4 Design Development

4.1 Introduction

4.1.1 This chapter outlines the iterative DMRB Stage 3 design and environmental review processes that has informed the development of the Proposed Scheme since DMRB Stage 2 selection of the preferred mainline and junction options. The principal aim of the iterative approach was to ensure that a range of potential environmental impacts could, in the first instance, be addressed or avoided by embedding mitigation through iterative design revisions.

4.2 Design Iterations

4.2.1 **Table 4-1** summarises the iterative design/ review processes undertaken during DMRB Stage 3, with further explanation provided below.

Table 4-1: DMRB Stage 3 iterative design and review process

DMRB Stage 3 design revision	Engineering design elements considered	Environmental inputs/ reviews
Preliminary DMRB3 design February 2017	• Revision of DMRB Stage 2 Insh Marshes embankment and River Spey crossing alignment to bring closer to existing crossing • Horizontal and vertical alignment of mainline and junctions • Initial earthworks extents (cuttings and embankments, engineered slopes) • Initial location and arrangement of principal structures and lay-bys	• Watercourse crossings workshop – mammal permeability – geomorphology and flood risk • Local landform review of earthworks (landscaped slope extents) • Potential locations for enhanced lay-bys considered
Design revision 1 February 2017	Changes to above following initial review, plus: • Initial SuDS and culvert locations, pre-earthworks cut-off drains and watercourse diversions • Vertical alignment revision to accommodate structures and culverts • Slope angle stability review in identified rock cut areas • Identification and relocation of accesses to properties, side roads and cycleways	• Overlay of earthworks extents and 1:200 year floodplain to identify encroachment areas • Interdisciplinary design review workshop Feb. 2017 – identifying potential conflicts with designated sites, peat, notable habitats and 1:200 flood plain extent
Design rev. 2 March 2017	Changes to above following 2nd design review, plus: • Earthworks extents and landscape slopes revised following flood model overlays to reduce areas of encroachment where possible • Revision of Newtonmore Junction layout • Initial compensatory storage locations based on flood model • Introduction of maintenance accesses to SuDS features	• Environmental review workshop March 2017 – Interdisciplinary review of initial compensatory flood storage locations to consider constraint conflicts • Landscape review of SuDS feature layouts
Design rev. 3 September 2017	Changes to above following 3rd design review, plus: • Localised adjustment of landscape earthworks slopes • Refinement of Newtonmore Junction and Glentruim/ Ralia access • Revisions to structures and culverts to include mammal ledges and geomorphological clearance, where feasible • Horizontal and vertical alignment confirmed across the Insh Marshes and for 270m long River Spey bridge, linking with vertical alignment of HML crossing at Kingussie	• Environmental review workshop Nov. 2017 - to identify further opportunity for embedded mitigation, and to outline preliminary land requirements for impact mitigation/ restoration/ compensation purposes • Design review record compiled on mitigation requirements • Design rev. used for Draft Flood Risk Assessment (FRA) – described in FRA as 'initial design'

DMRB Stage 3 design revision	Engineering design elements considered	Environmental inputs/ reviews
Design rev. 4 February 2018	Design 'freeze' for draft EIA and mitigation review • Introduction of northbound access to Ralia Lodge/ Nuide Farm • Inclusion of northbound access to Balavil Estate • Amended access to Knappach Cottage realigning NMU access • Updates recommended by Draft FRA, where achievable • Presented at Public Drop-in events April 2018	• Draft EIA chapter production assessing design freeze version • Development of required mitigation proposals, including Dellmore of Kingussie • Construction/ buildability review March 2018
Design rev. 5 May 2018	Changes made following EIA draft and consideration of mitigation and public consultation feedback • North bank extension of River Spey bridge (to 290m total) to include access provision beneath final span • Mapping of land required for mitigation purposes • Refinement of Ralia/ Nuide and Balavil northbound accesses	• Draft Environmental Statement (ES) for Environmental Steering Group (ESG) review • Consultation with SEPA on acceptability of removing compensatory flood storage where conflicted by other environmental constraints • Review of land required for mitigation
Design rev. 6 June/ July 2018 Proposed Scheme	Design 'fix' for final EIA, FRA and production of Draft Road Orders • Compensatory flood storage areas confirmed • Phoines underpass vertical clearance increased • Chapelpark Farm underpass relocated • Refinement of Croftcarnoch access • Church of Scotland (Kingussie Glebe) access amended • Lay-by positions fixed • Police Observation Platforms added	• Assessment updates following consideration of ESG feedback • Final EIA and FRA revisions assessing fixed Proposed Scheme design – FRA refers to the Proposed Scheme as 'final design' • Finalisation of required mitigation proposals • Environmental Statement compilation for publication with Draft Road Orders

Preliminary DMRB Stage 3 Design – February 2017

4.2.2 At the outset of DMRB Stage 3, the horizontal and vertical alignment (i.e. the route of the road) including earthworks (engineered embankments and cutting slopes), junction and lay-by locations were developed based on the preferred route outcome from DMRB Stage 2.

4.2.3 The main features driving the vertical alignment were crossing structures, road drainage and culvert levels. The various structural features were developed from DMRB Stage 2 level of detail to further consider vertical and horizontal clearances required. A watercourse crossings workshop considered potential ecological, geomorphological and hydrological issues which could affect the vertical alignment including, for example, culverts which could be increased in size to accommodate mammal ledges and which watercourses had erosion/ scour issues that different culvert sizes/ arrangements could help address.

4.2.4 In addition, one of the DMRB Stage 2 recommendations was to consider whether the offline alignment of the embankment and crossing at the Insh Marshes/ River Spey could be brought closer towards the existing crossing.

4.2.5 **Figure 4-1** shows the offline alignment as preferred at DMRB Stage 2 and the refined alignment as determined at the outset of DMRB Stage 3. Development of the refined offline alignment included consideration of the horizontal and vertical geometries and required linkages to the other bridges local to the area, including the B970 Ruthven Road underbridge to the south, and the Highland Main Line (HML) railway and A86 Kerrow Road underbridges to the north at the Kingussie junction.

4.2.6 It should be noted that this early design development focussed on the mainline alignment geometry, and not the form of the new River Spey bridge.

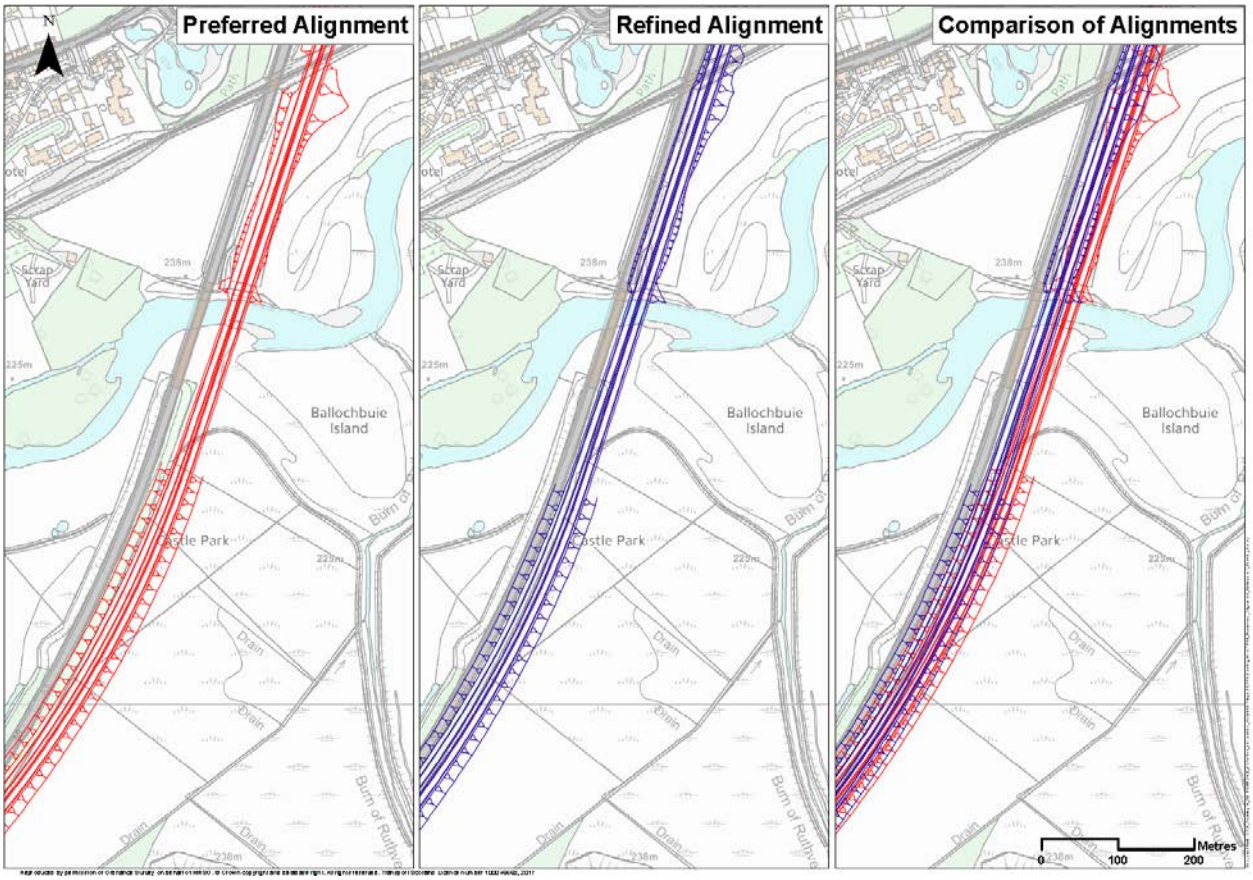

Figure 4-1: DMRB3 revision of offline alignment at Insh Marshes embankment and River Spey crossing

4.2.7 Other environmental inputs included an early landscape and visual review to consider the aesthetic appearance of earthworks slopes. As the Proposed Scheme is wholly situated within the Cairngorms National Park (CNP), landscape specialists reviewed design cross-sections aiming to better integrate the scheme into the surrounding landscape context. **Figure 4-2** shows an example cross-section with slopes that have been through a landscape/ visual review.

Figure 4-2: Illustrative cross-section showing typical landscaped earthworks slopes

4.2.8 The preliminary DMRB3 design extents were also reviewed against a range of environmental constraints, including known areas of peat, SAC/ SPA/ Ramsar/ SSSI/ NNR designation boundaries, and 1:200 year floodplain extents. This determined where softened landscape slopes resulted in conflicts that could be avoided by tightening up the slopes to a more suitable gradient.

4.2.9 It should be noted that in relation to designated nature conservation site boundaries, design reviews were based on boundaries as defined by the Scottish Natural Heritage (SNH) Geographical Information Systems (GIS) shapefiles for each designation.

Design Revision 1 – February 2017

4.2.10 Following initial consultations with affected landowners, The Highland Council and Network Rail, Design Revision 1 incorporated several changes to structures' headroom, side roads and private accesses, resulting in variations to horizontal and vertical alignments and modified landscape slopes. Landscape input to rock slope design was considered on the basis of information gathered from site walkover surveys of existing rock exposures.

4.2.11 Design Revision 1 included consideration of SuDS feature locations and layouts, the extents of watercourse diversions required to tie-in with culvert locations, and initial consideration of possible means of access for maintenance.

4.2.12 This revision was considered against a wide range of environmental constraints, including known areas of peat and other sensitive habitats (identified and mapped from site survey), and 1:200-year floodplain extents, to determine where potential conflicts could be avoided by adjustment of mainline, side road and access alignments or tightening up of earthwork and landscape slopes.

4.2.13 In general, engineering slopes were considered as the minimum required for slope stability (typically a 1:2, 1:2.5 or 1:3 gradient depending on local ground conditions) and, where conflicted, landscape slopes were brought back to no less than the engineering minimum, in order to develop a balance between hydrology, geomorphology, geotechnical, ecology and landscape inputs. The principal aim at this point was achieving aesthetically favourable earthwork slopes whilst avoiding unnecessary encroachment into environmentally and hydrologically sensitive areas.

Design Revision 2 – March 2017

4.2.14 One of the DMRB Stage 2 recommendations was to consider the potential benefits of a compact form grade separated junction at Newtonmore. Following a comparative assessment, which determined that there would be benefits, the design layout for the Newtonmore Junction was revised to a compact grade separated junction with loops, as shown in **Figure 4-3**.

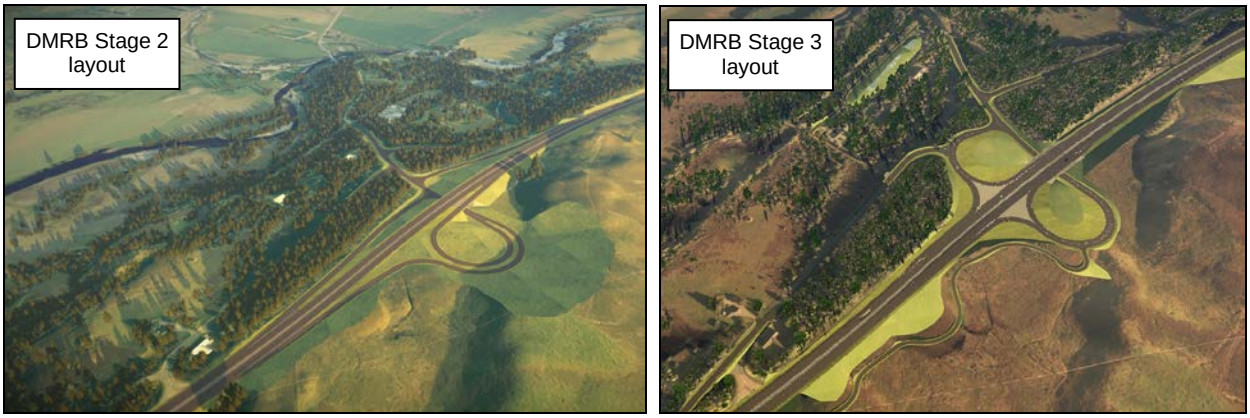

Figure 4-3: Newtonmore Junction development from DMRB2 (left image) to DMRB3 (right image)

4.2.15 This change enabled side road and access connections to the junction loops, reducing the overall junction footprint, including the earthworks and rock cuts required for the southbound loop.

4.2.16 Design Revision 2 also included detailed landscaping input to the shape of SuDS features, as well as the introduction of SuDS maintenance access routes. Input from geotechnical and soils specialists

helped with refinements to earthworks extents to avoid and minimise requirements for peat excavations where possible, and to reduce flood plain encroachments.

4.2.17 Preliminary flood model analysis of resultant floodplain encroachments informed the initial identification of areas that could potentially be excavated or profiled to provide hydraulically suitable compensatory flood storage.

Design Revision 3 – September 2017

4.2.18 This revision embedded further changes to landscape earthworks slopes following preliminary compensatory flood storage area analysis, as well as revisions to structures and culverts to include mammal ledges and geomorphological clearance (i.e. to offset structure walls/ abutments from channel banks to allow for watercourse migration), where feasible.

4.2.19 Availability of greater detail on watercourse diversions and required culvert sizes informed revisions to side road vertical alignments, where similarly upsized culvert requirements resulted in a new road level. Side road alignments to Glentruim (C1137) and Raliabeag (U3011) were locally rerouted and widened, or passing places were introduced, to enable two-way traffic. Passing places were also added to the Ralia-Nuide (U3036) side road.

4.2.20 A northbound carriageway left-in/ left-out access was included at Glentruim/ Raliabeag, to replace the existing Ralia Café access. This was linked, via the C1137 and U3011 side roads, to Glentruim properties (via a new rail bridge) and Phoines Estate (via underpass) to the south, and to Ralia Café and properties on the Raliabeag road, and the new Newtonmore Junction, to the north.

4.2.21 Parallel design development work to this point, continued to refine the horizontal and vertical alignments between a replacement underpass at Ruthven Cottage, the B970 Ruthven road crossing, the embankment at Insh Marshes, the River Spey crossing, the HML crossing at Kingussie and the A86 Kingussie Junction crossing. Each of these crossing locations 'fixes' a point on the new road network and, when considered in conjunction with SuDS network spatial requirements, some local adjustments were necessary to ensure gravity drainage.

4.2.22 Further information on Network Rail requirements on height and width clearances for the replacement HML crossing at Kingussie, and visibility requirement standards for the Kingussie Junction northbound slip road, set the new road level locally. Working from that road level, the gradient south from the HML to the River Spey crossing location informed limits/ tolerances on the required road level at the north end of a new River Spey bridge.

4.2.23 In addition, the design level of the new Spey bridge included consideration of the local 1:200 year flood level, as the underside of the bridge would have to be above this plus a 20% allowance for climate change, plus an additional freeboard (clearance) of at least 600mm. This then gave a range between underside and road level that the bridge structural form had to accommodate.

4.2.24 A range of structural forms were considered, including arched, cable-stayed suspension and concrete and steel composites. Different structural forms vary in deck and superstructure thicknesses and also the maximum limits on span between supporting foundation piers, all of which influences the bridge geometry and aesthetics.

4.2.25 Following stakeholder feedback on issues including the historic setting and prominence of the Ruthven Barracks Scheduled Monument as the principal elevated feature above the Insh Marshes floodplain, and concerns on possible increased risk of bird strike, structural forms with elevated features such as arches and cable-stays were discounted in favour of lower profile structural forms.

4.2.26 In terms of bridge length, DMRB Stage 2 stakeholder feedback varied with:

- RSPB advocating a full-length viaduct, or a minimum of 650m long in the Insh Marshes National Nature Reserve (NNR) area, in line with their vision to "*see the River Spey and its tributaries restored to a more naturally functioning river and floodplain system*", and to accord with public body duties to further the conservation of biodiversity
- SNH advocating as long a bridge as possible, recognising benefits for river morphology and improved river/ floodplain connectivity, but with a requirement to avoid and minimise potential adverse effects on the qualifying features of the internationally designated Special Area of Conservation (SAC), Special Protection Area (SPA) and Ramsar site boundaries, in accordance with Habitats Regulations requirements
- SEPA recognising that lengthening the overall span of the bridge could have morphological benefits (e.g. reducing long term need for bankside erosion protection measures on the River Spey) but also noting the need to comply with Flood Risk Management (Scotland) Act 2009 and Scottish Planning Policy, to avoid an overall increase in flood risk, and not materially increase the probability of flooding elsewhere. SEPA favoured a solution "*which demonstrates a clear upstream benefit whilst minimising floodplain encroachment and adverse downstream effects*"
- The Highland Council (THC) recognising that lengthening the bridge would result in an increase in downstream flood levels and that mitigation would be required for downstream effects. THC advocated, as a minimum, "*avoid an overall increase in flood risk*", whilst aiming to achieve "*net beneficial or neutral impacts on sensitive receptors*" and to "*reduce overall flood risk to Potentially Vulnerable Areas*" (PVAs)
- SEPA and THC both accepted that the practical provision of compensatory flood storage would be unlikely at the Insh Marshes and that increases in downstream flood risk to sensitive receptors would therefore require consideration of alternative mitigation
- Cairngorms National Park Authority (CNPA) recognising that "*there are a range of issues to be taken into account in this area*" and a solution that minimised "*the impact on the community, landscape and non-motorised users (land and water based)*" would be preferred. CNPA also recognised that a longer bridge than the existing would be beneficial for ecology
- Historic Environment Scotland (HES) advised that, in relation to the setting of the Ruthven Barracks, "*impacts are likely to be significant for HES interests although much will depend on the form of the Spey Crossing*"

4.2.27 With the revised crossing alignment pulled in closer to the existing bridge, the distance on that line between a bridge abutment on the north bank of the Spey and a bridge abutment on the south side, that spanned the SAC/ SPA/ Ramsar (Natura) site boundaries, was calculated at approx. 250m; and therefore, a minimum 270m long bridge was proposed to span the Natura boundaries.

4.2.28 Flood modelling at this stage considered the existing 138m long bridge (base case) and a range of alternative bridge lengths (shown on **Figure 4-4**) including:

- 270m – the minimum to span the Natura site boundaries, as noted above
- 310m – to consider inclusion of one additional 40m long bridge section
- 350m – to consider inclusion of two additional 40m long bridge sections
- 650m – to consider the minimum recommended by RSPB
- 950m – to consider a full viaduct, as recommended by RSPB

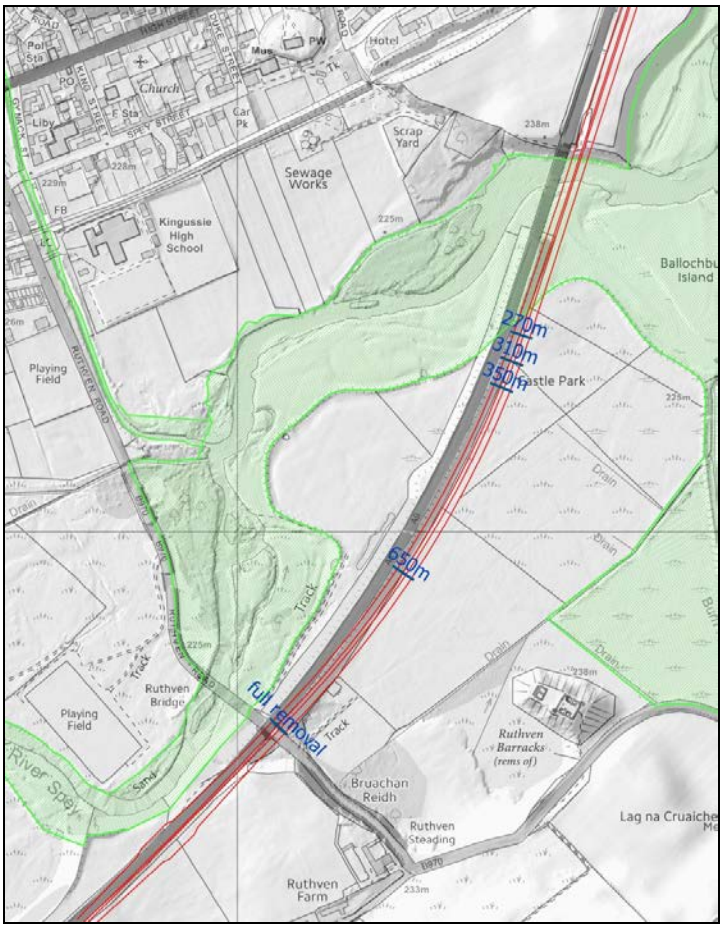

Figure 4-4: Alternative River Spey bridge lengths considered

4.2.29 The existing 138m bridge length was modelled in order to provide a base case for comparison between upstream and downstream effects on flood storage volume and change in flood levels at a range of sensitive upstream and downstream receptors, including the Kingussie Sewage Treatment Works, the Highland Main Line (HML) railway, the B970 local road and local properties.

4.2.30 As may be expected, the greater the length of bridge modelled, the greater the reduction in upstream flood storage volume, and the greater the change in downstream flood levels. However, given that the Insh Marshes and Loch Insh are downstream of the bridge, the upstream change (reduction) in flood storage volume was proportionately much greater than the increase in downstream flood levels, as flood water is dissipated across the wider area provided by the Loch and the Marshes.

4.2.31 When considered within the context of the Flood Risk Management (Scotland) Act and Scottish Planning Policy requirements, to avoid an overall increase in flood risk, and not materially increase the probability of flooding elsewhere, the 270m long bridge was determined as providing the least change in downstream flood risk when the alternatives were compared against the base case.

4.2.32 The 270m bridge length was also determined as providing:

- improvement to ecological permeability and River Spey/ Insh Marshes floodplain connectivity (270m is almost double the length of the existing 138m bridge)
- reduction in fluvial morphology risk
  (270m long and downstream of the existing bridge allows for River Spey migration and upstream bank erosion without needing to install significant bankside protection measures)

- reduction in upstream flood levels at some Kingussie properties in a Potentially Vulnerable Area (PVA), but with significant loss in upstream flood storage capacity as, within a peak flow time period, a greater volume of water will pass downstream through the longer bridge
- increased downstream flood levels, significantly attenuated but not fully absorbed by dissipation over the Insh Marshes; however, the 270m length minimised downstream change when compared with longer alternatives

4.2.33 Following the local assessment of alternative bridge lengths, the full extent of designed earthworks extents including side roads, watercourse crossings, culvert locations and sizes, bridges and SuDS features was subject to Draft Flood Risk Assessment (FRA). This was a scheme-wide review of flood related issues, building upon the detail developed for the Spey crossing area, to support consultation with SEPA and THC Flood team and to develop specific recommendations to be incorporated in later design revisions, i.e. before finalisation of the DMRB Stage 3 design.

Design Revision 4– design 'freeze' for draft environmental impact assessment – Feb. 2018

4.2.34 Design Revision 4 incorporated a number of changes to access proposals, including the addition of a new left-in/ left-out access off the northbound carriageway connecting to the U3036 Ralia-Nuide side road. This access connects the Newtonmore Junction via the U3036 to the south, to Inverton properties to the north, and provides maintenance access to three SuDS locations. An underpass included to the south of this access provides a link through to properties on the southbound side, including Milton of Nuide and Ralia Estate.

4.2.35 Side road access to Knappach Cottage and Ruthven Cottage was reviewed to bring a NMU route between the A9 and the rear of Knappach, as opposed to routing via the front of the property. Access to these properties is connected to the General Wade's Military Road (GWMR) which links to the B970 Ruthven Road.

4.2.36 A new left-in/ left-out access off the northbound carriageway was introduced for Balavil Estate at Mains of Balavil. During the design development process, Balavil Estate obtained Planning Permission for a development which included a direct access to/ from the A9. Direct access therefore had to be incorporated into the updated A9 dualling proposals; however, as the dualling will close the central reservation and prevent right turn manoeuvres across live carriageways, it was only possible to provide a direct access off the northbound carriageway. Southbound access will be via the Aviemore or Kingussie junctions and the B9152 to Balavil.

4.2.37 Where achievable, local refinements were made to earthworks extents in response to the Draft Flood Risk Assessment (FRA), where such adjustments reduced floodplain encroachment, reduced the scale of compensatory storage areas required, and did not conflict with other constraints.

4.2.38 Following these updates, this 'Design Freeze' revision was considered under Draft Environmental Impact Assessment (EIA) to enable preliminary identification of required mitigation proposals, i.e. where additional design development could help reduce environmental impacts, or where land adjacent to the scheme extents may be required for mitigation measures, for example, to replant woodland lost to the scheme.

4.2.39 The 'Design Freeze' was subject to a construction/ buildability review during March 2018, where each aspect of the scheme was challenged in terms of potential for construction issues, including:

- space required for laydown/ stockpiling of construction materials, structural plant (e.g. cranes for structures), storage of topsoil/ peat and construction stage SuDS
- clearance (headroom) provided under structures and potential construction sequencing to enable material transfer between northbound/ southbound sides of the route

- temporary haul routes and earthworks (cut/ fill) material transport to reduce construction traffic on live carriageways
- space required and potential sequencing for construction of the major bridges, watercourse diversions and culverts, including dualling parallel to existing carriageways with live traffic
- access for landowners and future maintenance of A9 infrastructure once completed

4.2.40 The 'Design Freeze' was also presented at drop-in events in Newtonmore and Kingussie during April 2018 where local landowners and other members of the public were invited to provide comment before finalisation of the DMRB Stage 3 design. During this time, Historic Environment Scotland (HES) and THC's Historic Environment Team were consulted on the design aspects at the River Spey crossing and embankment in proximity to Ruthven Barracks, and on earthworks, retaining walls and lay-by proposals in proximity to Raitts Cave Souterrain to the north of the Kingussie Junction.

Design Revision 5– revised following public consultation events – May 2018

4.2.41 Design Revision 5 included changes made following consideration Draft EIA mitigation requirements and public consultation feedback, including:

- Refinement of the Ralia/ Nuide and Balavil northbound accesses
- North bank extension of River Spey bridge (to 290m total) to include access provision beneath final span; note that the extension to the final span on the north side of the bridge did not affect downstream flood levels
- Mapping of land required for mitigation purposes, including replacement woodland areas

4.2.42 Changes made were included in the production of a Draft Environment Statement which was forwarded to the A9 Dualling Environmental Steering Group (ESG) for comment, and included consultation with SEPA on the acceptability of removing compensatory flood storage areas where conflicts with other environmental constraints were identified.

Revision 6 – design 'fix' – The Proposed Scheme – June/ July 2018

4.2.43 The 'Design Fix' revision confirmed the provision of required compensatory flood storage areas, as agreed with SEPA, as well as changes to NMU, private and other access provisions, including:

- Phoines underpass vertical clearance increased
- Chapelpark Farm underpass relocated locally
- Croftcarnoch access refined
- Church of Scotland access relocated to reduce land take from Kingussie Glebe Ponds
- Lay-by positions fixed
- Police Observation Platforms added

4.2.44 Following this, the land required for mitigation of the scheme was also fixed, encompassing feedback received from the ESG. This ES therefore presents the assessment of the Proposed Scheme, including identification of land required for mitigation purposes.

4.3 References

4.3.1 Relevant references for introductory **Chapters 1 to 7** of this ES are compiled and listed at the end of **Chapter 7**.