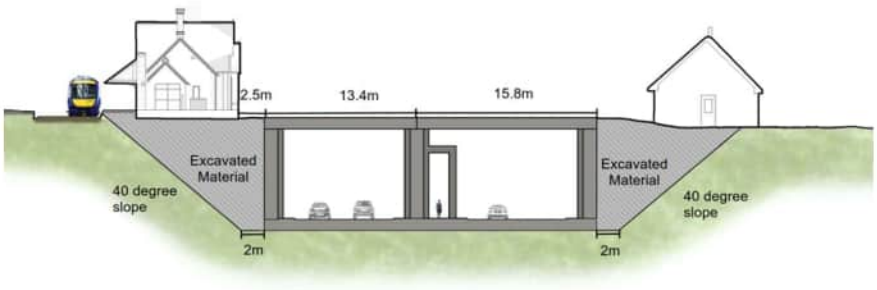
5.13.9 As adequate clearance between the soffit level to the ground level above would not be available immediately, a length of cut and cover tunnel would be required at the northern and southern extents of the tunnel. Facilitating construction of a cut and cover section of tunnel, alongside a TBM would introduce complexity to the scheme, particularly as construction would be on-line of the existing carriageway. Traffic Management, to maintain two-way traffic on the A9, while providing the necessary working and safety zones, would be complex. It would be necessary to move the tunnel extents off-line to maintain traffic on the A9, however, this would necessitate a greater land-take for the scheme, with increased impacts on adjacent environmental and physical constraints.

5.13.10 Given the required depths associated with a TBM, the volume of excavated material to be disposed of and the complexity at the tunnel extents, this technique would incur significant construction costs with a prolonged construction programme. The required depths also contradict one of the main principles of the Community's Preferred Route Option, which was for a near-surface tunnel. Indeed, this option was only considered as it would eliminate the need to lower Inchewan Burn.

Cut and Cover, Bottom-Up Construction

5.13.11 Construction of a structural box involves temporary excavation with sloped sides, as shown in Figure 5.5. For excavations up to 10 metres deep, 40° slopes (1 vertical: 1.2 horizontal) would be required for structural stability. For excavations greater than 10 metres deep, 35° slopes (1 vertical: 1.4 horizontal) would be necessary. Therefore, construction would require significant land-take within a constrained corridor, impacting adjacent environmental and physical constraints, including residential properties on the east side of the A9. Excavated material would also need to be stored temporarily and used as backfill. As such, a suitable area in close proximity to the site would be necessary, potentially further increasing land-take, with associated visual and landscape impacts. Maintaining two-way traffic on the A9 throughout construction would be difficult with bottom-up construction. To facilitate A9 traffic, temporary works (i.e., bored piles), which would be similar to that utilised for a top-down construction technique (as detailed below) would be necessary. As such, many of the advantages of applying this technique would be lost. A bottom-up construction technique is therefore generally more appropriate for an off-line construction where there are no space constraints.

Figure 5.5: Cut and Cover, Bottom-Up Construction

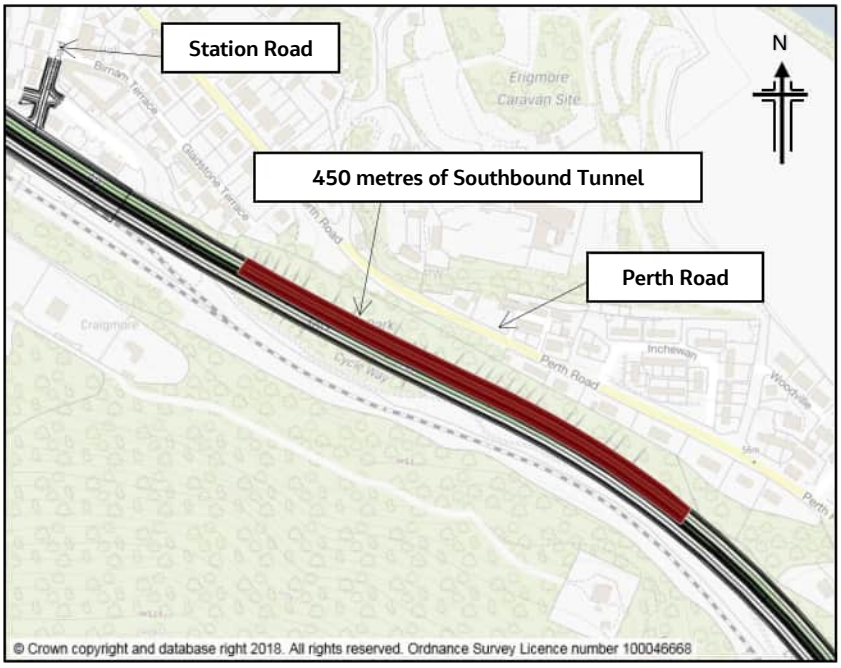


5.13.12 As this technique would involve construction closer to the existing ground level, there would be no difficulty in providing a roundabout junction generally at-grade at Dunkeld, averting significant increases in traffic on Perth Road. This technique would require Inchewan Burn to be lowered by approximately 8 metres, which would have significant environmental impacts.

5.13.13 It should be noted that the assessment undertaken has identified a 450 metre long section of the southbound tunnel, south of Dunkeld & Birnam Station, as shown in Figure 5.6, may be constructed

using bottom-up construction techniques, without significantly impacting adjacent constraints. It is noted however, that within this section, construction activities would be closer to residential properties. Considered in isolation, this section may introduce some limited programme and cost savings, compared to a top-down construction method. However, given this approach is not suitable elsewhere, the variation in construction techniques may limit any programme savings. It is not envisaged that there would be significant cost savings associated with utilising this technique for such a short section.

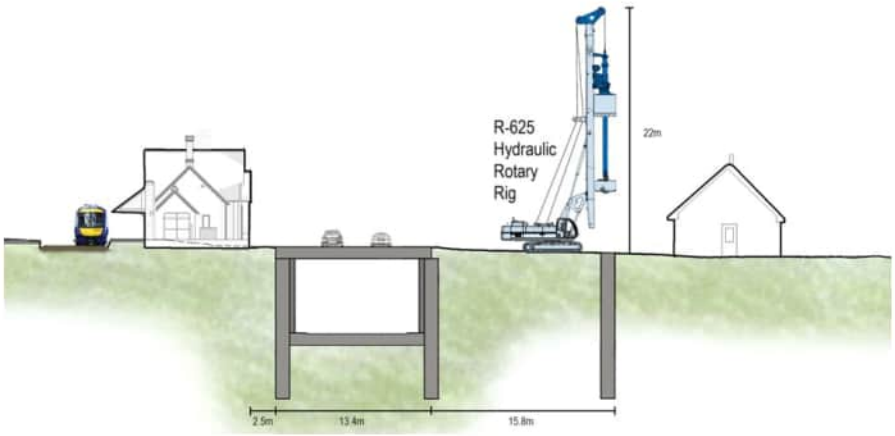
Figure 5.6: Potential Bottom-up Construction Section



Cut and Cover, Top-Down Construction

5.13.14 To form the tunnel walls in the central reserve and verge, it has been assessed that bored piles would be utilised, as shown in Figure 5.7. Bored piles, where soil is excavated to form a hole for reinforced concrete, are proposed rather than driven piles, which involve prefabricated steel sheet piles being driven into the ground by percussion, pressing or vibration. As this technique does not involve excavation with sloped sides (see Figure 5.5), it can be more readily undertaken within a constrained site and provides greater opportunity to maintain two-way traffic on the A9 throughout construction, albeit with reduced speed limits and narrow lane widths. It is noted however, that such a technique would require heavy plant in close proximity to residential properties, Dunkeld & Birnam Station and the Highland Main Line railway, introducing structural risks during construction that would require careful management.

Figure 5.7: Cut and Cover, Top-Down Construction



5.13.15 As excavated material would not be utilised as backfill, there is no requirement for temporary storage. Instead, all excavated material not required elsewhere on the scheme would be taken off site.

5.13.16 Similar to the bottom-up technique, this technique would involve construction closer to existing ground level, hence there would be no difficulty in providing a junction at-grade at Dunkeld, averting significant increases in traffic on Perth Road. Inchewan Burn would however require to be lowered by approximately 8 metres, introducing significant environmental impacts.

5.13.17 While the space requirement for a top-down construction technique is less than a bottom-up technique, a top-down approach would incur a longer construction period and likely increased costs.

Recommended Tunnel Construction Technique

5.13.18 A tunnel at-depth, utilising a TBM, will likely prevent a roundabout junction from being provided at Dunkeld, significantly increasing traffic flows on Perth Road. Furthermore, a TBM would involve significant complexity at the northern and southern tunnel portals, with the tunnel extents likely moved off-line to maintain traffic on the A9.

5.13.19 Given the space constraints, with the Highland Main Line railway and Dunkeld & Birnam Station to the west and residential properties to the east, bottom-up construction with temporary slopes is not considered a practicable solution.

5.13.20 As a result, top-down construction, which can be undertaken within a constrained site, providing greater opportunity to maintain two-way traffic on the A9 throughout construction, whilst allowing provision of an at-grade roundabout junction at Dunkeld, is considered the preferred technique.

Cut and Cover Tunnel Construction

5.13.21 Construction of the 1.5 kilometre cut and cover tunnel in such a constrained and sensitive corridor will be complex. As insufficient space exists for an open excavation, the walls that form part of the cut and cover tunnel would be constructed using large diameter (1.2 metres diameter) bored piles to retain a height of approximately 10 metres. The bored piles themselves will be approximately 15 metres long and approximately 3,700 piles would be required in total. A total of 430,000 tonnes (180,000m^3) of concrete is required to construct the cut and cover tunnel. At the most intense period of construction, it is anticipated that approximately 500 tonnes (210m^3) of concrete will be produced each day, requiring an on-site batching plant.

5.13.22 The GI information indicates that ground conditions are dense granular deposits with significant boulder obstructions. As a result, each bored pile will require the use of polymer mud support to maintain the structural integrity of the bored hole, prior to concrete pumping. As such, an on-site

polymer mud production plant is required. The requirement for an on-site polymer mud and concrete batching plant increases the land required to construct the scheme. It should be noted that an alternative method to form the bored piles, Continuous Flight Auger (CFA), has been considered, which negates the need for polymer mud support, thus possibly reducing construction duration. This would involve boring to the required depth utilising a hollow stem. Concrete is then pumped through the hollow stem, forming the pile as the CFA is retracted. However, there is a risk with this method that the pile may collapse due to the ground conditions in the locality. While this could be investigated at future stages of design, it has been discounted at present.

5.13.23 Piling works will likely generate noise in excess of 85dB $L_{Aeq,T}$ and vibration levels of approximately 1.7 millimetres per second (mm/s) Peak Particle Velocity (PPV) at residential properties within 10 to 15 metres of the works. It is not anticipated that the expected vibration will have a structural impact on residential properties, however prior to construction commencing, Pre-Construction Surveys may be undertaken to inspect the existing condition. This would be used as a baseline to monitor impacts of construction works and would highlight any structural issues that may be caused by the works. In the event of any damage, the appointed contractor would be liable and therefore responsible for any remediation works. Suitable mitigation, to restrict the level of impact on adjacent residential and commercial properties during construction, will be considered as part of the DMRB Stage 3 assessment.

5.13.24 Construction works will be undertaken approximately 2.5 metres from the Category A Listed station building. At this distance, it is not anticipated that there would be vibration damage to the building, however there is a risk of accidental damage and suitable monitoring, and possible strengthening works, may be required. Continuous monitoring, in conjunction with Network Rail, will also be required for the Highland Main Line railway to ensure construction works do not impact the route. Any impacts on the railway has the potential to close the route for a considerable period of time.

5.13.25 The cut and cover tunnel will require a control room, likely located on top of the tunnel near the southern portal, that will need full-time staff to monitor the tunnel. In addition, the tunnel equipment, such as the fire safety apparatus and ventilation equipment, will need to be checked and maintained regularly. As such, one direction of the tunnel would need to be closed for this operation, utilising bi-directional traffic in the other half of the tunnel. At this stage it is assumed maintenance will be undertaken monthly.

Access to Dunkeld & Birnam Station

5.13.26 Given the scale of the works in close proximity to the station and Highland Main Line railway, maintaining access to Dunkeld & Birnam Station during construction is challenging. However, a number of options have been considered to maintain access, which are detailed below. The options have undergone only a high level assessment at this stage to determine their viability and potential impacts.

- Option 1:
  - Extend Platform 1 (southbound) and Platform 2 (northbound) to the north of Inchewan Burn;
  - Existing pedestrian footbridge between platforms retained and utilised, therefore restricted access to Platform 1 (southbound) for disabled and less mobile users;
  - Extension of existing passing loop to the north to accommodate the new platforms, which will require signalling works and railway closures;
  - New railway structure over Inchewan Burn to link proposed new platforms to existing platforms and existing pedestrian footbridge, replacing existing masonry arch structure;
  - Implementation of lighting, possibly platform communications, shelters and Customer Information System (CIS);

- Vehicular access to the temporary station from the A822 (Old Military Road), immediately west of the current railway underbridge, which is the tie-in point for the works associated with Dunkeld Junction (Note: The access road from the A822 (Old Military Road) is required with a lowered A9 dual carriageway to provide access to properties on Birnam Glen to the west of Dunkeld & Birnam Station.);
- New car parking facility (north of the Inchewan Burn, on the west side of the Highland Main Line railway), which will include approximately thirty spaces, incorporating an appropriate number of accessible spaces and possibly a vehicle pick-up drop-off point and bus stop, possibly with Closed Circuit Television (CCTV) and lighting;
- Suitable footpaths, in accordance with current relevant accessibility and disability legislation, linking the proposed car parking facility to the extended platforms;
- No suitable WCH access from Birnam and Dunkeld or the A822 (Old Military Road), due to the existing railway bridge on the A822 (Old Military Road), which does not include a pedestrian footpath;
- No public vehicular access direct to the existing Category A Listed station building or Platform 1 (southbound). It is anticipated that access to the signal box, which is manned 24-hours a day, and access to the station building for maintenance purposes can be provided through the Traffic Management. However, this will need to be fully agreed with Network Rail and is subject to an evaluation of any additional risk; and
- Anticipated 30 week construction duration and £5.1 million estimated cost.

▪ Option 2:

- New temporary pedestrian footbridge, likely incorporating lifts, spanning across the A9 during construction;
- Provision of limited temporary car parking within the extent of Birnam Industrial Estate (Note: Land within the industrial estate required to accommodate construction of the lowered A9 dual carriageway.);
- No works to the existing station infrastructure, including platforms, pedestrian footbridge and track;
- No public vehicular access direct to the existing Category A Listed station building. It is anticipated that access to the signal box, which is manned 24-hours a day, and access to the station building for maintenance purposes can be provided through the Traffic Management. However, this will need to be fully agreed with Network Rail and is subject to an evaluation of any additional risk; and
- Anticipated 4 week construction duration and £0.7 million estimated cost.

▪ Option 3:

- Extend Platform 1 (southbound) and Platform 2 (northbound) to the north of Inchewan Burn, with a new pedestrian footbridge, likely incorporating lifts, spanning across the A9 during construction;
- Existing pedestrian footbridge between platforms retained and utilised;
- Extension of existing passing loop to the north to accommodate the new platforms, which will require signalling works;
- New railway structure over Inchewan Burn to link proposed new platforms to existing platforms and existing pedestrian footbridge, replacing existing masonry arch structure;
- Implementation of lighting, possibly platform communications and CIS;

- Vehicular access to the temporary station from the A822 (Old Military Road), immediately west of the current railway underbridge, which is the tie-in point for the works associated with Dunkeld Junction (Note: The access road from the A822 (Old Military Road) is required with a lowered A9 dual carriageway to provide access to the properties on Birnam Glen to the west of Dunkeld & Birnam Station.);
- New car parking facility, which will include approximately thirty spaces, incorporating an appropriate number of disabled spaces and possibly a vehicle pick-up drop-off point and bus stop;
- Suitable footpaths, in accordance with current relevant accessibility and disability legislation, linking the proposed car parking facility to the extended platforms;
- Provision of limited temporary car parking within the extent of Birnam Industrial Estate (Note: Land within the industrial estate required to accommodate construction of the lowered A9 dual carriageway.);
- No public vehicular access direct to the existing Category A Listed station building. It is anticipated that access to the signal box, which is manned 24-hours a day, and access to the station building for maintenance purposes can be provided through the Traffic Management. However, this will likely need to be fully agreed with Network Rail and is subject to an evaluation of any additional risk; and
- Anticipated 30 week construction duration and £5.8 million estimated cost.

▪ Option 4:

- New temporary pedestrian footbridge over the Inchewan Burn linking Platform 2 (northbound) with temporary parking and a new access road from the A822 (Old Military Road);
- Vehicular access to the temporary station from the A822 (Old Military Road), immediately west of the current railway underbridge, which is the tie-in point for the works associated with Dunkeld Junction (Note: The access road from the A822 (Old Military Road) is required with a lowered A9 dual carriageway, to provide access to properties on Birnam Glen to the west of Dunkeld & Birnam Station.);
- New car parking facility, which will include approximately thirty spaces, incorporating an appropriate number of disabled spaces and possibly a vehicle pick-up drop-off point and bus stop, possibly with CCTV and lighting;
- Suitable footpaths, in accordance with current relevant accessibility and disability legislation, linking the proposed car parking facility to the extended platforms;
- No suitable WCH access from Birnam and Dunkeld or the A822 (Old Military Road), due to the existing railway bridge on the A822 (Old Military Road), which does not include a pedestrian footpath;
- No works to the existing station infrastructure, including platforms, pedestrian footbridge and track;
- No public vehicular access direct to the existing Category A Listed station building or Platform 1 (southbound). It is anticipated that access to the signal box, which is manned 24-hours a day, and access to the station building for maintenance purposes can be provided through the Traffic Management. However, this will need to be fully agreed with Network Rail and is subject to an evaluation of any additional risk; and
- Anticipated 8 week construction duration and £0.4 million estimated cost.

- Option 5:
  - New temporary pedestrian footbridge over the Inchewan Burn linking Platform 2 (northbound) with temporary parking and a new access road from the A822 (Old Military Road) with a further temporary pedestrian footbridge, likely incorporating lifts, spanning across the A9 during construction;
  - Provision of limited temporary car parking within the extent of Birnam Industrial Estate (Note: Land within the industrial estate required to accommodate construction of the lowered A9 dual carriageway.);
  - No works to the existing station infrastructure, including platforms, pedestrian footbridge and track;
  - No public vehicular access direct to the existing Category A Listed station building. It is anticipated that access to the signal box, which is manned 24-hours a day, and access to the station building for maintenance purposes can be provided through the Traffic Management. However, this will need to be fully agreed with Network Rail and is subject to an evaluation of any additional risk;
  - Vehicular access to the temporary station from the A822 (Old Military Road), immediately west of the current railway underbridge, which is the tie-in point for the works associated with Dunkeld Junction (Note: The access road from the A822 (Old Military Road) is required with a lowered A9 dual carriageway to provide access to properties on Birnam Glen to the west of Dunkeld & Birnam Station.);
  - New car parking facility, which will include approximately thirty spaces, incorporating an appropriate number of disabled spaces and possibly a vehicle pick-up drop-off point and bus stop, possibly with CCTV and lighting;
  - Suitable footpaths, in accordance with current relevant accessibility and disability legislation, linking the proposed car parking facility to the extended platforms;
  - No suitable WCH access from Birnam and Dunkeld or the A822 (Old Military Road), due to the existing railway bridge on the A822 (Old Military Road), which does not include a pedestrian footpath;
  - No works to the existing station infrastructure, including platforms, pedestrian footbridge and track;
  - No public vehicular access direct to the existing Category A Listed station building or Platform 1 (southbound). It is anticipated that access to the signal box, which is manned 24-hours a day, and access to the station building for maintenance purposes can be provided through the Traffic Management. However, this will need to be fully agreed with Network Rail and is subject to an evaluation of any additional risk; and
  - Anticipated 8 week construction duration and £1.1 million estimated cost.

5.13.27 Options to extend the existing platforms to the south have been considered. However, approximately 70 metres south of the southern extent of Platform 1 (southbound) the railway track travels through a 400 metre radius horizontal curve. Provision of an appropriate length of platform to accommodate current rolling stock, approximately 95 metres, would therefore extend onto the radius, which is less than the Desirable Minimum quoted in railway design standards to accommodate a station. Extending Platform 2 (northbound) to the south will also conflict with the existing signal box. Furthermore, provision of any suitable safe vehicular access will not be possible during construction. Pedestrian provision could be provided via a temporary pedestrian footbridge, however, this structure would be south of Station Road and Birnam Industrial Estate and therefore more remote from the existing access and local services. It may also conflict with residential properties, WCH routes, areas of woodland and Torwood Park, a local recreational facility.

General Constructability

5.13.28 Transport Scotland has an aspiration to maintain two-way traffic flows on the A9 during construction, which will be challenging. Outwith the cut and cover tunnel section, the route options are generally on-line improvements, with some localised off-line sections. Off-line sections can be constructed without affecting the existing carriageway. On-line construction generally utilises the existing single carriageway whilst constructing the widened carriageway alongside. Works will be undertaken during a continuous Traffic Management system, with a temporary speed restriction and likely reduced lane widths. Operational traffic can then be moved to newly constructed sections to allow upgrading works to the existing carriageway. It is likely that temporary priority junctions, in similar locations to the current junctions will be provided during construction to maintain access. This is unlikely to be appropriate at the existing Birnam Junction, due to tunnel construction, so any temporary junction may be moved south. At the northern extent, a temporary tie-in with the existing single carriageway may be necessary. This, however, depends on the construction sequence of this project and the Tay Crossing to Ballinluig scheme.

5.13.29 As a result of the cut and cover tunnel, Inchewan Burn must be lowered by approximately 8 metres. It should be noted that alternative options were considered that would eliminate or reduce the extent of lowering of the burn. The first option considered involved discharging to the River Braan, which is approximately 1 kilometre to the north. The diverted burn would need to traverse existing side roads and the Highland Main Line railway and would be in close proximity to the Ladywell Landfill site (a potential contamination source). The River Braan is also subject to flooding, which may be increased if additional flows are introduced. The second option considered was to lower the proposed A9 dual carriageway by a further 11.5 metres, to enable the burn to flow over the proposed structure, generally following its existing alignment and elevation. Lowering the A9 deeper into the ground would increase the construction complexity significantly. Larger diameter bored piles may be required, along with additional temporary works, to support the piled walls. Increased excavation may also impact the adjacent Highland Main Line railway. As a result of the potential impacts on environmental constraints and possible contamination from Ladywell Landfill site, and the increased construction complexity, these options were not considered further.

5.13.30 Works to the burn will be complex given the degree of lowering required and the presence of existing adjacent constraints, including the Highland Main Line railway and masonry arch bridge, the A9, Ladywell Landfill site, residential properties and existing topography. To avoid impacts on the existing Highland Main Line railway masonry arch bridge and the A9 dual carriageway, and to ensure the downstream alignment tie-in is upstream of the crossing of Perth Road, a vertical drop structure is required to pass the culvert under the tunnelled section. The culvert will likely be 2.5 metres by 1.5 metres to ensure conveyance of the relevant flows and a sediment/silt trap included upstream of the Highland Main Line railway masonry arch bridge to prevent cobbles, gravels, sediment and silt entering the proposed structure. Construction for the burn lowering works will be complex in such a constrained and sensitive location. Permanent and temporary bored and sheet piling works will be required, as well as erection of a temporary A9 bridge, to allow the existing A9 structure to be demolished. The burn itself will also be diverted through a temporary culvert while the drop structure and permanent box culvert are constructed.

5.13.31 Construction of the cut and cover tunnel will involve excavation of a significant volume of earthwork material (approximately 535,000m^3 for the tunnel section alone) and the scheme overall will have a significant volume of material to be taken off-site for disposal (approximately 698,000m^3), which includes acceptable excavated material that is not needed (517,000m^3), topsoil disposal (40,000m^3) and unsuitable material (141,000m^3). This impacts the overall cost of the scheme and does not represent good practice in terms of overall sustainability. It should be noted that the volume of material to be excavated to form the tunnel will result in approximately 90,000 lorry movements to dispose of excess material, which equates to around 250 vehicle movements per day. In addition, the concrete required to construct the cut and cover tunnel would necessitate approximately 45,000 total lorry journeys. This may impact the Traffic Management for the scheme.

5.13.32 As detailed in Chapter 5.12, there is existing overhead and underground public utility apparatus in the locality of the A9. A number of these utilities will need to be diverted as a result of the work. The cut and cover tunnel will significantly impact apparatus owned by BT, SGN and Scottish Water in the locality of Dunkeld & Birnam Station. Significant temporary diversions may be necessary, particularly as the bored piled walls are erected. Post construction, subject to further design work and discussions with relevant stakeholders, utility apparatus may be incorporated within the top of the cut and cover tunnel.

5.13.33 Construction of the junctions within Options ST2A is not considered to be overly complex. The slip roads associated with the grade separated junctions at Murthly and Dalguise are generally outwith the current extent of the A9 and can therefore be constructed while traffic remains operational on the A9. The slip roads can then be utilised to accommodate temporary traffic movements along the route while works are being undertaken to the main carriageway. Some temporary junctions with side roads will be required and side roads may be subject to temporary closures and diversions. The A9 itself may be subject to short-scale closures as structural elements associated with the junctions are lifted into position. Any road closures would be undertaken during off-peak traffic periods and with suitable diversions in place to minimise disruption. The proposed roundabout at Dunkeld and left-in left-out junction at The Hermitage are generally at-grade, minimising impacts on adjacent constraints and limiting construction complexity.

5.13.34 It is anticipated that for Option ST2A, the construction duration will be between 4 ½ and 5 years. This assumes a 6 day working week (Monday to Friday, 7am to 7pm, Saturday, 8am to 1pm, with no night-time, Sunday and Bank Holiday working) with 6 piling rigs in operation, completing a total of 12 piles per day. This would increase to between 5 ½ to 6 years if a 5-day working week was employed. Piling works are expected to be between 12 to 18 months depending on working days and hours. PKC (Environmental Health) would decide permissible working days and hours in consultation with the local community.

Option ST2B

Underpass Structure

5.13.35 The underpass structure included in Option ST2B will be constructed in a similar way to the cut and cover tunnel for Option ST2A. The walls that form part of the underpass, which extend beyond the extents of the underpass itself, would be constructed using large diameter (1.2 metres diameter) bored piles to retain a height of approximately 10 metres. The bored piles themselves will be approximately 15 metres long and approximately 860 piles would be required in total. A total of 83,000 tonnes (35,000m^3) of concrete is required to construct the underpass. At the most intense period of construction, this would equate to approximately 170 tonnes (71m^3) of concrete production each day. While this is not as intense as Option ST2A, it would still require an on-site batching plant.

5.13.36 As Option ST2A, the bored piles for Option ST2B would require the use of polymer mud support to maintain the structural integrity of the bored hole, prior to concrete pumping. An on-site polymer mud production plant is therefore required. For the same reasons as that detailed for Option ST2A, the use of CFA has been discounted at this time.

5.13.37 The noise and vibration levels anticipated for the piling works will be in excess of 85dB $L_{Aeq,T}$ and 1.7mm/s PPV at residential properties within 10 to 15 metres of the works. As with Option ST2A, it is not anticipated that the expected vibration will have a structural impact on residential properties, however Pre-Construction Surveys may be undertaken by the Contractor. There is a risk during construction to the Category A Listed station building, with works being undertaken within 2.5 metres of the building. Suitable monitoring will be required of the building, and the Highland Main Line railway itself, to ensure construction works do not impact the assets.

5.13.38 Option ST2B does not require a control room. The requirement for a control room is only applicable for a tunnel.

Access to Dunkeld & Birnam Station

5.13.39 As with Option ST2A, maintaining access to Dunkeld & Birnam Station for Option ST2B during construction is challenging. The options identified in Paragraph 5.13.26 for temporary access to the station are therefore applicable to Option ST2B also.

General Constructability

5.13.40 Although the extent of piling works is not as significant as for Option ST2A, maintaining bi-directional flow on the A9 throughout construction will be challenging. Suitable Traffic Management, with reduced speed limits and lane widths would be employed.

5.13.41 The impacts noted on Inchewan Burn for Option ST2A are the same for Option ST2B. However, the burn is lowered by approximately 6 metres, which is less than Option ST2A. This is largely as the underpass does not require additional headroom clearance to accommodate overhead ventilation equipment. Construction of the burn lowering works, which includes implementation of permanent and temporary bored and sheet piling works and temporary burn diversions, will be complex in such a constrained and sensitive location.

5.13.42 Construction of the underpass section will involve excavation of approximately 168,000m^3 of material. The scheme overall will have a significant volume of material to be taken off-site for disposal (approximately 356,000m^3), which includes acceptable excavated material that is not needed (211,000m^3), topsoil disposal (43,000m^3) and unsuitable material (102,000m^3). This does not represent good practice in terms of overall sustainability. It should be noted that the volume of excavated material for the underpass section will result in approximately 28,000 lorry movements, which equates to approximately 75 vehicle movements per day. Furthermore, the concrete required to construct the underpass would necessitate approximately 6,000 total lorry journeys, which may impact the Traffic Management for the scheme.

5.13.43 The public utility apparatus in the locality of the A9 that require diversions is similar to that detailed for Option ST2A. Significant temporary diversions may be necessary as the bored piled walls are constructed. Post construction, utility apparatus may be incorporated within the top of the underpass structure, subject to further design work and discussions with relevant stakeholders.

5.13.44 Construction of the grade separated junctions at Birnam and Dalguise, the at-grade roundabout at Dunkeld and the left-in left-out junction at The Hermitage is not expected to be overly complex and therefore no significant issues are anticipated. Traffic Management will be employed to maintain safety of drivers and the workforce, and some short-scale road closures may be necessary to complete side road tie-in works and lift structural elements into position. Any road closures would be undertaken during off-peak traffic periods and with suitable diversions in place to minimise disruption. The Traffic Management measures employed to maintain bi-directional traffic on the A9, including temporary junctions, will be similar to that detailed for Option ST2A. At the northern extent, a temporary tie-in with the existing single carriageway may be necessary. This, however, depends on the construction sequence of this project and the Tay Crossing to Ballinluig scheme.

5.13.45 It is anticipated that for Option ST2B, the construction duration will be between 4 and 4 ½ years. This assumes a 6-day working week (Monday to Friday, 7am to 7pm, Saturday, 8am to 1pm, with no night-time working, Sunday and Bank Holiday working) with 2 piling rigs in operation, completing a total of 4 piles per day. Given the space constraints associated with the site, it is unlikely additional piling rigs could be employed, while maintaining A9 traffic and the necessary working and safety zones. Piling works are expected to be between 9 to 12 months depending on working days and hours. PKC (Environmental Health) would decide permissible working days and hours in consultation with the local community.

Option ST2C

Dunkeld Grade Separated Junction

5.13.46 Option ST2C is predominantly at-grade throughout, with the exception of the grade separated junction at Dunkeld. At this location, the A9 is raised approximately 13 metres higher than existing carriageway levels and substantial works to construct the embankment will be necessary. It is likely that temporary strengthened earthworks, that will eventually be buried, will be required to maintain traffic on the existing A9 during construction. The resultant A9 carriageway will be at a similar level to the adjacent railway and residential properties. To avoid encroachment towards the residential properties on the east, three short sections of retaining wall, up to 2 metres high, will be required. Simple in-situ concrete or pre-cast L-shaped gravity walls would be utilised. As the walls have a relatively low height, there would be no requirement for ground anchors.

5.13.47 It should be noted that there is currently an earthwork bund alongside the Highland Main Line railway approximately 5 metres high. The boundary of Network Rail's land ownership is at the top of the bund. Retaining walls on the west side of the proposed A9 are not required for Option ST2C, assuming this earthwork bund is removed. However, further discussions would be required as part of the DMRB Stage 3 assessment with Network Rail to determine any likely rail impacts from bund removal.

5.13.48 Option ST2C continues to be raised above existing carriageway levels at the River Braan crossing. As a result, a significant height retaining wall, up to approximately 14 metres high is required on the immediate south of the River Braan crossing to avoid encroachment towards Dunkeld & Birnam Recreation Club. While this structure is significant in height, construction will be undertaken in stages and is not deemed overly complex.

Dunkeld & Birnam Station Pedestrian Underpass

5.13.49 While general construction will generate noise and vibration for residential and commercial properties immediately alongside the works, it would not be as significant as for Options ST2A and ST2B. As the works are at-grade in the locality of the station, impacts on the Highland Main Line railway are not envisaged.

5.13.50 Dunkeld & Birnam Station is retained in its current position for Option ST2C, with Birnam Industrial Estate acquired and utilised as a replacement station car park with a new pedestrian underpass constructed below the proposed A9 dual carriageway linking the car park with Platform 1 (southbound).

5.13.51 It is likely that construction of the pedestrian underpass would be undertaken in two phases. Phase 1 would involve construction of the lift shaft and stairs, and western section of the concrete box that forms part of the pedestrian underpass, to the immediate west of the A9. To allow sufficient excavation space to form the pre-cast concrete box, which will be approximately 3 metres high and 5 metres wide, temporary sheet piles would be required. Temporary sheet piling would be undertaken in two parallel sections approximately 8 metres apart, with horizontal propping in place to limit the length of the pile, thus reducing construction complexity, as well as noise and vibration. The extent of the temporary sheet piling is anticipated to be approximately 1 metre from Platform 1 (southbound), approximately 22 metres from the Category A Listed station building,19 metres from the station canopy and 7 metres from the base of the footbridge.

5.13.52 Phase 2 would involve switching A9 traffic on top of the already constructed section of the pedestrian underpass, to allow the remaining length of underpass to be erected. To provide the appropriate excavation space to form the structure, a further length of sheet piling would be required. This would extend the piling erected in Phase 1 eastwards, towards Birnam Industrial Estate. Again, horizontal propping would be utilised to reduce complexity and associated noise and vibration.

5.13.53 It should be noted that specific installation methods for temporary sheet piling will be considered as part of the DMRB Stage 3 assessment if Option ST2C is identified as the Preferred Route Option. These installation techniques would take due cognisance of, and seek to reduce impact on, adjacent constraints, including the Highland Main Line railway, Dunkeld & Birnam Station and adjacent residential properties.

Access to Dunkeld & Birnam Station

5.13.54 Access to Dunkeld & Birnam Station at this time will be challenging, with the existing WCH access to the station, via Birnam Glen, likely to be closed as structural works are carried out in the locality. While the issue of access is likely to be over a relatively short period of time, alternative temporary access will be required.

5.13.55 Option ST2C does not require a permanent access road from the A822 (Old Military Road) to access properties on Birnam Glen to the west of Dunkeld & Birnam Station, which is included in Options ST2A and ST2B. Options 1, 3, 4 and 5, detailed in Paragraph 5.13.26, make use of this permanent access road to provide temporary access to the station during construction. As a result, Options 1, 3, 4 and 5 have not been considered for Option ST2C, and Option 2, implementation of a temporary pedestrian footbridge, which can be erected quickly and cheaply, is considered the most appropriate solution. This is the solution that has been assessed within Volume 1, Part 3 - Environmental Assessment.

General Constructability

5.13.56 Despite Option ST2C being largely at-grade, the adjacent constraints mean maintaining two-way traffic on the A9 during construction will be challenging. Localised off-line sections can be constructed without affecting the existing carriageway. On-line works generally utilise the existing single carriageway whilst constructing the widened carriageway alongside. Works will be undertaken under Traffic Management, with temporary speed restrictions and reduced lane widths implemented. Temporary junctions, in the locality of existing junctions will be provided to maintain access to Birnam, Little Dunkeld, Inver and Dunkeld. At the northern extent, a temporary tie-in with the existing single carriageway may be necessary. This, however, depends on the construction sequence of this project and the Tay Crossing to Ballinluig scheme.

5.13.57 While the grade separated junction at Dunkeld will have some complexity, it is expected that the slip roads can be constructed first, with some temporary earthworks or retaining walls utilised as necessary. The slip roads can then be utilised to accommodate temporary traffic movements along the route while works are being undertaken to the main carriageway. Similar construction methods will be followed for the grade separated junctions at Birnam and Dalguise, where the slip roads are generally outwith the extents of the current A9. The A9 may be subject to short-scale closures as structural elements associated with the junctions are lifted into position. Any road closures would be undertaken during off-peak traffic periods to minimise disruption. The left-in left-out junction proposed at The Hermitage is generally at-grade, with limited construction complexity.

5.13.58 Option ST2C does not require works to lower Inchewan Burn. Works will be undertaken in the vicinity of the burn, which will include dismantling the existing structure and erecting a new dual carriageway structure. Measures will be required to ensure the burn, which is a tributary of the River Tay, is not adversely impacted, however, no significant complexity is envisaged. The works in the vicinity of Inchewan Burn will also impact Birnam Glen, affecting access for properties to the west of Dunkeld & Birnam Station. Any road closures would be undertaken during off-peak traffic periods with residents notified in advance. Alternative arrangements would be made for access, which may involve temporary parking facilities or walking routes. Appropriate access for emergency services would be maintained at all times during any road closures.

5.13.59 To construct Option ST2C, a significant volume of imported fill material would be required. This import is predominantly due to the raised section in the locality of Dunkeld Junction. Approximately

287,000m^3 of material would be imported, impacting the overall scheme cost. The imported material required does also not represent good practice in terms of overall sustainability.

5.13.60 There are numerous existing overhead and underground public utility apparatus in the locality of the A9. A number of these utilities will need to be diverted as a result of the work. As the scheme is largely at-grade, diversionary works are unlikely to be overly complex. Utilities would need to be incorporated in the raised section of proposed A9 at Dunkeld Junction.

5.13.61 It is anticipated that for Option ST2C, the construction duration will be between 2 ½ and 3 years.

Option ST2D

Dunkeld & Birnam Station Pedestrian Underpass

5.13.62 Option ST2D is generally at-grade throughout. As such, construction is not anticipated to be overly complex. As detailed for Option ST2C, Dunkeld & Birnam Station is retained in its current position for Option ST2D. Birnam Industrial Estate is acquired and utilised as a replacement station car park with a new pedestrian underpass constructed below the proposed A9 dual carriageway, linking the car park to Platform 1 (southbound). Construction of the underpass would be undertaken in two phases. Phase 1 will involve construction of the lift shaft and stairs, and western section of the concrete box that forms part of the pedestrian underpass, to the immediate west of the A9. As detailed for Option ST2C, temporary sheet piling, which would extend approximately 1 metre from Platform 1 (southbound), approximately 22 metres from the Category A Listed station building, approximately 19 metres from the station canopy and approximately 7 metres from the base of the footbridge, would be required. Phase 2 would involve moving traffic on top of the newly constructed section of the underpass to allow the remainder of the structure to be erected. Again, temporary sheet piling works would be required.

5.13.63 Construction of Option ST2D will generate noise and vibration for residential and commercial properties alongside the works. However, the impact is not considered to be significant, given the scheme is largely at-grade. Impacts on the Highland Main Line railway during construction are not envisaged.

Access to Dunkeld & Birnam Station

5.13.64 As noted for Option ST2C, access to Dunkeld & Birnam Station will be challenging at this time and alternative access will be required for a relatively short period of time. Option 2, detailed in Paragraph 5.13.26, which involves implementation of a temporary pedestrian footbridge, is considered the most suitable solution to facilitate station access during construction. This is the solution that has been assessed within Volume 1, Part 3 - Environmental Assessment.

General Constructability

5.13.65 Maintaining two-way traffic on the A9 during construction will be challenging. Localised off-line sections can be constructed without affecting the existing carriageway. On-line works generally utilise the existing single carriageway whilst constructing the widened carriageway alongside. Works will be undertaken under Traffic Management, with temporary speed restrictions and reduced lane widths implemented. Temporary junctions, in the locality of existing junctions will be provided to maintain access to Birnam, Little Dunkeld, Inver and Dunkeld. At the northern extent, a temporary tie-in with the existing single carriageway may be necessary. This, however, depends on the construction sequence of this project and the Tay Crossing to Ballinluig scheme.

5.13.66 The slip roads that form part of the grade separated junctions at Birnam and Dalguise are generally outwith the current extent of the A9 and can therefore be constructed while traffic remains operational on the A9. The slip roads can then be utilised to accommodate temporary traffic movements along the route while works are being undertaken to the main carriageway. Some temporary junctions with side

roads will be required and side roads may be subject to temporary closures and diversions. The A9 itself may be subject to short scale closures as structural elements associated with the junctions are lifted into position. Any road closures would be undertaken during off-peak traffic periods and with suitable diversions in place to minimise disruption. The proposed roundabout at Dunkeld and left-in left-out junction at The Hermitage are generally at-grade, minimising impacts on adjacent constraints and limiting construction complexity.

5.13.67 Option ST2D does not require works to lower Inchewan Burn. Works will be undertaken in the vicinity of the burn, which will include dismantling the existing structure and erecting a new dual carriageway structure. Measures will be required to ensure the burn, which is a tributary of the River Tay, is not adversely impacted, however, no significant complexity is envisaged. The works in the vicinity of Inchewan Burn will also impact Birnam Glen, affecting access for properties to the west of Dunkeld & Birnam Station. Any road closures would be undertaken during off-peak traffic periods with residents notified in advance. Alternative arrangements would be made for access, which may involve temporary parking facilities or walking routes. Appropriate access for emergency services would be maintained at all times during any road closures.

5.13.68 Overall, Option ST2D will have a volume of approximately 163,000m^3 material to be taken off-site for disposal, which includes acceptable excavated material that is not needed (31,500m^3), topsoil disposal (45,000m^3) and unsuitable material (86,500m^3). This option performs relatively well in terms of earthworks balance, with only approximately 31,500m^3 of acceptable excess material to be disposed of off-site, representing good practice in terms of overall sustainability.

5.13.69 There are numerous existing overhead and underground public utility apparatus in the locality of the A9. A number of these utilities will need to be diverted as a result of the work. As the scheme is largely at-grade, diversionary works are unlikely to be overly complex

5.13.70 It is anticipated that for Option ST2D, the construction duration will be between 2 ½ and 3 years.

5.14 Engineering Assessment Summary

5.14.1 The engineering assessment, included in this Part 2 - Engineering Assessment, is summarised below, focussed on those elements of engineering design that demonstrate differences between the options under consideration.

WCH

5.14.2 There is a significant network of WCH routes within the Pass of Birnam to Tay Crossing section of the A9 Dualling Programme, comprising Core Paths, Rights of Way, NCN Routes and RCN Routes. The options impact WCH routes at various locations and suitable mitigation to maintain connectivity is necessary.

5.14.3 One of the most significantly impacted routes is NCN Route 77, which is currently segregated from vehicular traffic between the existing left/right staggered priority junction with the B867 and Perth Road at Birnam and Dunkeld & Birnam Station. The route will be diverted onto the realigned B867/Perth Road for all options, however with Option ST2A there is an opportunity that the route can be placed on top of the cut and cover tunnel.

5.14.4 All options improve accessibility to the station, compared to the existing condition. Options ST2A and ST2B provide a direct connection from Station Road by lowering the proposed A9 dual carriageway. Options ST2C and ST2D incorporate a pedestrian underpass structure, with associated lifts and stairs. There is potential to provide Equality Act 2010 compliant access between station platforms, which will be investigated as part of the DMRB Stage 3 assessment, in conjunction with Network Rail and Transport Scotland.

5.14.5 All options impact existing WCH routes in the locality of the River Braan, albeit this impact is heightened for Option ST2C due to the larger land-take associated with the grade separated junction at Dunkeld. The impacts in the locality of the River Tay crossing are common to all options.

5.14.6 The variation between route options is not considered to be a differentiator.

Lay-bys and Rest Areas

5.14.7 The options under consideration include junctions at Murthly/Birnam, Dunkeld, The Hermitage and Dalguise. In addition, Options ST2C and ST2D include a left-in left-out junction at Dunkeld & Birnam Station, to provide maintenance access to the station and Highland Main Line railway. As a result of the frequency of junctions within the 8.4 kilometre scheme and considering the required weaving length to lay-bys and other geometrical parameters for the design of lay-bys, it is not proposed to provide any parking lay-bys. However, as part of the DMRB Stage 3 assessment, consideration will be given to upgrading the existing lay-bys to the immediate south of the scheme (Lay-by 13 and Lay-by 14). This is applicable for all options and is therefore not a differentiator.

Relaxations & Departures from Requirements, A9 Dual Carriageway

5.14.8 Table 5.54 provides a summary of the Relaxations and Departures from requirements for the proposed A9 dual carriageway for each option.

Table 5.54: Relaxations and Departures from Requirements Summary, A9 Dual Carriageway

Option	No. of Relaxations	No. of Departures
Mainline		
Option ST2A	7	7
Option ST2B	15	6
Option ST2C	13	8
Option ST2D	14	6

5.14.9 As a result of existing constraints, the proposed A9 dual carriageway for all options includes a number of Relaxations and Departures from requirements. The number of Departures for Options ST2A (7), ST2B (6), ST2C (8) and ST2D (6) are comparable, however Option ST2A contains considerably less Relaxations than the other options. This is largely a result of the reduced speed limit of 50mph that is proposed for safety between the southern extent of the scheme and the proposed junction at Dunkeld. Options ST2B, ST2C and ST2D incorporate a 70mph speed limit throughout.

5.14.10 Options ST2A, ST2B and ST2D include an at-grade roundabout, which does not meet the recommendations of a D2AP (sub-category c) dual carriageway, whereas Option ST2C incorporates grade separated junctions throughout.

5.14.11 For safety reasons, pedestrians, cyclists, motorbikes (with engines less than 50cc), animals and animal drawn vehicles would not be permitted to use the cut and cover tunnel within Option ST2A.

Relaxations & Departures from Requirements, Junctions

5.14.12 Table 5.55 provides a summary of the Relaxations and Departures from requirements for the junction options.

Table 5.55: Relaxations and Departures from Requirements Summary, Junctions

Option	No. of Relaxations	No. of Departures
Junctions		
Murthly Junction (Option ST2A)	0	2
Birnam Junction (Options ST2B, ST2C and ST2D)	0	1
Dunkeld & Birnam Station Access (Options ST2C and ST2D)	0	0
Dunkeld Junction (Options ST2A, ST2B and ST2D)	5	17
Dunkeld Junction (Option ST2C)	2	4
The Hermitage Junction (Options ST2A, ST2B, ST2C and ST2D)	0	0
Dalguise Junction (Options ST2A, ST2B, ST2C and ST2D)	1	4

5.14.13 The Murthly Junction included in Option ST2A contains two Departures from requirements and the Birnam Junction for Options ST2B, ST2C and ST2D contains one Departure from requirements. For Option ST2A the Departure from requirements is for the stagger distance between priority junctions. For Options ST2B, ST2C and ST2D the Departure is for reduced SSD at the back of the nose on the northbound diverge loop.

5.14.14 Options ST2C and ST2D include a left-in left-out junction to provide maintenance access to Dunkeld & Birnam Station. This junction has no Departures from requirements or Relaxations.

5.14.15 The at-grade roundabout at Dunkeld Junction, included in Options ST2A, ST2B and ST2D incorporates 17 Departures from requirements. These Departures from requirements are on the side roads and are to limit the extent of realignment, which would impact adjacent physical and environmental constraints, and ensure an effective tie-in to the roundabout itself. It is noted however, that many of the Departures from requirements noted may be removed once additional design work has been undertaken as part of the DMRB Stage 3 assessment.

5.14.16 There are four Departures from requirements highlighted for Option ST2C at Dunkeld Junction. Two Departures from requirements are incurred for the stagger distances at the priority junctions connecting to the realigned A923/A822. This is largely due to the extent of side road being curtailed between the existing railway bridge on the A822 (Old Military Road) and the existing junction with Perth Road on the A923. Two further Departures from requirements are included for SSD on the diverge slip roads.

5.14.17 The left-in left-out junction at The Hermitage and grade separated junction at Dalguise are identical for all options. The left-in left-out junction at The Hermitage has no Departures from requirements or Relaxations. The grade separated junction at Dalguise incorporates 4 Departures from requirements. At Dalguise Junction, the Departures from requirements are on the junction slip roads and are for forward visibility and the length of near straight at the back of the diverge slip roads. There is a further Relaxation included at Dalguise Junction, for the B898 horizontal alignment.

Relaxations & Departures from Requirements, Whole Route Options

5.14.18 The combined total of Relaxations and Departures from requirements for the Whole Route Options are as follows:

- Option ST2A: 13 Relaxations and 30 Departures;
- Option ST2B: 21 Relaxations and 28 Departures;
- Option ST2C: 16 Relaxations and 17 Departures; and
- Option ST2D: 20 Relaxations and 28 Departures.

5.14.19 The variation between route options is considered to be a differentiator, with Option ST2C the most favourable and Option ST2A the least favourable. Option ST2A is considered the least favourable due to its reduced speed limit and as it prohibits certain usage.

Geotechnics and Earthworks

5.14.20 Option ST2A requires significant excavation to form the 1.5 kilometre cut and cover tunnel (approximately 535,000m^3). Option ST2B also requires excavation to form the underpass structure at Dunkeld & Birnam Station. While not as significant as Option ST2A, the excavated volume (approximately 168,000m^3) is still extensive.

5.14.21 Options ST2A and ST2B also impact the Ladywell Landfill site, located to the west of the Highland Main Line railway, north of Inchewan Burn, as a result of the access road to properties on Birnam Glen, west of Dunkeld & Birnam Station. While the works are largely outwith the known boundary of the site, there is potential for contaminated ground to be encountered in this area, which may require treatment.

5.14.22 Option ST2C is raised above existing carriageway levels north of Dunkeld & Birnam Station to facilitate a grade separated junction at Dunkeld. This requires imported fill material (approximately 287,000m^3). Option ST2D is largely at-grade and on-line, therefore there are no significant excavations or embankments.

5.14.23 A summary of the total volumes of material required for import and export for each route option is given in Table 5.56.

Table 5.56: Earthwork Volume Summary

Route Option	Total Import (m^3)	Total Disposal (m^3)
Option ST2A	0	698,000
Option ST2B	0	356,000
Option ST2C	287,000	146,000
Option ST2D	0	163,000

5.14.24 Option ST2A requires structural walls, formed with bored piles, to form the cut and cover tunnel. Similarly, Option ST2B also requires structural walls, formed with bored piles, on the northbound and southbound approaches to the underpass structure at Dunkeld & Birnam Station. These walls will be up to approximately 8 metres maximum height. Option ST2C requires three short length of low height retaining walls to avoid encroachment towards residential properties adjacent to the southbound merge slip road that forms part of Dunkeld Junction. More significantly however, Option ST2C includes a retaining wall up to 14 metres high alongside Dunkeld & Birnam Recreation Club.

5.14.25 The variation between route options is considered to be a differentiator, with Option ST2D the most favourable and Options ST2A and ST2B the least favourable.

Hydrology, Hydrogeology and Drainage

5.14.26 The effects of the four route options on the water environment are considered fully in Volume 1, Part 3 - Environmental Assessment, Chapter 10 (Road Drainage and the Water Environment). Overall, when considering the essential mitigation that would be developed further as part of the DMRB Stage 3

assessment, effects to flood risk as a result of the proposed scheme are similar in nature for the proposed route options. Although there may be some variation in the extent of specific effects between the proposed route options, this is not considered to be a differentiator.

5.14.27 Road drainage for the proposed cut and cover tunnel included in Option ST2A is complex, primarily due to the lowered road alignment, existing topography and narrow corridor. Within the tunnel section, sump tanks will be required, which will need to be emptied via a manhole within the tunnel. As such, one direction of the tunnel would need to be closed for this operation, utilising bi-directional traffic in the other half of the tunnel. Bi-directional traffic in a tunnel is not desirable due to the risk of head-on collisions, and reduced speed limits would likely be employed.

5.14.28 At the northern cut and cover tunnel portal within Option ST2A, further complications exist, which requires surface run-off, collected from outwith the tunnel, to be passed through the tunnel to reach Inchewan Burn. To limit the potential impact on the tunnel during flood events, an additional sump tank with pump is required.

5.14.29 Option ST2B incorporates an underpass in the locality of Dunkeld & Birnam Station. Filter drains on the A9 dual carriageway would continue through the underpass structure with an HVS included beneath carriageway level to treat run-off. A geocellular/modular system is also required below the carriageway, which extends the depth of excavation and introduces a requirement for maintenance, albeit this is irregular.

5.14.30 Options ST2C and ST2D are generally at-grade throughout, albeit Option ST2C is raised at Dunkeld Junction. Both options include filter drains and detention basins throughout, however Option ST2C includes a geocellular/modular system at Dunkeld Junction, to attenuate surface run-off.

5.14.31 The variation between route options is considered to be a differentiator, with Options ST2C and ST2D the most favourable and Options ST2A and ST2B the least favourable.

Structures

5.14.32 Option ST2A includes a 1.5 kilometre cut and cover tunnel that will be a two-span structure, constructed using 1.2 metre diameter bored piles. Option ST2B incorporates a 150 metre long underpass structure that, given the site constraints, would also be formed utilising 1.2 metre diameter bored piles. Both options include a drop-structure and culvert at Inchewan Burn. As a result of the A9 dual carriageway lowering works, a further structure is necessary for Options ST2A and ST2B across Birnam Glen and Inchewan Burn to the west of Dunkeld & Birnam Station to provide access to properties.

5.14.33 The grade separated junctions at Murthly/Birnam and Dalguise for all options include structures and the grade separated junction included in Option ST2C at Dunkeld requires an additional structure. All options include structural works to lengthen the existing Inver and Inch Rail Underbridges and a new structure alongside the existing River Tay crossing.

5.14.34 The total number of major structures for each route option is summarised in Table 5.57 below.

Table 5.57: Structures Summary

Route Option	Number of Structures	List of Structures
Option ST2A	10	1. Murthly Junction Overbridge 2. Cut and Cover Tunnel 3. Inchewan Burn Culvert 4. Birnam Glen Access Bridge 5. River Braan Underbridge 6. Inver Mill Lade Culvert 7. Inver Rail Underbridge

Route Option	Number of Structures	List of Structures
		8. Dalguise Junction Underbridge 9. Inch Rail Underbridge 10. River Tay Underbridge
Option ST2B	11	1. Murthly Estate Underbridge 2. Birnam Junction Underbridge 3. A9 Dual Carriageway Underpass 4. Inchewan Burn Culvert 5. Birnam Glen Access Bridge 6. River Braan Underbridge 7. Inver Mill Lade Culvert 8. Inver Rail Underbridge 9. Dalguise Junction Underbridge 10. Inch Rail Underbridge 11. River Tay Underbridge
Option ST2C	11	1. Murthly Estate Underbridge 2. Birnam Junction Underbridge 3. Pedestrian Underpass (at Dunkeld & Birnam Station) 4. Birnam Glen and Inchewan Burn Underbridge 5. Dunkeld Junction Underbridge 6. River Braan Underbridge 7. Inver Mill Lade Culvert 8. Inver Rail Underbridge 9. Dalguise Junction Underbridge 10. Inch Rail Underbridge 11. River Tay Underbridge
Option ST2D	10	1. Murthly Estate Underbridge 2. Birnam Junction Underbridge 3. Pedestrian Underpass (at Dunkeld & Birnam Station) 4. Birnam Glen and Inchewan Burn Underbridge 5. River Braan Underbridge 6. Inver Mill Lade Culvert 7. Inver Rail Underbridge 8. Dalguise Junction Underbridge 9. Inch Rail Underbridge 10. River Tay Underbridge

5.14.35 The variation between route options is considered to be a significant differentiator, with Option ST2D the most favourable and Option ST2A the least favourable.

Public Utilities

5.14.36 The route options interact with underground and overground public utility apparatus owned by BT Openreach, SGN, SSE and Scottish Water. The number of interfaces for each type of apparatus is summarised in Table 5.58.

Table 5.58: Public Utilities Interface Summary

Utility Type	No. of Impacts			
	Option ST2A	Option ST2B	Option ST2C	Option ST2D
Telecommunications	25	25	23	23
Gas	5	5	5	5
Electricity	58	58	49	47
Water Supply & Sewerage	10	10	10	10
TOTAL	**98**	**98**	**87**	**85**

5.14.37 The impacts between route options are broadly comparable. Options ST2A and ST2B include lowering works in the locality of Dunkeld & Birnam Station, which will add complexity to diversion works. However, it is envisaged that post construction, measures can be employed to divert the utility apparatus.

5.14.38 The variation between route options is not considered to be a differentiator.

Constructability

5.14.39 Construction of the 1.5 kilometre cut and cover tunnel for Option ST2A, and the underpass for Option ST2B, in such a constrained and sensitive corridor, will be complex. As insufficient space exists for an open excavation, the walls that form part of the cut and cover tunnel, and the underpass, would be constructed using large diameter bored piles (1.2 metre diameter) to retain a height of approximately 10 metres. Installation will require heavy plant in close proximity to residential properties, Dunkeld & Birnam Station, the Highland Main Line railway and the Category A Listed station building. Construction will generate noise and vibration, with the potential to affect residential properties immediately adjacent to the proposed A9 as bored piles are formed over a significant length. Maintaining bi-directional traffic flows on the A9 throughout construction will be challenging, and reduced speed limits and narrow lane widths will be required.

5.14.40 For Options ST2A and ST2B, construction works will be undertaken approximately 2.5 metres from the Category A Listed station building, with potential risk of accidental damage. It is not anticipated that the works will have a structural impact on residential properties. However, before commencement of piling works, Pre-Construction Condition Surveys may be undertaken to inspect the existing condition.

5.14.41 Works to lower Inchewan Burn for Options ST2A and ST2B are complex and will require permanent and temporary bored and sheet piling works, as well as the erection of a temporary A9 bridge, to allow the existing A9 structure to be demolished. The burn itself would be diverted through a temporary culvert while the permanent drop structure and box culvert are constructed.

5.14.42 As Option ST2C is above existing carriageway levels, it requires retaining walls of less than 2 metres high for short lengths on the east side adjacent to residential properties. These walls will likely be simple in-situ concrete or pre-cast L-shaped gravity walls, which are relatively simple to construct. No retaining wall solutions are required on the west side alongside the Highland Main Line railway as a natural earthwork slope can be accommodated, subject to the existing railway bund being removed.

5.14.43 Option ST2D is largely at-grade and while there will be some construction challenges, they are not as significant as the other options.

5.14.44 Anticipated construction durations for the route options are shown below. This assumes a 6-day working week (Monday to Friday, 7am to 7pm, Saturday 8am to 1pm, with no night-time, Sunday and Bank Holiday working).

- Option ST2A: 4 ½ to 5 years;

- Option ST2B: 4 to 4 ½ years;
- Option ST2C: 2 ½ to 3 years; and
- Option ST2D: 2 ½ to 3 years.

5.14.45 The variation between route options is considered to be a differentiator, with Option ST2D the most favourable and Options ST2A and ST2B the least favourable.