4 Iterative Design Development

4.1 Introduction

4.1.1 The DMRB Stage 3 design for the proposed scheme as assessed and reported in this ES is the result of approximately 13 months of design development of the preferred route option that was identified at DMRB Stage 2 for the sections of the existing A9 between Killiecrankie and Pitagowan and Pitagowan and Glen Garry (refer to Chapter 3: Alternatives Considered).

4.1.2 Environmental considerations have influenced the design, based on knowledge gained through the EIA process, from the engineering teams, consultees, and Transport Scotland. Through this process, the design has been iteratively updated and improved to reach the final DMRB Stage 3 design.

4.1.3 DMRB Stage 3 represents an opportunity to avoid or mitigate potential impacts through changes to aspects such as road alignment, land requirements, or the type and form of major structures. Changes incorporated into the DMRB Stage 3 design during the design process that have 'already' avoided or reduced potential environmental impacts are often referred to as embedded mitigation.

4.1.4 The potential impacts and proposed mitigation as reported in this ES are those identified following assessment of the final DMRB Stage 3 design of the proposed scheme. As such, the potential impacts of earlier scheme design iterations are not described in the EIA chapters. This chapter (Chapter 4) therefore provides an overview of the iterative design process, and sets out the key environmental constraints and considerations that informed the final DMRB Stage 3 design. Where locations and 'chainages' ('ch') are referred to, these are shown on Figure 5.1.

4.2 Iterative Design Process

Constraints Review

4.2.1 One of the key project tools used to consider environmental constraints was the Jacobs GIS-based ProjectMapper®. All relevant environmental datasets, including those provided by statutory consultees and other environmental bodies (refer to Chapter 7: Consultation and Scoping) and those gathered through desk-based research and field surveys, were loaded onto an interactive database as 'layers'. Each environmental GIS dataset layer can be switched on or off to show its extents in relation to the design of the proposed scheme.

4.2.2 The ProjectMapper® tool was accessible to all those working on the project, enabling engineers to undertake preliminary siting prior to review and input by the environmental team (e.g. locating Sustainable Drainage Systems (SuDS) features outside of designated sites). The datasets were used extensively throughout the design process to enable quick identification of potential issues to inform design development. Photograph 4.1 (Section 4.3) provides an example of how the proposed scheme interacts with environmental constraints at specific locations using the datasets. Figure 5.1 shows the proposed scheme together with the environmental constraints.

Design Assessment

4.2.3 As part of the design process, the engineering design is subject to constant development and refinement. Examples of design refinement include revisions made to reflect landowner consultation, modelling or survey results (e.g. traffic movements, flood levels, geotechnical surveys), or adding further technical design detail.

4.2.4 To enable informed and timely input to the design, a programme of 'interim design fixes' was therefore established. These snapshots of the draft design enabled all environmental specialists to review the same proposals and provide feedback to the engineering design team to inform ongoing scheme development.

4.2.5 A total of seven interim design fixes were issued, each a refinement of earlier design, having been informed by environmental, engineering/technical and consultation input.

4.2.6 Design fixes typically included refinements to:

- horizontal alignment (i.e. altering the precise route of the road);
- vertical alignment (i.e. altering the road height relative to existing ground);
- structures design (e.g. bridge and retaining wall design including pier locations, and culvert positioning);
- routeing of access tracks, side roads and NMU provision;
- positioning of drainage features and associated outfalls; and
- gradients of earthworks slopes (embankments and cuttings).

Mitigation Workshops

4.2.7 Following assessment of each of the interim design fixes, a schedule of proposed design changes was prepared by the environmental specialists. The schedules typically included changes such as modifications to road alignment, suggestions regarding siting of drainage features, proposals for grading out of slopes, or identification of environmentally sensitive areas to be avoided if possible.

4.2.8 A mitigation workshop was then held by the project team to enable the environmental specialists, EIA Coordinators and engineering design teams to discuss proposals and influence the ongoing design development.

Stakeholder Input

4.2.9 As explained in Chapter 7 (Consultation and Scoping), the A9 Dualling Environmental Steering Group (ESG) met on a monthly basis through DMRB Stages 2 and 3, covering all A9 dualling projects. In addition to input to environmental mitigation as described in the respective chapters of this ES, statutory consultees were able to advise and influence various aspects of the draft DMRB Stage 3 design. Statutory consultee input to draft designs for this project include, for example:

- gradient of sides slopes and earthworks along the route;
- the approach to mitigating flood risk;
- the drainage design;
- landscape and ecology mitigation;
- Essangal Underbridge; and
- treatment of the rock cuts at Glen Garry SSSI.

4.2.10 The DMRB Stage 3 design has also been informed by discussions with landowners and the owners of affected properties. These discussions have influenced:

- Refinement of access tracks to the properties at Clunebeg adjacent to the Aldclune Junction (ch3900), to Shierglas Quarry (between ch5100-5600), to Garrybank (ch6250), under the A9 to fields and the Aldclune Invervack Meadows SSSI (ch9150), to the SuDS feature at ch1350 and to Tomban farmhouse (ch10700).
- Design of the proposed landscape and ecology planting (particularly at ch4400-4800, ch11700 and ch21300) to reduce potential impacts on existing land use whilst maintaining the essential mitigation requirements of the proposed planting.

4.3 Embedded Mitigation

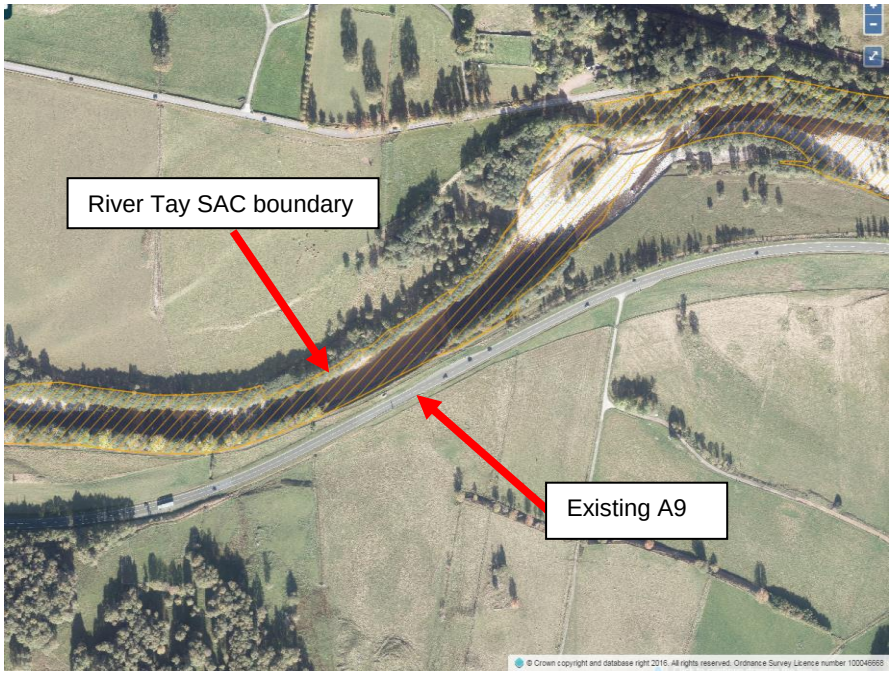
4.3.1 Some of the key design considerations during DMRB Stage 3 design development that avoided or reduced potential impacts are described further below.

Avoiding Loss of Designated Areas (River Tay SAC)

4.3.2 The River Tay is designated as a SAC under the EU Habitats Directive, providing protection in relation to otter, Atlantic salmon and lamprey (sea, brook and river).

4.3.3 For most of its length, the existing A9 between Killiecrankie and Glen Garry runs close to the River Garry, which forms part of the River Tay SAC. The River Tay SAC also includes habitat to each side of the River Garry itself, and the distance between the designated area and the edge of the existing A9 is within 10m at some locations, as shown in Photographs 4.1 and 4.2 below.

Photograph 4.1: Aerial imagery and the River Tay SAC boundary adjacent to the existing A9 (ProjectMapper®, 2017)



Photograph 4.2: Proximity of the River Garry, part of the River Tay SAC, to the existing A9 adjacent to existing Lay-by 52, north of Invervack

4.3.4 The River Tay SAC was identified as a key constraint during design development, with the aim of avoiding or reducing the potential impacts of construction and operation such as habitat loss, changes to the watercourse and water quality.

4.3.5 Examples of specific design changes that removed elements of the proposed scheme from River Tay SAC terrestrial habitat were:

- Moving the SuDS feature west of Garrybank further north east to its location at ch6750. The access track to this SuDS feature and the outfall from the SuDS feature were both moved out of the River Tay SAC.
- Moving a lay-by approximately 200m east and out of the River Tay SAC to its location between ch7700 and ch7800.
- Inclusion of the access track under the mainline at the Allt Bhaic crossing (ch9150), allowing farm access and SNH access for inspection of the Aldclune and Invervack Meadows SSSI without the requirement for an access track on the north side of the mainline which was previously located within River Tay SAC terrestrial habitat between ch8600-9300. A series of SuDS features has also been moved to south of the mainline in this location and out of the River Tay SAC.

4.3.6 Further details of the design development that avoided encroachment of the River Tay SAC adjacent to Shierglas Quarry (centred on ch5000) are given in paragraphs 4.3.8-4.3.10.

4.3.7 Following design refinement to avoid the River Tay SAC where possible, the DMRB Stage 3 design requires approximately 2.29ha of temporary and permanent loss of terrestrial and aquatic habitats of the River Tay SAC. The majority would be required to facilitate the construction of the proposed scheme (2.15ha) which would be returned to their former habitat type post-construction. The loss of terrestrial and aquatic habitats of the River Tay SAC are considered to represent a practicable minimum, taking into account other constraints and technical/safety considerations such as road gradient and visibility.

Avoiding Building Demolition and Encroachment into River Tay SAC (Shierglas)

4.3.8 The existing A9 passes through a heavily constrained area to the south of Blair Atholl, with the River Garry very close to the southbound carriageway, and Shierglas (industrial quarry, Category B Listed farmhouse and associated buildings) immediately adjacent to the northbound carriageway.

4.3.9 A best-fit alignment was identified at DMRB Stage 2, and has been carried through to the final DMRB Stage 3 design with further minor refinements. This alignment avoids encroachment into the River Tay SAC to the north of the mainline and avoids loss (demolition) of Shierglas Farmhouse and a Category B-listed building to the south of the mainline. To avoid these constraints, the design requires a low retaining feature made of locally sourced stone/boulders adjacent to Shierglas Farmhouse, reducing the overall footprint of the proposed scheme at this particular location.

4.3.10 While the alignment of the mainline of the proposed scheme avoids Shierglas Farmhouse, construction impacts were still considered to be potentially significant. A structural survey of Shierglas Farmhouse was undertaken in June 2016 which informed mitigation measures required to avoid significant impacts on the building during construction and operation. Details of this are provided in Chapter 15 (Cultural Heritage) and Appendix A15.2 (Shierglas Farmhouse Structural Overview).

Essangal Underbridge Design to Reduce Ecological and Landscape Impacts

4.3.11 The existing A9 currently crosses the River Garry (part of the River Tay SAC) via the existing Essangal Underbridge, where the river is approximately 60m wide. The proposed scheme necessitates construction of a new bridge for northbound traffic, located immediately downstream of the existing structure.

4.3.12 The key environmental issues were recognised as the potential for impacts on the River Tay SAC and the landscape/visual impacts of the new bridge. Other issues related generally to the footprint of the bridge options, with potential consequent impacts on farming operations and flood risk.

4.3.13 The A9 Dualling SEA (Transport Scotland, 2013) established a principle of avoiding construction within watercourses where possible and as such two options were initially considered for the Essangal Underbridge. A clear span bridge option is provided (i.e. no piers in the watercourse) where the structure is necessarily higher than the existing and of a different form with a deeper deck structure. Conversely, a new bridge option with piers in the watercourse could be designed to closely resemble the existing bridge, which would result in a better landscape fit and lower visual impacts within the Cairngorms National Park and the Killiecrankie Battlefield.

4.3.14 Given the above challenges in terms of engineering and conflicting environmental factors, three additional options were considered. The first option retained the existing bridge and included a new clear span structure 29m to the south of the existing so the two structures would appear at a similar elevation. The second option required demolishing the existing structure and provided two new clear span structures that would mirror each other, while the third option retained the existing structure and provided a new clear span bowstring arch structure that is aligned at the same elevation and length as the existing structure. Table 4.1 below provides a summary of the five options considered.

4.3.15 A sifting assessment was undertaken to consider the potential impacts of each option. This was presented to the ESG, who were asked to consider the assessment and associated illustrations of these five options. With the location of the Essangal Underbridge within the national park, CNPA raised concern with the visual impact of the deep deck option (existing structure retained for southbound carriageway with new adjacent structure provided for northbound carriageway, with consequent level difference between carriageways) due to the deck height as well as the driver experience and landscape impacts in relation to the bowstring arch option (existing structure retained for southbound carriageway with new bowstring arch structure for northbound carriageway; levels matched between old and new structures). CNPA also noted an issue with respect to the bowstring arch option which may become a focal point in the landscape at a location considered to be a gateway to the national park.

4.3.16 Following the assessment and consultation, it was considered that the pier in the watercourse design achieves a balance between the engineering, environmental and economic constraints. Responses from the ESG are summarised in Appendix A7.2 (Summary of Consultation Responses).

Table 4.1: Summary of Essangal Underbridge structure options

Option	Existing Bridge	New Bridge	Piers
Pier in the watercourse (assessed as the proposed scheme)	Retained	Multiple Girder. New structure would mirror the existing form and span configuration to the south of the existing structure. See Illustration 4.1.	There would be two piers within the channel width, both of which would be positioned within the River Tay SAC and one of which would be within the Aldclune and Invervack Meadows SSSI. One further pier and the bridge abutments would be set back from the channel.
Bowstring arch	Retained	Steel bowstring arch with approach span on new bridge. See Illustration 4.2.	All new supports/piers would be outwith the SAC, but the central support pier on the new crossing would be within the SSSI.
Deep deck	Retained	Steel Box Girder. New clear-span structure to the south of the existing bridge for northbound traffic. The clear span structure would be approximately 2.5m higher than the existing bridge and of a different form with deeper deck structure. See Illustration 4.3.	Supports/piers positioned outwith the boundaries of the SAC, while the eastern support pier would be within the SSSI.
Deep deck (separated)	Retained	Steel Box Girder. New structure would be a separate crossing 29m to the south of the existing bridge for northbound traffic. The clear-span structure is 100m longer than the retained existing structure.	Supports/piers positioned outwith the boundaries of the SAC, while the eastern support pier would be within the SSSI.
Demolition	Demolished	Steel Box Girder. New clear-span structure in the location of the existing structure and south of existing structure as per the deep deck option.	Supports/piers positioned outwith the boundaries of the SAC, while the eastern support pier would be within the SSSI.

Illustration 4.1: Pier in the watercourse option for Essangal Underbridge (assessed as the proposed scheme)

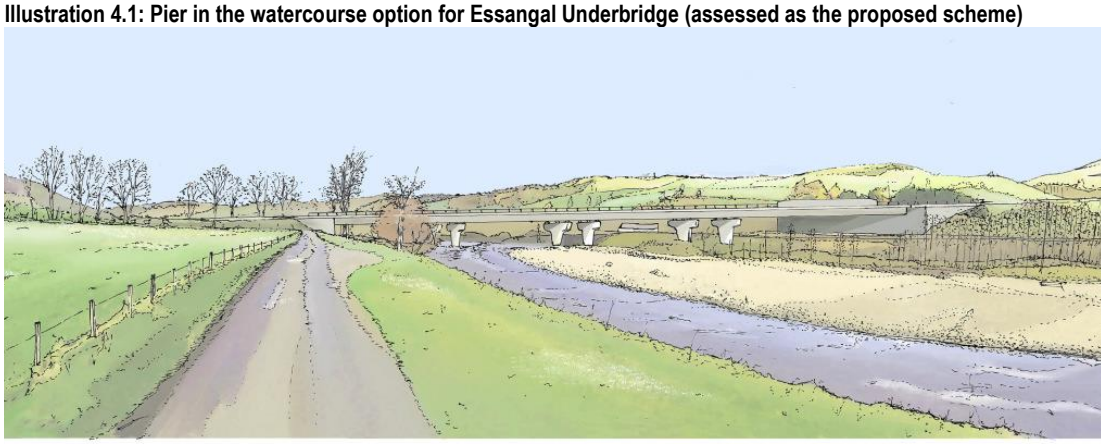
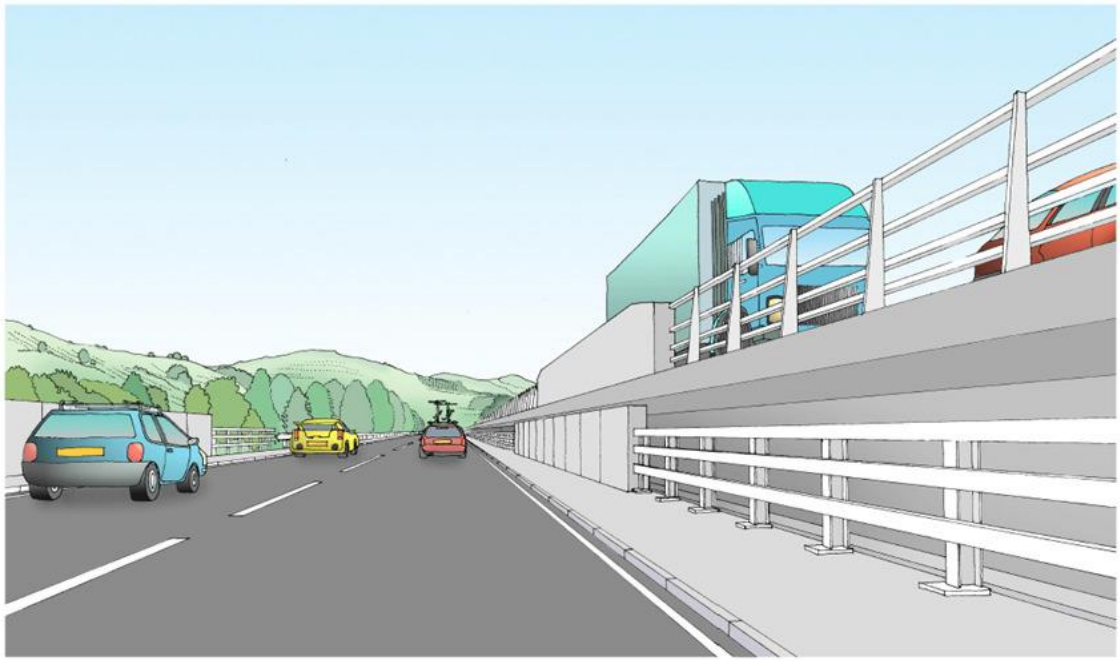


Illustration 4.2: Bowstring arch option for Essangal Underbridge (sifted out)

Illustration 4.3: Deep deck option for Essangal Underbridge (sifted out)



Cultural Heritage Assets

4.3.17 As well as the design of the proposed scheme adjacent to Shierglas Farmhouse outlined in paragraphs 4.3.8-4.3.10, potential impacts on a number of cultural heritage assets have been avoided or reduced through the iterative design process, as detailed below:

- Clach na h'Iobairt Standing Stone (Asset 446, Figure 15.1e) is located adjacent to the proposed scheme at ch11700, positioned on elevated ground in-between the existing A9 and B847 roads (Photograph 4.3). Earlier alignments were refined such that the final DMRB Stage 3 design avoids the Scheduled Monument completely.
- The design of the mainline alignment between ch2200 and ch2400 has been developed to avoid physical impacts on Urrard House Walled Garden and Bothies (Asset 343, Figure 15.1a).
- The SuDS feature near Old Faskally House (Asset 333, Figure 15.1a, ch1400) was moved from an earlier proposed location. The SuDS feature at Calvine Village (Asset 585, Figure 15.1e) has also been relocated. The location of these SuDS features in the final Stage 3 design lessened the requirement for tree felling and consequently reduced potential impacts on the setting of the cultural heritage assets.
- Controlled use of planting has been included to allow open views within Killiecrankie Battlefield (Historic Landscape Type 23, Figure 15.2a) (see Chapter 13: Landscape). Further design measures to reduce impacts on the Killiecrankie Historic Landscape Type include the grading out of varied earthwork slopes which feather into the adjoining landform, and returning land to agricultural use where practicable.

Photograph 4.3: Clach na h'Iobairt Standing Stone

4.3.18 The assessment of impacts on cultural heritage assets is presented in Chapter 15 (Cultural Heritage).

Reducing Woodland Loss

4.3.19 The existing A9 passes through extensive areas of woodland, some of which are identified on SNH's Ancient Woodland Inventory (AWI) and/or identified as native woodland through the Native Woodland Survey for Scotland.

4.3.20 The largest areas of AWI near the proposed scheme exist adjacent to the proposed Aldclune Junction (ch3900), between the existing A9 and the River Garry from ch6600 to ch7600, north of Tomban at ch10750 and around Clunes Lodge from ch14850 to ch17100 (Photograph 4.4).

Photograph 4.4: Ancient Woodland north east of Clunes Lodge, north of the A9

4.3.21 The iterative design process has developed so that the final DMRB Stage 3 design avoids the loss of AWI and native woodland at the following locations:

- The SuDS feature at ch1350 was moved from a previous location immediately to the north to avoid a loss of approximately 0.72ha of AWI. The outfall pipe between the SuDS feature and the Allt Girnaig watercourse has also been realigned from a direct route to one which is adjacent to the existing A9 crossing of the watercourse to minimise felling requirements. The access track to the SuDS feature has been realigned to reduce the loss of veteran trees on southbound side of the A9.
- Narrowing of the central reserve between ch900-1200 reduced the proposed scheme footprint through areas of AWI and native woodland.
- The turning head of the SuDS access at ch3250 has been relocated out of an area of native woodland.
- The SuDS feature at ch4050, adjacent to the southbound diverge of the Aldclune junction has been moved from a previous location approximately 50m to the east to avoid the loss of approximately 0.1ha of native woodland.
- The SuDS feature at ch6750 was moved from a previous location within native woodland immediately to the east which avoids the loss of approximately 0.69ha of native woodland.
- The SuDS feature to the west of Calvine (ch13650) was moved from a previous location in an area of AWI south of Calvine. While the location of the SuDS feature remains within an area of native woodland, its revised location avoids the requirement for the outfall to pass through ancient woodland between the SuDS feature and the River Garry.
- The SuDS feature at ch22050 was moved from a previous location to the south within an area designated as AWI.

4.3.22 The woodland loss is considered to represent a practicable minimum, taking into account other constraints, particularly the River Tay SAC and technical/safety considerations such as road gradient and visibility.

Drainage Design and Minimising Impacts on Watercourses

4.3.23 Various iterations have been made to the DMRB Stage 3 drainage design to avoid or reduce potential water quality and geomorphology impacts on watercourses. These include moving SuDS features away from watercourses to reduce the risk of sediment and pollutants entering watercourses during

construction, moving outfall locations to areas of faster flowing water to maximise the rate of dispersal of treated water, and separating outfalls into the same watercourse to minimise the concentration of treated water entering watercourses. Specific examples include:

- The outfall from the SuDS feature at ch4500 was moved to a minor watercourse before entering the River Garry (part of the River Tay SAC at this location).
- The SuDS feature at ch6750 was moved from a previous location closer to the River Garry. The location in the DMRB Stage 3 design is approximately 37m from the River Garry at the closest point, compared to approximately 9m in its previous location. This also allowed the outfall to be directed to a minor watercourse from a previous location in the River Garry which is an area of good juvenile salmonid habitat and is part of the River Tay SAC.
- The outfalls into the Allt Girnaig (adjacent to ch1500) and Allt Bhaic (adjacent to ch9200) watercourses have been staggered to reduce the concentration of treated water from the A9 entering the watercourses which form part of the River Tay SAC at these locations.
- The outfall from the SuDS feature at ch12480 was moved from a previous location approximately 20m upstream to avoid an area of good adult salmon habitat.
- The outfall from the SuDS feature at ch15400 was moved from a previous location approximately 75m upstream, away from a drop into the River Garry. This reduces potential geomorphological impacts and avoids secondary currents affecting the outfall.

SuDS: Detention Basin, Retention Pond or Wetland

4.3.24 The proposed scheme includes 22 SuDS detention basins/retention ponds/wetlands to attenuate runoff from the dual carriageway, via filter drains. The SuDS features are designed to treat road runoff pollutants to acceptable levels before it enters watercourses. The construction and footprint of the SuDS feature is included as part of the DMRB Stage 3 design of the proposed scheme as an embedded measure to mitigate potential water quality impacts.

4.3.25 During design development, engineering and environmental factors were considered to confirm the design of each SuDS feature, including whether attenuation should be achieved by a dry detention basin, a wet retention pond or wetland. The decision was based on guidance in the Construction Industry Research and Information Association (CIRIA) SuDS Manual (2015), which sets out the four pillars of SuDS design which are water quantity, water quality, amenity and biodiversity and on feedback from CNPA. As such, the following were considered:

- Highways Agency Water Risk Assessment Tool (HAWRAT) assessment, which shows the attenuation levels of a retention pond are typically higher that a detention basin;
- size and topography of the catchment area;
- potential issues with seepage into the structural embankment;
- integrating the SuDS feature within the surrounding landscape character and topography;
- potential to contribute to visual amenity; and
- potential to contribute to biodiversity including areas of potential habitat for northern damselfly.

4.3.26 Table 11.19 (Chapter 11: Road Drainage and the Water Environment) provides the outcomes of the process, while further details of the SuDS design principles to be adopted as part of the detailed design and construction of the proposed scheme are set out in Appendix A13.7 (SuDS Design Principles).

River Bank Erosion at Lay-by 52

4.3.27 A study was undertaken to identify potential river bank erosion risks across the southern sections of the A9 dualling programme between Pass of Birnam and Glen Garry. A reach of the River Garry, adjacent to Lay-by 52 of the existing A9 (adjacent to ch10000 of the proposed scheme), was identified as a high risk site due to significant historical bank erosion exposing a now highly susceptible section of river bank. Photographs 4.1 and 4.2 illustrate the area of river erosion and show the proximity of the river bank to the existing A9 at the present time.

4.3.28 The requirement for an immediate solution to safeguard the existing A9 in advance of construction of the proposed scheme is currently being assessed by the Trunk Road Operating Company. To safeguard the proposed scheme, the mainline alignment was moved up to 25m from the River Garry between ch8900 and ch10500 to form a localised offline alignment. This provides a buffer zone to allow geomorphological processes to continue as well as providing adequate space for the construction of a mitigation solution intended to protect the proposed scheme should the River Garry continue to erode south eastwards at this location.

4.3.29 The mitigation solution identified and included in the proposed scheme is a gravity wall combined with a rock armour toe which would be constructed at the rear of the verge adjacent to the proposed southbound carriageway. The detailed design of the protection works will be influenced by the ground conditions and in particular the presence, or otherwise, of bedrock at river bed level. They will also be influenced by the presence, or otherwise, of a solution to safeguard the existing A9 that is currently being investigated by the Trunk Road Operating Company. A further phase of detailed ground investigation will be undertaken and details of any measures implemented to protect the existing A9 alignment will be given to the Contractor, to inform the detailed design of the mitigation for the proposed scheme.

4.4 Conclusions

4.4.1 The DMRB Stage 3 design for the proposed scheme is the result of an iterative design development process that reduces the potential for impacts on the surrounding environment. It has developed and improved the preferred route option that was identified at DMRB Stage 2 (refer to Chapter 3: Alternatives Considered) to reach a design that is described in Chapter 5 (The Proposed Scheme) and assessed as part of the DMRB Stage 3 EIA.

4.5 References

Construction Industry Research and Information Association (2015). The SuDS Manual, CIRIA C753.

Transport Scotland (2013) A9 Dualling Programme Strategic Environmental Assessment (SEA) – Environmental Report