A9 DUALLING
PERTH TO INVERNESS

Appendix 11.3

Flood Risk Assessment

Transport Scotland

August 2018

TRANSPORT SCOTLAND
CÒMHDHAIL ALBA

ATKINS mouchel

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Tables

Abbreviations

AEP	Annual Exceedance Probability
AMAX	Annual Maximum Flood
AMJV	Atkins Mouchel Joint Venture
BGS	British Geological Survey
BHS	British Hydrological Society
CEH	Centre for Ecology and Hydrology
CWI	Catchment Wetness Index
DMRB	Design Manual for Roads & Bridges.
DTM	Digital Terrain Model
EA	Environment Agency
FEH	Flood Estimation Handbook
FRA	Flood Risk Assessment
FRM	Flood Risk Management
GIS	Geographical Information System
JV	Joint Venture
LCA	Land Capability for Agriculture
LiDAR	Light Detection and Ranging
m AOD	Meters above Ordinance Datum
MORECS	Met Office Rainfall and Evaporation Calculation System
NGR	National Grid Reference
NPF	National Planning Framework
OS	Ordnance Survey
PES	Preliminary Engineering Support
PSSR	Preliminary Source Study Report
PVA	Potentially Vulnerable Areas
Q	Flow
QMED	Median Annual Maximum Flood (m^3/s)
ReFH	Revitalised Flood Hydrograph
RR	Rainfall Runoff
SAAR	Standard Average Rainfall
SAC	Special Areas of Conservation
SEA	Strategic Environmental Assessment
SEPA	Scottish Environment Protection Agency
SFDAD	Scottish Flood Defence Asset Database
SFRA	Strategic Flood Risk Assessment
SoP	Standard of Protection
SPA	Special Protection Areas
SPP	Scottish Planning Policy (SPP) Planning
SSSI	Site of Special Scientific Interest
SUDs	Sustainable Drainage System
SW	Scottish Water
T(p)	Time to Peak
TS	Transport Scotland

Event Severity

The severity of the events discussed in this document are defined as Annual Exceedance Probabilities (AEP), the table below provides a summary of AEP and corresponding Return Periods.

The AEP is the probability that there will be an event exceeding a particular severity in any one year. The Return Period is the average duration (in years) between events of a particular severity.

Annual Exceedance Probability	Return Period
50%	1 in 2 years
20%	1 in 5 years
10%	1 in 10 years
4%	1 in 25 years
3.33%	1 in 30 years
2%	1 in 50 years
1.33%	1 in 75 years
1%	1 in 100 years
0.5%	1 in 200 years
0.5% with 20% increase as allowance for climate change	1 in 200 years with 20% increase as allowance for climate change

1. Introduction

1.1 Background

1.1.1 In December 2011, the Scottish Government's Infrastructure Investment Plan committed to dual the A9 Trunk Road between Perth and Inverness by 2025. The A9 corridor forms a strategic link between Central Scotland and the Scottish Highlands and is vital to the growth and development of northern Scotland.

1.1.2 In September 2012, Transport Scotland commissioned the Design Manual for Roads and Bridges (DMRB) Stage 1 Assessment, A9 Dualling: Preliminary Engineering Support Services Report (PES)[i]. The PES undertook an engineering assessment of the A9 route and proposed corridor options and strategies for the improvement works in line with that of a DMRB Stage 1 assessment.

1.1.3 Concurrent with the PES, Transport Scotland also commissioned the A9 Dualling Strategic Environmental Assessment (SEA) Environmental Report[ii]. The SEA identified the key environmental and landscape issues along the length of the A9 route and assessed the potential impacts associated with dualling the A9. Alongside the SEA, a Strategic Flood Risk Assessment (SFRA) was undertaken by CH2MHill (2014)[iii]. The SFRA was a route wide assessment for the A9 between Perth and Inverness. The SFRA report provides information on the most likely sources of flooding along the A9 Route. The SFRA is a high level assessment which:

- identified areas sensitive to flooding along the A9 between Dalraddy to Slochd,
- provided a high level assessment of the potential constraints; and
- developed design principles and guidance for the A9 dualling scheme specific FRAs.

1.1.4 Following the completion of the PES and SEA, the Atkins-Mouchel Joint Venture (AMJV) was appointed by Transport Scotland to undertake a DMRB Stage 2 Assessment for the upgrade to dual carriageway of the stretch of the northern section of the A9 Trunk road between Dalraddy and Inverness. The Proposed Scheme referred to in this report is the upgrade of the A9 Dalraddy – Slochd which includes approximately 25km of new road, and new watercourse crossings. The scheme objectives for the A9 Dualling Perth to Inverness are as follows:

- To improve the operational performance of the A9 by:
  - Reducing journey times; and
  - Improving journey time reliability.
- To improve safety for motorised and non-motorised users by:
  - Reducing accident severity; and
  - Reducing drivers stress.
- To facilitate active travel within the corridor; and
- To improve integration with Public Transport Facilities.

1.1.5 The PFRA included a review of all available data, identified potential sources of flooding and sensitive receptors and presented an assessment of the flood risk associated with the route alignment options considered at DMRB Stage 2. One dimensional (1D) hydraulic models were used to calculate the hydraulic capacity of existing water

crossings and so to assess the impact of replacing these structures. 1D-2D hydraulic models were used to define the 0.5% Annual Exceedance Probability (AEP) and 0.5% AEP plus climate change flood outlines.

1.1.6 The PFRA identified the primary source of flooding to the Proposed Scheme as being fluvial, with the Proposed Scheme having the potential to result in a loss of floodplain storage at Avielochan, Granish, Feith Mhor and Lynwilg. The PFRA concluded that the DMRB Stage 3 Flood Risk Assessment (hereafter referred to as the FRA) should assess the options available to determine how the impact will be mitigated.

1.1.7 The PFRA proposed the following scope for FRA:

- The baseline model would be refined to improve floodplain definition for key locations of floodplain and the surrounding area where land for floodplain storage may be required.
- The baseline model would be developed to include the Proposed Scheme alignment allowing the assessment of impacts in the locality of the Proposed Scheme and downstream receptors to be assessed. Where floodplain storage is lost as a direct impact of the scheme the hydraulic model would be used to develop mitigation measures. This would include identifying locations for compensatory flood storage, and providing floodplain connectivity. Compensatory storage should be provided close to the point of lost floodplain, provide the same volume and be at the same level relative to the design flood level as that lost.
- The assessment should demonstrate that proposed works would not affect sensitive downstream flood receptors (e.g. if structure sizes are increased thus inadvertently increasing peak flows passing downstream).
- Consultation would be undertaken with key stakeholders.

1.1.8 This document is the FRA and provides the detailed modelling and assessment identified in the PFRA to inform the detailed alignment design and flood mitigation measures.

1.2 Legislation and Policy

1.2.1 The impacts of flooding are well documented and are often devastating with regard to cost of repairs, replacement of damaged property and loss of business. The Scottish Government is working to create a sustainable approach to flood risk management and the impact of climate change, through the implementation of the Flood Risk Management (Scotland) Act 2009[iv].

1.2.2 The Act introduces a sustainable approach to flood risk management taking into consideration the impact of climate change. It creates a joined up and coordinated process to manage flood risk at both national and local level. The Scottish Environment Protection Agency (SEPA) are the overarching authority and have a strategic role for flood risk management. SEPA are working closely with local authorities, Scottish Water, and other responsible authorities to deliver flood risk management planning in Scotland.

1.2.3 The National Flood Risk Assessment (NFRA) was the first step in developing a Flood Risk Management Strategy and Local Flood Risk Management Plans. The assessment increased the understanding of the sources of flooding and the impacts, allowing areas at the greatest risk to the impact of flooding to be identified. These have been identified as Potentially Vulnerable Areas (PVAs).

1.2.4 In addition to the Act, Scottish Planning Policy (SPP) sets out national policies which reflect the Scottish Minister priorities. Managing Flood Risk and Drainage is included within the National Planning Framework 3 (NPF)[v].

1.2.5 SPP states that planning authorities should promote:

- A precautionary approach to flood risk from all sources of flooding including coastal, watercourse (fluvial), surface water (pluvial), groundwater, reservoirs and drainage systems (sewers and culverts) taking account of the predicted effect of climate change;
- Flood avoidance; by safeguarding flood storage and conveying capacity, and location development away from functional floodplains and medium to high risk areas;
- Flood reduction; and
- Avoidance of increased surface water flooding through requirements of Sustainable Drainage Systems (SuDS) and minimising the area of impermeable surface.

1.2.6 The planning system aims to prevent development which would have a significant probability of being affected by flooding or would increase the probability of flooding elsewhere. For coastal and watercourse flooding SPP introduces a risk framework that characterises areas for planning purposes by their annual probability of flooding and gives the appropriate planning response:

- Little or no risk area (annual probability of watercourse, tidal or coastal flooding is less than 0.1% AEP;
- Low to medium risk area (annual probability of watercourse, tidal or coastal flooding in the range of 0.1% to 0.5% AEP; and
- Medium to high risk area (annual probability of watercourse, tidal or coastal flooding greater than 0.5% AEP.

1.3 Guidance

1.3.1 A complete list of guidance used for the Road Drainage and the Water Environment assessment is given in the main chapter (Chapter 11). The following guidance documents have been used to inform the flood risk assessment:

- A9 Dualling Programme Strategic Flood Risk Assessment (SFRA)[vi].
- Scottish Planning Policy (SPP) (paragraphs 254 – 268)[vii].
- Highways Agency et al., Design Manual for Roads and Bridges (DMRB):
  - Volume 11, Section 3, Part 10 HD 45/09 – Road Drainage and the Water Environment; and
  - DMRB Part 7 HA 107/04 Design of Outfall and Culvert Details[viii].
- The Highland Council - Flood Risk and Drainage Impact Assessment Supplementary Guidance[ix];
- Scottish Environment Protection Agency (SEPA) publications:
  - Technical Flood Risk Guidance for stakeholders V8 – Feb 2015)[x]; and
  - Flood Modelling Guidance for Responsible Authorities version 1.1[xi].
- Construction Industry Research and Information Association (CIRIA) publications:

  - C624 - Development and flood risk – guidance for the construction industry
  - C688 - Flood Resilience for Critical Infrastructure
  - C689 - Culvert design and operation guide[xii]; and
  - C720 - Culvert design and operation guide supplementary technical note on understanding blockage risks[xiii].
- Environment Agency publications:
  - The Fluvial Design Guide[xiv]; and
  - Accounting for residual uncertainty: updating the freeboard guide (Report – SC120014)[xv].

1.4 Design Principles and Standards

1.4.1 A key output from the A9 Dualling SEA was a set of Strategic Environmental Design Principles (SEDP) that were developed in collaboration with SEPA, Scottish Natural Heritage (SNH), Historic Environment Scotland and the Cairngorms National Park Authority. The SEDP are included as Appendix 4.1 in Volume 2; Table 1.6 in the appendix covers water, flooding and SuDS. The SEDPs are summarised as follows:

- SEDP Principle W1 stipulates that the A9 and any associated works should not be located within the functional floodplain. Where this is not possible, the A9 should remain operational and safe for users during times of flood; result in no loss of floodplain storage; and the movement of water should not be impeded and flood risk should not be increased elsewhere. The functional floodplain is defined by the 0.5% AEP flood event.
- The impact of the Proposed Scheme has therefore been assessed for the 0.5% AEP flood event.
- Any mitigation measures, including compensation storage, have been designed to ensure that flood risk does not increase for the 0.5% AEP event.
- In line with SEDP Principle W1 the Proposed Scheme has been designed to ensure that the A9 remains free from floodwater up to and including the 0.5% AEP with a 20% allowance for climate change. A minimum freeboard of 600mm has been allowed for between the maximum water level and road surface in line with guidance from SEPA[x], CIRIA[xii] and DMRB[xvi].
- SEDP Principle W2 directs designers to avoid developing SUDs in the functional floodplain. Where this is unavoidable they should not be inundated up to the 3.33% AEP and compensatory storage should be provided for all loss of capacity up to the 0.5% AEP event.
- The design process for the watercourse crossings is complex, taking account of a range of design criteria and constraints to develop the most appropriate crossing for each watercourse. The primary technical standards driving the design of culverts are DMRB HA107/04 Design of Outfall and Culvert Details (2004) and the CIRIA Culvert design and operation guide (C689) (2010).
- Culverts that pass under the main alignment have been designed to pass the 0.5% AEP plus a 20% allowance for climate change unless an under-sized structure is proposed to protect sensitive flood risk receptors. Culverts that pass under side roads have been designed to comply with the same standard as the main alignment where they are located on the same watercourse and are located immediately upstream or downstream of the main culvert crossing.

1.4.2 It has been assumed that mammal ledges within culverts will be 150 mm above the 4% AEP water level, 500 mm wide and have a 600 mm headroom from ledge to soffit. For the purpose of hydraulic calculations it has been assumed that ledges will be provided along both sides of a culvert and the area below the ledges is not available for flow.

1.4.3 The minimum freeboard allowances adopted for structures, culverts and drains are summarised below:

- 600 mm for culverts or structures with a height greater than 1.2m;
- 300 mm for culverts with a height of 1.2m or less and that pass under the main alignment; and
- Not less than D/4 for drains of 900mm diameter or less (where D is the pipe diameter).

1.5 Study Area

1.5.1 The Study Area is based on the River Spey Catchment, to allow for the assessment of the impacts on downstream sensitive receptors as well as in the immediate vicinity of the Proposed Scheme. The immediate vicinity is considered to be 5km surrounding the Proposed Scheme. The Proposed Scheme begins south of Dalraddy and extends to north of Slochd Summit (Figure A11.3.1).

1.5.2 Figure A11.3.2 shows the River Spey catchment and Figure A11.3.3 shows that the nearest Potentially Vulnerable Areas (PVA) that could potentially be impacted by the Proposed Scheme are PVA 05/10 and PVA 05/11.

1.5.3 PVA 05/11[xvii] covers Aviemore and Boat of Garten, and identifies 70 residential properties and 30 non-residential properties at risk of flooding. The sources of flooding are 37% river and 63% surface water. Surface water flood risk is noted for Aviemore, with the River Spey mostly affecting agricultural land. However, there are small impacts on built up areas in Aviemore from the Aviemore Burn. The PVA identifies the A95, A9, B970 and B9153 as being potentially affected by flooding. There are 80 roads within the PVA identified as having a Medium Likelihood of flooding.

1.5.4 PVA 05/10[xviii] covers Carrbridge, and identifies fewer than 10 residential properties and a further 10 non-residential properties at risk of flooding. The sources of flooding are 43% river and 57% surface water. The PVA identifies the A9, A938 and B9153 as being potentially affected by flooding. It documents that there are 3 sections of the A9, with a total length of 90m at risk of flooding and have outlined an objective to reduce the physical risk and disruption risk.

1.5.5 In addition to the PVAs located along the route of The Proposed Scheme, PVA 05/09[xix] has been identified as a potential downstream receptor, which is located 65km downstream of Aviemore on the River Spey. PVA 05/09 covers Rothes and Aberlour, with 350 residential properties at risk of flooding. The sources of flooding are 52% river and 48% surface water.

1.5.6 The Proposed Scheme lies between approximately 33km and 55km southeast of Inverness, skirting the southern extent of the Monadhliath Mountains and northern extent of the Cairngorm Mountains and National Park. The Proposed Scheme is located in the glacial valley of the River Spey.

1.5.7 The southern extent of the study area at Dalraddy lies at approximately 220 mAOD (above Ordnance Datum), where the Allt an Fhearna crosses the existing A9.

Continuing north the elevation of The Proposed Scheme rises to 280m AOD at Carrbridge and 405mAOD at Slochd Summit (283450 825660).

1.5.8 There are two main areas of settlement within the study area, Aviemore, which is close to the southern extent, and Carrbridge. There are also a number of small isolated properties and settlements along the route, including Dalraddy, Lynwilg, Granish, Avielochan, Kinveachy and Slochd.

1.5.9 The Highland Main Line Railway runs parallel to The Proposed Scheme, running east of the existing A9 from Aviemore to Slochd Beag at 285210 823883 where it crosses under the existing A9.

1.5.10 The PVAs derived from the NFRA are based on the national scale SEPA Flood Maps. The SEPA flood maps provide a strategic national overview of areas estimated to be at risk of flooding from river and/or sea, showing the indicative flood extents from fluvial and coastal flooding. It is acknowledged that the maps have limitations, as these are based on broad scale hydrological and hydraulic modelling techniques along with a coarse digital terrain model. They also do not take account of hydraulic structures or flood prevention schemes. The maps provide only a broad indication of flood risk at the community scale as they do not map catchments with areas less than 3km^2. This FRA considers a more detailed review of potential flood risk receptors as detailed in Section 4.

2. Methodology

2.1 Approach

2.1.1 The impact of the Proposed Scheme on flood risk has been assessed based on the sensitivity and magnitude matrix shown in Table 2.1.

Table 2-1 - Criteria used to Estimate the Significance of Potential Impacts

Sensitivity	Magnitude			
	Major	Moderate	Minor	Negligible
Very High	Very Large	Large/Very Large	Moderate/ Large	Neutral
High	Large/ Very Large	Moderate/ Large	Slight/ Moderate	Neutral
Medium	Large	Moderate	Slight	Neutral
Low	Slight/ Moderate	Slight	Neutral	Neutral

2.1.2 Following the screening carried out for the preliminary assessment, the appraisal of flood risk impacts for the FRA considers:

- Changes to surface water flows where proposed changes to existing culverts or the introduction of new culverts and associated infrastructure may result in increased flow capacity; and
- Changes to floodplains due to disconnection of the floodplains by the Proposed Scheme and floodplain storage loss or displacement through encroachment by proposed permanent earthworks and land raising.

2.1.3 The magnitude and significance of these impacts has been assessed for the 0.5% AEP. The 0.5% AEP plus climate change event has been used to check for sustainability and resilience.

2.1.4 Flooding from coastal, overland flow, reservoir and groundwater sources were scoped out during the preliminary assessment due to the following reasons:

- Coastal flooding was screened out due to the locality of the Proposed Scheme; there is no risk of coastal flooding.
- Cut off drains will intercept overland flow preventing it from ponding upstream of the scheme or flooding of the scheme. These drains discharge to watercourses separate to the road drainage, and are sized to accommodate a 0.5% AEP plus climate change flow. Details of the road drainage design can be found in the A9 Dualling Dalraddy to Slochd: Stage 3 Environmental Statement Chapter 5 – The Proposed Scheme.
- Inundation from reservoir failure was scoped out due to the locality of the Proposed Scheme; there is no risk of reservoir inundation.
- The surrounding geology is of low permeability and water strike levels from boreholes indicate that there is no significant risk of groundwater flooding. An assessment of the interception of groundwater at cuttings and the potential impact on aquifers is presented in Chapter 10 (Geology, Soils and Groundwater) and Appendix 10.4 Groundwater Assessment.

2.2 Sensitivity Criteria

2.2.1 Receptors of flood risk include anything from property to people and the surrounding environment. Receptors located within the Medium (0.5% AEP) flood outline were identified along the Proposed Scheme and also those within 100m of the Medium flood outline.

2.2.2 The sensitivity of water features in general takes into account their quality, rarity, scale and substitutability. With respect to flood risk, sensitivity is determined by the number and type of receptors that are hydrologically linked with the water feature. The criteria used in determining the sensitivity of each water feature are detailed in Table 2.2.

Table 2-2 - Sensitivity Criteria: Flood Risk Examples

Sensitivity	General Criteria	Typical Examples for Flood Risk
Very High	Attribute has a high quality and rarity on regional or national scale.	Water feature with direct flood risk to > 100 residential properties or critical infrastructure (e.g. trunk roads, main line railways, hospitals, schools, safe shelters etc.).
High	Attribute has a high quality and rarity on local scale.	Water feature with direct flood risk to 1 -100 residential properties, > 10 industrial premises, and/or other land use of high value or indirect flood risk to critical infrastructure.
Medium	Attribute has a medium quality and rarity on local scale.	Water feature with direct flood risk to recreational land or high value agriculture (e.g. arable land, pastures, complex cultivation patterns and agro-forestry) and/or affecting < 10 industrial premises.
Low	Attribute has a low quality and rarity on low scale.	Water feature with little or no flood risk, affecting low value agricultural land (e.g. rough grazing land).

Table Source: DMRB Volume 11 Section 3 (HD 45/09).

2.3 Magnitude Criteria

Watercourse Crossings

2.3.1 Existing watercourse crossings were identified from OS Mastermap data, Transport Scotland's structures database and confirmed from site visit. Peak flows were derived for each watercourse crossing catchment using the methodologies outlined in the Flood Estimation Handbook[xx] and methods agreed with SEPA. The capacities of each crossing have been calculated using one dimensional (1D) hydraulic models.

2.3.2 For the purposes of assessment each watercourse crossing was provided a unique crossing reference ID, this is referenced as DS-WC-xx and is numbered sequential from south to north. In addition to this, each watercourse crossing has a corresponding watershed/catchment reference ID, this is referenced as DS-xx. The Transport Scotland reference ID has been retained, for continuity between the DMRB Stage 2 and Stage 3 reports. In addition, there is a new proposed Transport Scotland Structure ID, which from herein will be referred to.

2.3.3 A matrix was developed using professional judgement to determine the magnitude of an increase in the hydraulic capacity based on the size of the watercourse and the existing capacity of the structure. By applying the matrix set out in Table 2.3, an assessment of the impact of replacing all existing crossings could be determined.

Table 2-3 - Watercourse Crossings - Future Impact Matrix

Existing Capacity	0.5% Peak Flows (m^3/s)			
	<1m^3/s	1-5m^3/s	5-25m^3/s	>25m^3/s
Existing Capacity is >0.5% AEP. No flood attenuation potential, upsizing will not have an impact on downstream hydrograph.	Negligible	Negligible	Negligible	Negligible
Existing Capacity 1%-0.5% AEP. Small potential for increasing downstream flows if culvert is upsized.	Negligible	Minor	Moderate	Major
Existing Capacity 10% - 1% AEP. Some potential for increasing downstream flows if culvert is upsized.	Minor	Moderate	Moderate	Major
Existing Capacity <10% AEP. Significant potential for increasing downstream flows if culvert is upsized.	Minor	Moderate	Major	Major

2.3.4 The 1D models were developed further as part of Stage 3 to assess in detail the potential impacts downstream for the crossings resulting in an impact of 'Minor' or above and recommend mitigation measures to reduce this impact.

Floodplain Impacts

2.3.5 This assessment uses the DMRB criteria for estimating magnitude of impact from flood risk, as shown in Table 2.4, with the exception that the 0.5% AEP event has been used rather the 1% AEP to be consistent with SPP.

2.3.6 In addition to considering the DMRB criteria for estimating criteria of impact, this assessment considers the requirements of the SPP in terms of impacts of changes to

water levels. Changes in water levels will be assessed case by case to ensure that changes to water levels are in line with the requirements of the SPP.

Table 2-4 - Assessment Criteria in Relation to Floodplain Impact

Magnitude of Impact	Criteria	Typical Example
Major Adverse	Results in loss of attribute and/or quality and integrity of the attribute.	Increase in peak flood level (0.5% annual probability) >100mm.
Moderate Adverse	Results in effect on integrity of attribute, or loss of part of attribute.	Increase in peak flood level (0.5% annual probability) >50mm.
Minor Adverse	Results in some measurable change in attribute quality or vulnerability.	Increase in peak flood level (0.5% annual probability) >10mm.
Negligible	Results in effect on attribute, but of insignificant magnitude to affect the use or integrity.	Negligible change in peak flood level (0.5% annual probability) <+/-10mm.

Source: DMRB Volume 11 Section 3 (HD 45/09)

2.3.7 Hydraulic models were developed to estimate the magnitude of the impacts and to develop mitigation options where required. The models are described in Section 4.

2.3.8 For impacts associated with floodplain loss sequential tests have been developed to determine the need for storage compensation. The tests, given in Table 2.5 to Table 2.7 are based on the approach used in Planning Policy Statement 25 (PPS25) relating to flood risk and development.

Table 2-5 - Floodplain Loss Sequential Test 1

Test 1	Pass?	Actions
Can the impact on the 0.5% AEP floodplain be avoided?	Yes	No action required.
	No	Can we adjust the alignment? Do we need to improve the accuracy of the floodplain extent? If the floodplain cannot be avoided then go to Test 2.

Table 2-6 - Floodplain Loss Sequential Test 2

Test 2	Pass?	Actions
Is there is an overriding need for the development to be located on an area that is floodplain?	Yes	Proceed to Test 3
	No	Consider adjusting the alignment and reapply Test 1.

Table 2-7 - Floodplain Loss Sequential Test 3

Test 3	Pass?	Actions
Can direct or indirect full replacement of floodplain volume be provided subject to the following constraints? • Available land take.	Yes	Preference will be given to direct compensatory storage which is located close to the point of impact, provides level for level compensation and is hydraulically linked with the floodplain. If necessary, in-direct compensatory storage will be used which should hydraulically connect the floodplain and storage area and be

Test 3	Pass?	Actions
• No detrimental impact on the environment, landscape or cultural heritage. • No long term issues relating to land ownership. • No increase in flood risk elsewhere. • Other site or scheme specific issues.		controlled to ensure level for level compensation.
	No	On the basis of a satisfactorily robust model it should be clearly demonstrated that there would be no increase in flood risk upstream or downstream of the development at sensitive receptors. The criteria to be satisfied should be agreed with SEPA and other stakeholders as necessary.

2.4 Limitations

2.4.1 The accuracy of the 1D hydraulic modelling of the watercourse crossings is limited by the accuracy of the topographic information. The delineation of the upstream catchment and estimation of the design flows are the most uncertain aspects of the hydraulic analysis. In general, a precautionary approach has been taken whereby the method giving the largest design flow estimate has been used.

2.4.2 The accuracy of 1D/2D linked hydraulic models are primarily constrained by quality of hydrological and topographical data. Key factors include the resolution of the topographic data, the accuracy of surveys of hydraulic structures, the availability of data on past flooding and the limitations of the modelling software. SEPA and the Environment Agency (EA) guidance[x,xiv] advises that model accuracy is site specific and recommends that modellers use sensitivity analysis to assess model accuracy.

2.4.3 Many of the proposed watercourse crossings drain small catchments are not accurately defined by the Flood Estimation Handbook (FEH) CD ROM (v3). Catchment boundaries have therefore been defined using topographic data and observations made during site visits. Freeboard allowances and model sensitivity have been used to include allowance for this uncertainty in the culvert design.

2.4.4 Due to the rural nature of the watercourses there are few accurate records of past flooding along the route of the existing A9 that can be used to calibrate the 1D and 1D/2D models. The Dulnain model at Carrbridge has made best use of SEPA gauged flows and wrack mark level data to verify the model outputs. We have followed SEPA guidance and used sensitivity analysis to test assumptions.

3. Data Collection

3.1 General Data

3.1.1 The key sources of information which were provided by Transport Scotland, SEPA, and The Highland Council; and data that is in the public domain are listed below:

- A9 Dualling Perth to Inverness Strategic Flood Risk Assessment (SFRA)[iii];
- Topographical Survey (including aerial imagery) for the A9 Dualling Corridor (Blom);
- SEPA indicative Flood Maps;
- The National Flood Risk Assessment[xxi];
- OS Mapping;

- NextMap DTM[xxii];
- FEH CD ROM (Version3)[xxiii];
- Road Drainage Record Drawings;
- Network Rail Structures;
- BGS 1:50,000 superficial and bedrock geology mapping;
- BGS Hydrogeological Map of Scotland 1:625,000 scale, both the 1988 hardcopy and 1995 digital version available via the BGS GeoIndex online data viewer;
- BGS Groundwater Vulnerability Map of Scotland 1:625 000 scale, the 1988 hardcopy only; and
- A9 Perth to Inverness Dualling Geotechnical Preliminary Sources Study Report (PSSR) Moy to Inverness (Rev 2) (October 2013), Jacobs [i].

3.1.2 Site visits to consider the flood risk aspects of existing watercourse crossings were undertaken in March 2016 and October 2017. Information and photographs recorded by other AMJV teams have also been available to this study.

3.1.3 The topographic and hydrometric data are key to the accuracy of the FRA and therefore this data is described in more detail in the following sections.

3.2 Topographical Data

3.2.1 Transport Scotland appointed Blom AEROFILMS to undertake topographical survey works to provide information to facilitate outline and detailed design work for the A9 Dualling Programme. Transport Scotland provided the following key information:

- 1:2500 ortho-photo and grid DTM;
- Topographical survey at 1:500 Scale;
- High precision 1:500 survey of the carriageway envelopes; and
- 3D models, including elevations and information of spans, headroom and clearance for each watercourse crossing and road structure.

3.2.2 The topographic survey was available for a 200m wide strip along the existing A9 as MX ground models. The data was converted into points, strings and contours and elements that were not ground levels were removed. Strings and contours were densified to enable more accurate triangulation to minimise the potential for triangulation through linear features. Finally, the three sets of points were combined to produce a 1m elevation grid.

3.2.3 In addition to the above information, Transport Scotland provided the LiDAR coverage for a 1km wide strip surrounding the A9. The data provides elevations at 10m grid postings and is quoted to have a vertical accuracy of +/- 700mm. Data was provided in two forms: as a 10m grid and as elevations along line features.

3.2.4 Nextmap DTM (5m resolution and a vertical accuracy of 0.7 - 1m and captured between 2002 and 2003) is available for the study area but was only used when no higher accuracy elevation data was available.

3.2.5 AMJV undertook additional topographical survey of the following watercourses in December 2015, April 2016 and October 2017. This included:

- Allt an Fhearna;
- Allt Chriochaidh;
- Loch Alvie;
- Allt na Criche (Lynwilg);
- Aviemore Burn;
- The Shieling / Easter Aviemore Burn;
- Allt na Criche (Granish);
- Avielochan;
- Allt Cnapach;
- Fèith Mhòr;
- River Dulnain;
- Bogbain Burn; and
- Allt Slochd Mhuic.

3.2.6 Figure A11.3.4 shows the coverage of each topographic survey.

3.2.7 Table 3-1 compares the topographical survey data available and the error within the dataset. These values were calculated by AMJV based on a direct comparison of the data sets and using AMJV topographic survey data as reference. They should be treated as being indicative only.

Table 3-1: Available Topographical Survey Data and its Associated Error

	BLOMTopo Survey	LiDAR 1Km - Survey	Nextmap DTM
Average Absolute Error (m)	0.14	0.21	0.18
Average Positive Error (m)	0.15	0.24	0.22
Average Negative Error (m)	-0.12	-0.10	-0.15
Maximum Positive Error (m)	0.41	1.47	1.08
Maximum Negative Error (m)	-0.31	-0.66	-0.45

3.2.8 The composite ground model data facilitates hydrological catchment delineation and hydrological flow estimation and can also be utilised for 2D overland flow modelling.

3.3 SEPA Rainfall and Hydrometric Data

3.3.1 SEPA operates a number of gauges on the River Spey catchment. Figure A11.3.2 and Table 3.2 details the gauges identified within the study area of The Proposed Scheme.

Table 3-2: Gauging Stations within the River Spey Catchment

Gauging Station Number	Name	Watercourse	NGR	Catchment Area	Record Length
8002	Kinrara	River Spey	NH 880082	1012	1951-Present
8005	Boat of Garten	River Spey	NH 946192	1268	1951-Present

8009	Balnaan Bridge	River Dulnain	NH 977247	272	1952-Present
8010	Grantown	River Spey	NJ 032267	1749	1951-Present

3.3.2 In addition to the gauges identified in Table 3.2, a level only gauge was identified at Sluggan on the River Dulnain upstream of The Proposed Scheme. This gauge is operated and maintained by SEPA.

3.3.3 Kinrara and Boat of Garten gauging stations are suitable for use as QMED donor station. Balnaan Bridge and Grantown are suitable for pooling in FEH. Annual maxima (AMAX) and flow series for the following high flow events were received from SEPA for potential model calibration or verification:

- 18/12/1966;
- 05/02/1990;
- 03/01/1992;
- 17/01/1993;
- 02/03/1997;
- 11/01/2005;
- 05/12/2014; and
- 30/12/2014.

3.3.4 SEPA also provided 15-minute rainfall data for 2 gauges located within the River Spey catchment, 2 gauges within the River Findhorn Catchment and a further gauge within the River Dulnain Catchment. Summary information for each gauge is given in Table 3.3.

Table 3.3: Rain gauges within study catchment

Rain Gauge	NGR	Location	Interval (min)	Records Available 1966	Records Available 1990	Record Available 1992	Record Available 1993	Record Available 1997	Record Available 2005	Record Available 2014
Coignafearn	NH 70963 17820	River Findhorn	15		Yes	Yes	Yes	Yes		
Freeburn	NH 79547 30023	River Findhorn	15					Yes	Yes	Yes
Sluggan	NH 86980 21930	River Dulnain	15					Yes		Yes
Auchdergannach	NJ 00345 15642	River Spey	15							Yes
Glenmore Lodge No2	NH 98640 09400	River Spey	15						Yes	Yes

4. Baseline Information

4.1 Existing Watercourse Crossings

4.1.1 The Proposed Scheme is located almost entirely within the River Spey hydrological catchment with its northernmost extent just encroaching upon the River Findhorn catchment. The Proposed Scheme crosses several larger tributaries of the River Spey including the River Dulnain and its tributary Allt Ruighe Magaig, the Allt an Fhearna and Allt-na-Criche; in addition to numerous minor burns and ditches which flow directly into the Spey.

4.1.2 For each watercourse crossing the catchments were delineated using the FEH CD Rom Version 3, NextMap, LIDAR, topographical survey, and aerial imagery. Peak flow estimations were derived for each catchment using the FEH standard methodologies including the:

- FEH Rainfall Runoff Method; and
- FEH Statistical Approach (where catchment > 5km^2).

4.1.3 Hydrological estimates using the ReFH2 utilising FEH2013 data were carried out for a number of sample catchments for comparison purposes only to check for anomalies in the hydrological outputs. The outcome of the comparison showed that the FEH rainfall runoff and FEH Statistical approaches selected for each of the catchments were the most precautionary.

4.1.4 The catchments can be seen in Figure A11.3.5 with Table 4-1 below providing details of each crossing. The catchment and watercourse names are consistent with the system used in Chapter 11, where a structure already exists its Transport Scotland identification number has been given and in all cases the identification number for the new or replacement structure has been given.

4.1.5 The sensitivity categories are based on Table 2.2 and professional judgment. A precautionary approach has been taken to assigning sensitivities to the watercourses in general. For example, the presence of access tracks has been used to justify increasing the sensitivity to Medium. Forestry and agricultural land (this includes arable land, pastures, complex cultivation patterns and agro-forestry) has been assigned a Medium sensitivity.

4.1.6 The sensitivities of the watercourses for Allt Cnapach and unnamed drains originating from Torr Mhuic and Torr na Mallachd are judged to be High rather than Very High as the Highland Main Line railway is substantially above the 0.5%AEP floodplain and the watercourses are judged to represent an indirect flood risk to the railway.

4.1.7 Watercourses have been included in Table 4-1 where a crossing is proposed but no asset currently exists to show the baseline receptors and sensitivities. Whereas only existing assets that could be modelled are included in Table 4-2.

4.1.8 Table 4-2 gives details of the estimated peak flows for each watercourse calculated. The precautionary approach has been applied to the determination of the peak flows for each watercourse crossing at this stage (i.e. the highest value for flow estimation has been adopted, generally from the FEH Rainfall Runoff method). It should be noted that during the Stage 3 assessment, some catchments were delineated to reflect the repositioning or merging of culverts. This is discussed further for each detailed hydraulic model within Annex 11.3a: Modelling Technical Note.

4.1.9 Where Table 4.2 identifies that the capacity to the road level is <0.5% AEP, the A9 mainline is considered to be sensitive to flooding impacts, and therefore the sensitivity of receptors at that structure is assigned ‘Very High’.

Table 4-1: Delineated Catchment Information between Dalraddy and Slochd

Watercourse	Existing Structure ID	Catchment ID	Area (km^2)	Catchment Description	Downstream Receptor	Sensitivity
Allt an Fhearna	A9 1090	DS-WS-038	20.21	Draining a large area, several tributaries contribute to flows as Allt an Fhearna crosses the A9 in an easterly direction before flowing into Loch Alvie.	Agricultural land.	Medium
Allt Chriochaidh	A9 1100	DS-WS-037	2.58	Originating in the Geal-charn Mor, Chriochaidh Allt flows south easterly and is joined by a tributary at Ballinluig before it crosses the A9 and flows into Loch Alvie	Land use is forestry.	Low
Caochan Ruadh	A9 1100 C70	DS-WS-036		Drainaing Creag Ghleannain and Creag na-Uamha, Caochan Ruadh flows south easterly as it crosses the A9 before flowing into Loch Alvie	Rural Land, with land classification as land capable of producing a narrow range of crops.	Low
Ballinluig Burn	A9 1100 C10	DS-WS-035	0.99	Draining Creag Ghleannain the unnamed watercourse flows south before crossing the A9 and flows into Loch Alvie.	Rural Land, with land classification as land capable of producing a narrow range of crops.	Low
Unnamed Drain	A9 1120	DS-WS-034B	0.21	Drainage path	Rural land associated with Lynwilg Farm, with land classification as land capable of moderate crop ranges and good yields.	Medium
Unnamed Drain	A9 1120 C19	DS-WS-034A	0.008	Drainage path	Rural land associated with Lynwilg Farm, with land classification as land capable of moderate crop ranges and good yields.	Medium
Allt na Criche (Lynwilg)	A9 1130	DS-WS-034	6.47	Draining from the Carn Dearg Mor the Allt na Criche (Lynwilg) flows south towards the A9, before crossing under	Agricultural Land, Highland Main Line railway, B9152 and grassland.	Very High

Watercourse	Existing Structure ID	Catchment ID	Area (km^2)	Catchment Description	Downstream Receptor	Sensitivity
				the A9, and discharging into the River Spey.		
Kinakyle	A9 1130 C54		0.3	Draining from Creag na h-lolaire	Woodland, Highland Main Line railway, B9152 and grassland	Very High
Loch Puladdern	A9 1150 C7	DS-WS-033	1.18	Loch Puladdern and an associated Loch are within this catchment with a drain crossing the A9.	Rural Land, with classification as land capable of producing a narrow range of crops.	Low
Unnamed Drain	A9 1150 C49	DS-WS-032	0.44	Draining Craigellachie National Nature Reserve the drain flows north before crossing the A9.	Craigellachie National Nature Reserve. Forestry land.	Medium
Unnamed Drain	A9 1150 C92	DS-WS-031	0.23	Draining Craigellachie National Nature Reserve	Aviemore Residential and Non Residential properties.	High
Aviemore Burn	A9 1150 C95	DS-WS-030	6.29	Aviemore Burn, consists of 3 main tributaries including Milton Burn, Steallan Dubh and Allt Dubh flowing east through Aviemore before joining the River Spey.	Aviemore Residential, Non Residential properties and former Aviemore Primary School.	High
The Shieling / Easter Aviemore Burn	A9 1150 C11	DS-WS-029	0.6	The unnamed watercourse flows east as it crosses the A9 before joining the River Spey.	Rural grasslands of Easter Aviemore. Land use is grazing and rough pasture.	Low
Granish Underpass Culvert	A9 1170 C1	DS-WS-029	0.6	The unnamed watercourse flows east as it crosses the A9 before joining the River Spey.	Land use is a mixture of forestry and agricultural land.	Low
Shunem Culvert	A9 1170 C6	DS-WS-028B	1.71	Tributary of Allt na Criche	Land use is a mixture of forestry and agricultural land	Low
Southern bifurcation of Allt na Criche (Granish)	3534	DS-WS-028B	1.71	Originating in the Allt na Criche, the unnamed watercourse flows east as it crosses the A9 before joining the River Spey.	Land use is a mixture of forestry and agricultural land associated with Granish Farm.	Low

Watercourse	Existing Structure ID	Catchment ID	Area (km^2)	Catchment Description	Downstream Receptor	Sensitivity
Northern bifurcation of Allt na Criche (Granish)		DS-WS-028A	0.22	Originating in the Allt na Criche, the unnamed watercourse flows east as it crosses the A9 as it flows toward Lochan Ban	Rural grassland and General Wades military road.	Low
Allt na Criche (Granish)	A9 1170 C12	DS-WS-028	2.71	Watercourse flowing east as it crosses the A9 before flowing into Loch na Carraigean.	Forestry commission land. A9, B9152, residential and non-residential properties	Very High
Unnamed Drain	A9 1170 C18	DS-WS-027	0.12	Drainage path	Forestry commission land. Discharges to Avielochan.	Medium
Unnamed Drain	A9 1170 C20	DS-WS-025	0.16	Drainage path	Forestry commission land. Discharges to Avielochan.	Medium
Southern Avie Lochan Burn	A9 1170 C22	DS-WS-026	1.15	Watercourse flowing east as it crosses the A9 before flowing into Avie Lochan	Forestry commission land. Discharges to Avielochan.	Medium
Northern Avie Lochan Burn	A9 1170 C23	DS-WS-024	0.51	Drainage path flowing east toward Avie Lochan	Residential Properties at Avielochan	Very High
Unnamed Drain	A9 1170 C26	DS-WS-023	0.31	Drainage path originating from Beinn Ghuilbin	Agricultural Land. No land classification.	Low
Unnamed Drain	A9 1170 C32	DS-WS-022	0.16	Drainage path	Agricultural Land. No Classification.	Low
Unnamed Drain		DS-WS-021	0.02	Drainage path	Agricultural Land. No Classification.	Low
Allt Cnapach		DS-WS-020	2.09	Rising through Kinveachy Forest, flowing east as it crosses the A9.	Highland Main Line railway.	High
Unnamed Drain	A9 1170 C53	DS-WS-019	0.13	Allt na Criche tributary	Agricultural Land. No Classification.	Low
Unnamed Drain		DS-WS-018	0.31	Drainage paths originating from Torr Mhuic	Highland Main Line railway.	High
Unnamed Drain		DS-WS-017	0.0	Drainage path	Forestry Land.	Medium

Watercourse	Existing Structure ID	Catchment ID	Area (km^2)	Catchment Description	Downstream Receptor	Sensitivity
Feith Mhor	A9 1170 C75	DS-WS-016	2.37	Rising from Carn na h-Eilde and flows northeast, where it crosses the A9 before joining the River Dulnain.	Forestry Commission Land. Highland Main Line railway.	High
Unnamed Drain	A9 1170 C77	DS-WS-015	0.60	Drainage path draining Carn Lethendry before flowing into Feith Mhor	Forestry Commission Land. Highland Main Line railway	High
Unnamed Drain	A9 1170 C81	DS-WS-014	0.004	Drainage path	Forestry Commission Land. Highland Main Line railway	High
Unnamed Drain		DS-WS-013	0.02	Drainage path	Forestry Commission Land. Highland Main Line railway.	High
Unnamed Drain	4160	DS-WS-012	0.87	Drainage path	Forestry Commission Land.	Medium
Unnamed Drain		DS-WS-011	0.18	Drainage path draining Torr na Mallachd	Highland Main Line railway and Carrbridge train station.	High
River Dulnain	A9 1190	DS-WS-010*	188.1	Rising in the Monadhliath Mountains draining peaks such as Carn Sgulain and Cnoc Fraing the watercourse flows in a north westerly direction before its crossing with the existing A9 before flowing through Carrbridge.	Agricultural land.	Medium
Allt nan Ceatharnach	A9 1200	DS-WS-009*	16.0	Rising from Carn lain Ruaidh and flowing south towards its confluence with Allt a Bhainne and Bogbain burn before crossing the existing A9 as Allt nan Ceatharnach where it meets the River Dulnain.	Agricultural land.	Medium
Unnamed Drain	4159	DS-WS-008	0.10	Drainage path	Forestry Land.	Medium
Unnamed Drain	3421	DS-WS-007	0.17	Drainage path draining Black Mount	Grassland and scrub.	Low
Unnamed Drain		DS-WS-006	0.01	Drainage path	Grassland and scrub.	Low
Unnamed Drain		DS-WS-005	0.24	Drainage path	Grassland and scrub.	Low

Watercourse	Existing Structure ID	Catchment ID	Area (km^2)	Catchment Description	Downstream Receptor	Sensitivity
Unnamed Drain	3422	DS-WS-004	0.27	Drainage path draining Carn nam Bain-tighearna	Grassland and scrub.	Low
Unnamed Drain		DS-WS-004A	0.27	Drainage path	Steep hillside consisting of grassland and scrub.	Low
Slochd Mhuic	A9 1210 C31	DS-WS-003	0.27	Drainage path draining Carn nam Bain-tighearna	Grassland and scrub.	Low
Unnamed tributary of Slochd Mhuic	3649	DS-WS-002	1.4	Drainage paths originating from Torr Mor	Steep hillside within a rock outcrop.	Low
Slochd Mhuic	A9 1210 C45	DS-WS-002			National Cycle Network track.	High
Slochd Mhuic	3648 A9 1210 C46	DS-WS-002			Grassland and scrub.	Low

Table 4-2 Existing Watercourse Crossing Structure Details

Watercourse	Existing Structure ID	Structure Type	Size	Flow Estimation Method	Peak Flow (m^3/s)		Capacity to soffit (flow in m^3/s / AEP)	Capacity to road level (flow in m^3/s / AEP)
					0.5%	0.5% plus Climate Change		
Allt an Fhearna	A9 1090	Bridge	4.38m x7.3m	Statistical	32.43**	38.92	95.2 / >0.1%*	126.2 / >0.1%*
Allt Chriochaidh	A9 1100	Bridge	1.5m x 4m	Rainfall Runoff	6.60	7.92	20.9 / >0.1%*	28.3 / >0.1%*
Caochan Ruadh	A9 1100 C70	Circular Culvert Corrugated	1.9 m Ø	Rainfall Runoff	5.02	6.03	5.42 / 0.5%	21.83 / >0.1%
Ballinluig Burn	A9 1110 C10	Circular Culvert Corrugated	2.3m Ø	Rainfall Runoff	2.26	2.5	9.1 / >0.1%	12.00 / >0.1%
Unnamed Drain	A9 1120	Culvert	0.9m Ø	Rainfall Runoff	1.42	1.71	0.76 / 10%	1.18 / 2%

Watercourse	Existing Structure ID	Structure Type	Size	Flow Estimation Method	Peak Flow (m^3/s)		Capacity to soffit (flow in m^3/s / AEP)	Capacity to road level (flow in m^3/s / AEP)
					0.5%	0.5% plus Climate Change		
Unnamed Drain	A9 1120 C19	Circular Culvert, Concrete	0.9m Ø	Rainfall Runoff	0.54	0.65	0.98 / 0.5%	2.13 / >0.1%
Allt na Criche (Lynwilg)	A9 1130	Bridge	4m x 6m	Rainfall Runoff	14.95	17.94	83.7 / >0.1%*	109.9 / >0.1%*
Loch Puladdern	Unrecorded	2 x Circular Culvert, Corrugated	0.9m Ø 0.5m Ø	Rainfall Runoff	4.97	5.97	0.3 / <50%	0.5 / <50%
Unnamed Drain	Unrecorded	Culvert	0.8m Ø	Rainfall Runoff	0.82	0.98	0.99 / 0.5%*	2.46/ >0.1%*
Aviemore Burn	A9 1150 C95	Circular Culvert, Corrugated	2.4m Ø	Rainfall Runoff	15.32	18.39	8.05 / 10%*	9.64 / 4%*
The Shieling / Easter Aviemore Burn	A9 1150 C11	Circular Culvert, Corrugated	0.9m Ø	Rainfall Runoff	1.76	2.11	0.89 / 10%*	2.15 / 0.5%*
Southern bifurcation of Allt na Criche (Granish)	3534	Circular Culvert, Corrugated	1.2m Ø	Rainfall Runoff	5.75	6.90	1.78 / <50%	1.12 / <50%
Northern bifurcation of Allt na Criche (Granish)		Circular Culvert, Corrugated.	0.4m Ø	Rainfall Runoff	0.66	0.79	0.124 / <50%	0.163 / <50%
Allt na Criche (Granish)	A9 1170 C12	Circular Culvert, Corrugated	1.1m Ø	Rainfall Runoff	8.35	10.02	1.44 / <50%	3.08 / 50%
Unnamed Drain	A9 1170 C18	Circular Culvert, Corrugated	0.9m Ø	Rainfall Runoff	0.59	0.71	1.05 / >0.1%	2.09 / >0.1%
Southern Avie Lochan Burn	3690 A9 1170 C22	Circular Culvert, Corrugated	1.45m Ø	Rainfall Runoff	4.14	4.97	1.43 / 50%	1.85 / 20%
Unnamed Drain	3689 A9 1170 C20	Circular Culvert, Corrugated	0.9m Ø	Rainfall Runoff	0.55	0.66	1.00 / >0.1%	1.33 / >0.1%

Watercourse	Existing Structure ID	Structure Type	Size	Flow Estimation Method	Peak Flow (m^3/s)		Capacity to soffit (flow in m^3/s / AEP)	Capacity to road level (flow in m^3/s / AEP)
					0.5%	0.5% plus Climate Change		
Northern Avie Lochan Burn	3688 A9 1170 C23	Circular Culvert, Corrugated	0.9m Ø	Rainfall Runoff	1.75	2.10	0.9 / 1%	0.9 / 1%
Unnamed Drain	A9 1170 C26	Circular Culvert, Corrugated	0.4m Ø	Rainfall Runoff	1.06	1.27	0.09 / <50%	0.20 / <50%
Unnamed Drain	A9 1170 C32	Circular Culvert, Corrugated	0.6m Ø	Rainfall Runoff	0.55	0.66	0.38 / 3.3%	1.21 / >0.1%
Unnamed Drain	Unrecorded	Circular Culvert, Corrugated	0.5m Ø	Rainfall Runoff	2.8	3.3	0.5 / < 50%	3 / >0.5%
Allt Cnapach	A9 1170 C50	Circular Culvert, Corrugated	1.5m Ø	Rainfall Runoff	4.0	4.8	3.17 / 1%	6 / >0.1%
Unnamed Drain	A9 1170 C53	Circular Culvert, Corrugated	0.8m Ø	Rainfall Runoff	0.4	0.46	0.65 / >0.5%	0.84 / >0.1
Unnamed Drain	Unrecorded	Circular Culvert, Corrugated	0.3m Ø	Rainfall Runoff	0.93	1.12	0.11 / <50%	0.16 / <50%
Unnamed Drain	Unrecorded	Circular Culvert, Corrugated	0.3m Ø	Rainfall Runoff	0.35	0.41	0.04 / <50%	0.12 / 50%
Feith Mhor	A9 1170 C75	Circular Culvert, Corrugated	2.0m Ø	Rainfall Runoff	6.2	7.4	4.74 / 2%*	3.13 / 10%*
Unnamed Drain	A9 1170 C77	Circular Culvert, Corrugated	1.58m Ø	Rainfall Runoff	1.4	1.70	2.69 / 0.1%	2.08 / 0.5%+CC
Unnamed Drain	A9 1170 C81	Circular Culvert, Corrugated	0.5m Ø	Rainfall Runoff	0.02	0.02	0.19 / >0.1%	0.32 / >0.1%

Watercourse	Existing Structure ID	Structure Type	Size	Flow Estimation Method	Peak Flow (m^3/s)		Capacity to soffit (flow in m^3/s / AEP)	Capacity to road level (flow in m^3/s / AEP)
					0.5%	0.5% plus Climate Change		
Unnamed Drain	Unrecorded	Circular Culvert, Corrugated and Mitred.	0.5m Ø	Rainfall Runoff	0.07	0.08	0.16 / >0.1%	0.31 / >0.1%
Unnamed Drain	4160	Circular Culvert, Corrugated with a square headwall.	1.1m Ø	Rainfall Runoff	2.9	3.48	1.35 / 20%	1.78 / 10%
Unnamed Drain	Unrecorded	Catch pit	0.45m	Rainfall Runoff	0.47	0.56	0.15 / 50%	N/A
River Dulnain	A9 1190	Bridge	14m x 34m	Statistical	206.1**	247.42	5550 / >0.1%*	N/A
Allt nan Ceatharnach	A9 1200	Bridge	10m x 13m	Statistical	34.84**	44.74	3765 / >0.1%*	N/A
Unnamed Drain	4159	Circular Culvert, Corrugated and Mitred.	0.45m	Rainfall Runoff	0.38	0.45	0.15 / 50%	0.26 / 3.33%
Unnamed Drain	3421	Circular Culvert, Corrugated and Mitred.	0.6m	Rainfall Runoff	0.66	0.79	0.24 / 50%	0.34 / 10%
Unnamed Drain	Unrecorded	Culvert	0.45m Ø	Rainfall Runoff	0.07	0.09	0.15 / >0.1%	0.40 / >0.1%
Unnamed Drain	Unrecorded	Circular Culvert, Corrugated and Mitred.	0.5m Ø	Rainfall Runoff	1.4	1.69	0.20 / 50%	0.62 / 20%
Unnamed Drain	3422	Circular Culvert, Corrugated and Mitred.	1.0m Ø	Rainfall Runoff	1.6	1.88	1.22 / 1%	2.5 / >0.1%
Unnamed Drain	Unrecorded	Circular culvert, Corrugated and Mitred.	0.7m Ø	Rainfall Runoff	1.6	1.93	0.47 / 50%	1.4 / 1%
Slochd Mhuic	A9 1210							
Slochd Mhuic	A9 1210 C31	Rectangular, concrete box with 90degree headwall with 45 degree bevels.	1.6m x 2.18m	Rainfall Runoff	1.6	1.92	10.35 / >0.1%	N/A

Watercourse	Existing Structure ID	Structure Type	Size	Flow Estimation Method	Peak Flow (m^3/s)		Capacity to soffit (flow in m^3/s / AEP)	Capacity to road level (flow in m^3/s / AEP)
					0.5%	0.5% plus Climate Change		
Unnamed tributary of Slochd Mhuic	3649	Rectangular, concrete box with 90degree headwall with 45 degree bevels.	1.5m x 2.2m	Rainfall Runoff	7.6	9.1	7.6 / 0.5%	15.6 / >0.1%
Unnamed tributary of Slochd Burn	Unrecorded	Circular Culvert, Corrugated	0.4m Ø	Rainfall Runoff	7.6	9.1	0.13 / >0.1%	>0.1%
Slochd Mhuic	A9 1210 C45	Circular Culvert, Corrugated	1.6m Ø	Rainfall Runoff	7.6	9.1	2.7 / 50%	8.83 / 0.5%
Slochd Mhuic	3648 A9 1210 C46		1.6m Ø	Rainfall Runoff	7.6	9.1	3.53 / 20%	9 / 0.5%

4.1.10 The existing hydraulic capacities of the watercourse crossings were calculated through the use of unsteady-state one dimensional (1D) hydraulic models. The models were built in either ISIS 3.7 or Flood Modeller software, with cross sectional information taken from surveyed cross sections. Unsteady state models were used to allow for the effect of upstream storage on flood flows and maximum flood levels. The models typically extend 5 cross sections upstream of the A9 crossings, with a spacing of approximately 15m between each section. Sufficient cross sections were added to the downstream end of the models to minimise the potential for downstream boundary impact on the culverts.

4.1.11 The capacity of the culverts is based on the surcharge to the soffit. This is the flow required in the model to achieve a water level at the culvert inlet equal to the soffit level. The maximum surcharge available is the flow required in the model to achieve a water level that exceeds the highest point on the existing road surface or laterally to the channel whereby flow will exceed a high point on the bank and flow towards the next adjacent crossing structure. The impact of new and replacement structures is assessed in Section 5.2.

4.2 Floodplain Extents

4.2.1 The SEPA Flood Maps have been reviewed as part of the baseline assessment for the Proposed Scheme which shows the existing A9 in relation to Medium Likelihood river flooding.

4.2.2 The baseline assessment identifies eleven floodplain locations, which would potentially be impacted by the dualling, via either disconnection, displacement and/or encroachment of earthworks onto the floodplain:

- Allt an Fhearna and Loch Alvie;
- Allt na Criche (Lynwilg);
- Aviemore Burn South;
- Aviemore North / Easter Shieling;
- Allt na Criche (Granish);
- Avielochan;
- Feith Mhor;
- Allt Cnapach;
- River Dulnain at Carrbridge;
- Bogbain Burn; and
- Slochd Mhuic.

4.2.3 To improve the floodplain definition 1D/2D linked hydraulic models were developed. Model schematics for each 1D/2D linked model are shown in Figure A11.3.6.

4.2.4 Full details of the hydrological and hydraulic methodology is shown in Annex 11.3a. gives a detailed description of the model development.

4.2.5 The hydrological model for each of the 1D/2D linked models involved the detailed catchment delineation, which takes account of the inflows to the river reach. The catchments were delineated using the FEH CD ROM version 3, and detailed topographical information.

4.2.6 Peak flows were calculated for each catchment using a combination of FEH Rainfall Runoff and Statistical estimations. For each of the model reaches the storm duration was optimised hydraulically.

4.2.7 The chosen methodology for each of the catchments modelled along with critical storm durations and peak flows for a range of return periods are provided in Annex 11.3a for each of the model reaches.

4.2.8 The channel and floodplain roughness coefficients are estimated from site inspection and photographs taken during the survey and are based on Manning's 'n' values. Annex 11.3a shows the values used for each of the 1D/2D Linked Hydraulic models.

4.2.9 The catchments are mainly small and ungauged. It has therefore not been possible to calibrate the models. However, we have followed SEPA guidance and good practise and used sensitivity analysis to test sensitivity to assumed parameters.

4.2.10 The downstream model boundaries were checked using a 20% increase of downstream water levels. This check was carried out to determine the sensitivity of the model to conditions downstream. There was some sensitivity to variations in downstream water level but this sensitivity did not extend significantly into the reach of interest and is not considered significant enough to materially affect model results.

4.2.11 The hydraulic models were also tested by varying the roughness conditions (Manning's 'n') by +/- 20 % to assess model sensitivity. Generally, the variation of Manning's 'n' roughness yielded a sensible and constant variation in water levels.

4.2.12 Following the modelling of selected watercourses and floodplains, the floodplain extents have been refined as discussed in Table 4.3 below. Table 4.3 also provides a summary of receptors sensitive to flood risk for each watercourse/floodplain. Figures A11.3.7, A11.3.8 and A11.3.9 show the baseline floodplain extents for the AMJV 3.33%, 0.5% and 0.5%AEP plus climate change.

River Dulnain at Carrbridge

4.2.13 The River Dulnain model through Carrbridge has been validated using event data and wrack marks for the August 2014 events but as the model does not extend far enough upstream or downstream to the Sluggan or Balnaan Bridge gauges respectively a full calibration of the model was not possible. A comparison of the Rainfall Runoff event hydrographs with a number of peaks recorded at the Balnaan gauge was undertaken and adjustments to Tp were made to better represent the hydrograph shape. A Tp factor of 1.5 has been applied to the design rainfall runoff hydrographs as part of this validation exercise. Further details are provided in Annex 11.3a.

4.2.14 A comparison has also been made with model water levels and wrack marks for the August 2014 event. During the August 2014 event there was significant blockage of structures with a partial washout of a structure so the observed wrack marks are based on displaced overland flows around blockages. By modelling the blockages and increasing roughness to represent the large amount of debris in the channel during the event a better match to the observed wrack mark outlines could be achieved. As the verification was a blockage event, it is not appropriate to apply the hydraulic parameters to the baseline flood risk modelling, therefore, only the hydrological validation parameters were incorporated into the Dulnain hydraulic model.

Table 4-3: Floodplain Receptors and Sensitivity

Floodplain	Description	Receptors	NGR	Sensitivity
Allt an Fhearna	The floodplain of the Allt an Fhearna is constrained through forested areas until approximately 15m upstream of the confluence with Allt Each. At this location the Allt an Fhearna appears to be spilling to both the left and right bank, with potential interaction of floodwater from the Allt Each and Allt an Fhearna, upstream of the confluence. Downstream of the Allt Each confluence the Allt an Fhearna floodplain appears to be primarily located on the left bank following the 245m contour, maintaining a constant width. As the channel flows toward the crossing of the existing A9 the floodplain begins to increase in width and flows along the toe of the A9 embankment. In this area the AMJV floodplain is narrower than the SEPA floodplain extents Downstream of the A9 crossing the Allt an Fhearna flows to Loch Alvie with the floodplain widening from 40m to approximately 300m and following the shape of the 220m contour. In this area the AMJV floodplain is similar in extent and shape to the SEPA flood map.	A9	285410 809200	Very High
		Agricultural Land	285670 809370	Medium
		SSSI and Forestry Commission Land	285560 809290	Medium
Loch Alvie	Loch Alvie is approximately 500m downstream of the existing A9. At Loch Alvie, the flood extents generally surround the loch, with the AMJV modelling indicating that the floodplain extent is uniformly wider than the area of flooding shown on the SEPA flood map. Along the existing A9 route corridor a minimum distance of 20m is maintained between the A9 and flood extents. To the south of Loch Alvie the floodplain width increases to inundate the B9152, with residential and non-residential properties potentially being inundated	B9152	286860 809160	High
		Residential & Non Residential Properties	286700 809100	High
		Agricultural Land	286280 808850	Medium
		Grasslands	285980 809240	Low
Allt na Criche (Lynwilg)	The modelling shows that the floodplains upstream of the A9 are constrained by the valley and follows the 225m contour. It remains a relatively constant width on the approach to the existing A9 crossing. The floodplain width increases on approach to the B9152 and again on the Highland Main Line railway, this is due to a reduction in channel capacity at these locations. The flood extents at these locations are slightly greater than those shown on the SEPA flood map, although there are no additional third parties receptors identified. In addition to the fluvial flood extents, the modelling has identified two locations where surface water ponding would occur at the 0.5% AEP.	A9	288370 810610	Very High
		Agricultural land	288412 810661	Medium
		Grassland	288384 810593	Low
		B9152	288398 810575	High
		Highland Main Line railway	288416 810559	Very High

Floodplain	Description	Receptors	NGR	Sensitivity
	These are located at Lynwilg Farm immediately upstream of the A9, on both the east and west of the Allt na Criche (Lynwilg)			
Aviemore Burn	The Aviemore Burn is fed by three main tributaries including Milton burn, Steallan Dubh and Allt Dubh draining the slopes of Carn Dearg Mor (712mAOD). The SEPA flood maps show that there is limited flood risk at the upstream extents of the tributaries and becomes defined at the confluence, 500m from the crossing of the A9. The AMJV floodplain modelling shows that there are differences in the SEPA and AMJV floodplains and flow pathways along the existing A9 between chainage 7400 and 7600. The Aviemore Burn comes out of bank on both the left and right bank upstream of the A9 Crossing (DS-WC-014), and flows both north and south along the line of the existing A9. These flood flows are conveyed through the existing A9 underpasses and cattle-creeps (A9 1150 C87, unnamed at NGR 2893 8137, and A9 1162) and subsequently over land to the east of the A9 to rejoin the Aviemore Burn channel. The channel then continues through Aviemore with no defined floodplain before its confluence with the River Spey. There are several residential and non-residential receptors within the AMJV flood outline.	A9	289326 813856	Very High
		Residential & Non Residential Properties	289394 813871	High
		Grassland	289317 813889	Low
The Shieling/ Easter Aviemore Burn	The Shieling/Easter Aviemore Burn, is not shown on the SEPA flood outline. The AMJV floodplain extents are approximately 4m wide and are well contained to the channel. Receptors are restricted to woodland and scrub in the immediate vicinity of the channel.	A9	289330 813850	Very High
		Woodland and Scrub	289410 814170	Low
Allt na Criche (Granish)	The Allt na Criche (Granish), and the two separate bifurcating channels, are not shown on the SEPA flood outline. The AMJV floodplain modelling shows that the Allt na Criche (Granish) spills onto the right bank immediately upstream of the northern bifurcation channel (NGR 289662, 815130) and along the length of the northern bifurcation channel. The floodplain extents on the right bank of the bifurcating channel varies between 25m to 100m, and flows towards and overtops the A9 at two locations NGR 2898 8149, and 2898 8149.	Forestry Commission Land	289731 814913	Medium
		A9	289905 814999	Very High

Floodplain	Description	Receptors	NGR	Sensitivity
	This flow pathway continues towards the B9152, connecting with the southern bifurcation channel of Allt na Criche, at Granish Farm. Immediately downstream of the of the bifurcating channel, the Allt na Criche spills onto the right bank for approximately 100m and flows towards and overtops the A9 at 2898 8150. The extent of overtopping of the A9 at this location is 40-50m. It continues to flow north east and surrounds the Residential Property. Between 2898 8153 and 2901 8156 the Allt na Criche floodplains are constrained by the surrounding topography with the floodplain width varying between 10 and 20m. Downstream of the A9 the floodplain extends between 20-40m with no preferential spill direction. There are several receptors to flooding in this area including the A9, B9152, General Wades Road, and both residential and non-residential properties.	B9152	289941 814737	High
		Residential & Non Residential Properties	289885 815047	High
		Grassland	289869 814935	Low
Avielochan	Avielochan Burn drains forestry on the northbound side of the existing A9 carriageway flowing east to the crossing. There is significant floodplain both upstream and downstream of the A9 which is if of shallow depth. The receptors are forestry and scrub as well as the existing A9 and the A95 downstream.	A9	290229 816405	Very High
		A95	290472 816405	Very High
		Forestry Commission Land	290201816460	Medium
		Grassland and scrub	290325 816344	Low
Allt Cnapach	Allt Cnapach is a small watercourse that drains forestry on the northbound side of the existing A9 carriageway at Kinveachy. The watercourse flows east to be crossed by the A9 and the adjacent Highland Main Line railway. Upstream of the crossing, there is little to no floodplain with the channel dominated by a series of cascades over steps. Downstream, the channel becomes increasingly more modified and affected by downstream impoundments but floodplain flow is limited to small areas of grassland adjacent to the channel	A9	291040 818510	Very High
		Highland Main Line railway	291096 818513	Very High
		Grassland	291062 818466	Low
Feith Mhor	The SEPA flood maps show no flooding on the Feith Mhor upstream of the existing A9 crossing. However, the AMJV flood extents indicate the floodplain upstream of the A9 watercourse crossing DS-WC-036 is approximately 70m wide.	A9	290763 820734	Very High
		Forestry Commission Land	290808 820873	Medium
		Highland Main Line railway	290825 820931	Very High

Floodplain	Description	Receptors	NGR	Sensitivity
	Downstream of the A9 the floodplain is approximately 250-300m wide in the land between the A9 and the Highland Main Line railway. This is significantly larger than the SEPA flood extents.			
River Dulnain	The River Dulnain drains a catchment of approximately 190km^2 with a defined network of functional floodplain within the upstream extent. The rural areas within the upstream extent contain no known receptors with approximate floodplain extents reaching 120m. In this area the SEPA and AMJV flood extents are generally similar. As the River Dulnain approaches the A9 there are differences in the SEPA and AMJV flood extents, with the SEPA flood outline extending south of the Dulnain. However, the AMJV extents show that flow is contained close to the channel on the approach to the existing A9 crossing (DS-WC-046) with limited floodplain in this area. Downstream of the A9 and Highland Mainline crossing towards Carrbridge there is little to no floodplain with most flow remaining in channel.	A9	289668 822549	Very High
		Agricultural Land	289630 822530	Medium
Allt nan Ceatharnach	Allt nan Ceatharnach is fed by several watercourses that include Allt Ruighe Magaig, Allt a Bhainne and Bogbain Burn. The SEPA flood extents indicate an increased area at risk of flooding at the confluence of these burns, in the vicinity of the A938 and the HML railway. Functional floodplain extents are reduced in the vicinity of the A9 crossing and are constant until the confluence with the River Dulnain begins to have a hydraulic influence.	A9	289119 823152	Very High
		Agricultural Land	289150 822580	Medium
Bogbain Burn	Bogbain Burn is situated at Black Mount and is formed from several headwaters which rise on the southeastern slopes of Carn a' Chuaille and Carn nam Bain-tighearna, which subsequently converge to the north of the Highland Main Line railway. The burn then flows broadly southeast through forestry plantation, roughly parallel with the existing A9, and is crossed several times by the railway and the A938 before joining the Allt nan Ceatharnach at NGR 2888 8239. The floodplain extends between the A938 and the railway affecting agricultural land and the existing A938.	A938	288170 824050	Very High
		Highland Main Line Railway	287804 824140	Very High
		Grassland and Scrub	287840 824160	Low
Slochd Mhuic	The Slochd Mhuic has a catchment area of 7.3km2 draining upland moor and forestry. A heavily modified section of the headwater drains Slochd Summit, flows southeast, and is crossed several times over a distance of	A9	283500 825670	Very High

Floodplain	Description	Receptors	NGR	Sensitivity
	approximately 1.3km by the existing A9 carriageway (NGR 2841 8250, NGR 2838 8254, NGR 2835 8256 and NGR 2835 82567). The watercourse continues south, running broadly parallel to the existing A9, to the confluence with Allt Ruighe an t-Sabhail, at NGR 2843 8243. From here the Slochd Mhuic flows predominantly south for approximately 4km, converging with several large streams to become the Allt an Aonaich, which converges with the River Dulnain at NGR 2864 8217. Flows are confined within channel with only small floodplain extents downstream affecting grassland and scrub. There is no floodplain extending to the National Cycle Network track.	National Cycle Network track	283590 825510	High
		Grassland and Scrub	284350 824210	Low

5. Proposed Scheme

5.1.1 The Proposed Scheme involves upgrading the existing A9 single carriageway road between Dalraddy and Slochd (a length of approximately 25 km) to dual carriageway standard. A full description is given in Chapter 5 in Volume 1 and the scheme general layout is shown in Figures 5.2 (Proposed Scheme Layout) and typical cross sections in Figure 5.3 (Plan and Profile). Junction layout plans are shown in Figures 5.4 to 5.6. Indicative designs for key structures are shown in Figures 5.7 (Dulnain Bridge) and 5.8 (Slochd Beag Bridge).

5.1.2 This flood risk assessment is based on proposals included in the 7a design iteration. Several design iterations have been required to avoid and minimise potential clashes with environmental or physical constraints, and further develop the preferred option to better meet stakeholder needs.

5.1.3 The findings of the assessment of previous design iterations have been fed back into the design and flood risk mitigation options have been developed where necessary and incorporated into the 7a design iteration.

5.2 Watercourse Crossings

5.2.1 As part of the Proposed Scheme the existing watercourse crossings will be either upgraded and/or replaced or demolished. There are also additional watercourse crossings for access roads. Details of the water crossings for the proposed scheme are given in Table 5-1.

5.2.2 All watercourses crossing the proposed mainline will require a culvert and these have been largely sized to accommodate the required flood design flows of 1 in 200 year plus climate change plus an appropriate freeboard allowance. There are a few locations where structures have been intentionally undersized to attenuate flood water in order to provide flood risk mitigation for the effects of the scheme.

5.2.3 All of the existing corrugated steel pipe culverts will be replaced. The new culverts will consist of reinforced precast concrete box or portal construction thus minimising construction and maintenance operations. Portal frame culverts are proposed on the Caochan Ruadh, Ballinluig Burn, Aviemore Burn, Easter Aviemore Burn, Allt na Criche, Southern Avie Lochan Burn, Northern Avie Lochan Burn, Allt Cnapach, Fèith Mhòr and Allt Slochd Mhuic watercourses. Culverts with natural beds will be constructed, where possible. Where box culverts are being constructed, 300mm of suitable bed material is proposed. Mammal ledges will also be installed where required and will be designed to meet the 1 in 25 year flood level.

5.2.4 The majority of the culverts will be constructed offline from the existing culverts in order to maintain flows of the watercourses during construction. Minor local watercourse diversions at the inlets and outlets will also be necessary to allow offline construction. Cascades and plunge pools have been indicatively identified where required. By building the culverts offline, it will allow construction to take place without contaminating the watercourse. After this, the existing watercourse will be diverted through the new culvert, and allow demolition of the existing culvert to take place, again with reduced risk of contamination of the watercourse. Constructing the culverts offline has the added benefit of realigning the watercourses to their historical alignments. These watercourses were diverted when the A9 was first constructed and we have taken care to match them to their historical alignment wherever possible.

5.2.5 Access to culverts for maintenance inspection purposes will be provided either from stepped accesses from a hardstanding area in the verge of the A9 or via SuDS ponds maintenance tracks or local roads.

Table 5-1: Proposed Watercourse Crossings

Watercourse Name	New Structure ID	Watercourse ID	NGR	Existing Dimension	Existing capacity to Soffit	Type	Proposed Height (m)	Proposed Width (m)	Length (m)	Gradient (%)
Allt an Fhearna	A9 1090 S	DS-WC-001		-	-	Culvert	2.5	6.5	7	1.2
Allt Chriochaidh	A9 1100	DS-WC-002	285658 809540	4m span	20.9 / >0.1%	Bridge	1.5	4	21.8	6.0
Allt Chriochaidh	A9 1100S	DS-WC-002		-	-	Culvert	1.5	6.5	7	1
Caochan Ruadh	A9 1100 C70	DS-WC-004	286625 810129	1.9 x 1.9	5.42 / 0.5%	Culvert	2.5	2.5	80	2.6
Ballinluig Burn	A9 1110 C10	DS-WC-005	286857 810176	2.3 x 2.3	9.1 / >0.1%	Bridge	2.5	2.0	31	4.6
Allt na Criche (Lynwilg)	A9 1130	DS-WC-007	288363 810614	6m span	83.7 / >0.1%	Bridge	6.0	3.4	38	0.3
Loch Puladdern	A9 1150 C7	DS-WC-010	289113 812141	0.5 Ø and 0.9 Ø	0.3 / <50%	Culvert	1.2	1.2	34	0.9
Unnamed watercourse	A9 1150 C92	DS-WC-013A	289291 813778	0.8 Ø	0.99 / 0.5%	Culvert	1.2	1.2	44.0	7.3
Aviemore Burn	A9 1150 C95	DS-WC-014	289319 813851	2.4 Ø	8.05 / 10%	Culvert	2.5	2.5	32.0	6.1
The Shieling / Easter Aviemore Burn	A9 1160 C14	DS-WC-016	289407 814145	1 Ø	0.89 / 10%	Culvert	1.2	1.2	46.0	5.0
Unnamed watercourse	A9 1170 C4	DS-WC-018	289723 814861	0.5 Ø	1.78 / <50%	Culvert	0.5	0.5	47.7	2.1
Allt na Criche tributary	A9 1170 C6	DS-WC-019	289818 815029	0.9 Ø	0.124 / <50%	Culvert	1.2	1.2	34.0	3.5
Allt na Criche tributary	A9 1170 C6S	DS-WC-019	289723 814861	-	-	Culvert	1.2	1.2	12	7.1
Allt na Criche (Granish)	A9 1170 C12	DS-WC-022	290062 815638	1.8 Ø	1.44 / <50%	Culvert	2.5	2.5	64	2.7

Watercourse Name	New Structure ID	Watercourse ID	NGR	Existing Dimension	Existing capacity to Soffit	Type	Proposed Height (m)	Proposed Width (m)	Length (m)	Gradient (%)
Allt na Criche (Granish)	A9 1170 C12S	DS-WC-022		-	-	Culvert	1.2	1.2	12	1.3
Unnamed watercourse	A9 1170 C20	DS-WC-024	290215 816391	1.5 Ø	1.00 / >0.1%	Culvert	1.2	1.2	30.0	5.0
Unnamed watercourse	A9 1170 C20S	DS-WC-024		-	-	Culvert	1.2	1.2	30.0	5.0
Northern Avie Lochan Burn	A9 1170 C23	DS-WC-026	290335 816757	1 Ø	0.9 / 1%	Culvert	1.8	1.2	30.0	5.0
Unnamed Drain	Drain 8		291003 818432	0.5m Ø	3 / > 0.5%	Culvert	0.5 Ø			
Allt Cnapach	A9 1170 C50	DS-WC-032	291026 818531	1.6 Ø	3.17 / 1%	Culvert	2.5	1.2	44	5.0
Allt Cnapach	A9 1170 C50S	DS-WC-032		-	-	Culvert	2 x 750 mm pipes		14	6.8
Unnamed Drain	A9 1170 C53	DS-WC-033	291067 818962	0.9 Ø	0.65 / >0.5%	Culvert	1.2	1.2	50	8.0
Feith Mhor	A9 1170 C75	DS-WC-036	290740 820734	2.1 Ø	4.74 / 2%	Culvert	1.8	1.8	64	0.9
Feith Mhor	A9 1170 C75S	DS-WC-036		-	-	Culvert	1.8	1.8	16	1.6
Unnamed Drain	A9 1170 C77	DS-WC-039	290685 820871	1.6 Ø	2.69 / 0.1%	Culvert	1.8	1.8	62	1.5
Unnamed Drain	A9 1170 C77S	DS-WC-039		-	-	Culvert	1.2	1.2	1.2	2.9
Unnamed Drain	Drain 14		290601 821129	0.5 Ø	0.16 / >0.1%	Culvert	0.5 Ø			
Unnamed Drain	Drain 14S			-	-	Culvert	0.5 Ø			
Unnamed Drain	A9 1170 C81	DS-WC-041	290555 821228	1 Ø	0.19 / >0.1%	Culvert	1.8	1.8	38.4	1.9

Watercourse Name	New Structure ID	Watercourse ID	NGR	Existing Dimension	Existing capacity to Soffit	Type	Proposed Height (m)	Proposed Width (m)	Length (m)	Gradient (%)
Unnamed Drain	A9 1170 C81S	DS-WC-041		-	-	Culvert	1.2	1.2		
Unnamed Drain	Drain 16		289756 822436	0.5 Ø	0.15 / 50%	Culvert	0.5 Ø			
River Dulnain	A9 1190	DS-WC-046	289703 822513	14m x 34m	5550 / >0.1%	Bridge	13	14	84	
River Dulnain		DS-WC-046	289711 825513	-		Bridge	13	14.6	83	
Allt nan Ceatharnach	A9 1200		289114 823147	13.7m span	3765 / >0.1%	Bridge	16	10	12	
Allt nan Ceatharnach			289121 823170	-		Bridge	18	10	26	
Unnamed Drain	Drain 18		288501 823842	0.5 Ø	1.22 / 1%	Culvert	0.5 Ø			
Slochd Mhuic	A9 1206 F		284045 824926	1.8 Ø	9.0 / >0.1%	Culvert	1.7	1.7	50	1
Slochd Mhuic	A9 1210 C31	DS-WC-057	284060 825137	1.6 x 2.18m	10.35 / >0.1%	Culvert	1.4	2.5	100	3
Unnamed tributary of Slochd Mhuic	A9 1210 C39		283747 825400	1.5 x 2.2m	7.6 / 0.5%	Culvert	2.5	2.5	48.1	3
Slochd Mhuic	A9 1207 F		283741 825396	2.66 x 0.82m	10.0 / >0.1%	Culvert	2.66	0.82	8.95	2
Slochd Mhuic	A9 1208 F		283697 825510	1.67 x 1.76m	3.5 / 20%	Culvert	1.67	1.76		1
Slochd Mhuic	A9 1209 F		283439 825663	1.54 x 1.41m span	3.0 / 20%	Culvert	1.54	1.41	26.08	2

5.3 Floodplains

5.3.1 The areas where the Proposed Scheme could potentially impact on the 0.5% AEP floodplain are:

- Allt an Fhearna and Loch Alvie;
- Allt na Criche Lynwilg;
- Aviemore South;
- Aviemore North / Easter Shieling;
- Allt na Criche (Granish);
- Avielochan;
- Allt Cnapach;
- Feith Mhor;
- Carrbridge;
- Bogbain Burn; and
- Slochd Mhuic.

5.3.2 Details of the Proposed Scheme are given in Chapter 5. A summary is given in the following sections highlighting those elements that are most pertinent to flood risk.

5.3.3 The Proposed Scheme in the vicinity of Allt an Fhearna includes an access track for SuDS. This road is required to cross the floodplain to enable it to tie-in to the necessary access point from the existing track. The alignment of the access track has been designed such that it does not encroach on the SSSI and the Ancient Woodland. The elevation of the road surface has been kept to a minimum and for the majority of the track's length is lower than the culvert soffit level. There are no locations where changes in the mainline earthworks ground levels impinge on the Allt an Fhearna and Loch Alvie modelled flood extents. The SuDS access pond to the north shore of Loch Alvie, side road to the eastern shore and cycle track are built at existing grade and do not encroach on the floodplain.

5.3.4 At Allt na Criche Lynwilg, the existing A9 1130 bridge will be replaced with a 6 x 3.4 m 38 m length clear span bridge to allow for the revised road alignment and levels. 600 mm mammal ledge are included in the structure positioned 150 mm above the 0.25% maximum water level. The 0.5% AEP is contained within the channel and no flood plain is displaced by earthworks. The Proposed Scheme also includes two SUDS ponds located upstream of the A9 1130 crossing and either side of the watercourse. The ponds and their access tracks are above the 0.5% AEP flood level.

5.3.5 At Aviemore South, the A9 1150 C92 and A9 1150 C92 along with the Milton Sheep Creep access will be replaced. The proposed A9 1150 C95 will be a portal frame 2.5 x 2.5 m of 32m in length with 600 mm mammal ledges included. The A9 1150 C92 will be replaced with a 1.2 m box culvert, 44m in length. The Milton Sheep Creep will be replaced with a 2.0 m box culvert, 34 in length and will be a dry culvert used only for flood relief, mammal passage and access. The proposed earthworks of the A9 do not encroach on the existing floodplain.

5.3.6 At Aviemore North / Easter Shieling the earthworks for the proposed widening encroach on the existing flood risk upstream of the A9. The two new Suds ponds are located

outside of the 0.5% AEP flood outline but the SuDS access track crosses the existing floodplain.

5.3.7 The A9 at Allt na Criche (Granish) is at a similar elevation to the floodplain and is easily overtopped for a 0.5% AEP event. The Proposed Scheme includes a grade separated junction, underpasses on the main alignment (A9 1170) and junction (A9 1171), replacement of the culverts A9 1170 C6 and A9 1170 C12, four SUDS ponds and associated tracks. The junction is located outside of the 0.5% AEP flood outline but the earthworks for the mainline dualling and the access tracks do impact on the 0.5% AEP flood outline.

5.3.8 At Avielochan the existing A9 floods for the 0.5% AEP event and the SuDS pond is located within the 0.5% AEP flood extent, although is outside of the 3.33 % AEP flood extent.

5.3.9 The proposed scheme at Allt Cnapach includes the replacement of the A9 culvert, new access road structure and an access track from the A95.

5.3.10 The Proposed Scheme in the vicinity of Feith Mhor includes enlarged embankments, new junction, replacement water crossings, SuDS ponds and access tracks to SuDS. The proposed earthworks encroach on the existing floodplain.

5.3.11 The proposed scheme in the vicinity of Carrbridge includes new Dulnain and Baddengorm bridges across River Dulnain and Allt nan Ceatharnach respectively. There are two new SuDS ponds and access tracks that have been located outside of the 0.5% AEP flood outline.

5.3.12 At Bogbain Burn, the scheme includes a grade separated junction to connect the A938 with the dualled A9, an auxiliary junction connects the southbound GSJ loop with the U2400. A small SUDS pond is located in the loop of the GSJ which together with a below ground tank attenuation road drainage.

5.3.13 At Slochd Mhuic, the proposed earthworks are located along the existing channel and the watercourse is diverted adjacent to the railway in a 2m x 2m channel for a short section before flowing into a rock trap in a half hexagonal trapezoidal shape before cascading into the original watercourse alignment.

6. Flood Risk Impact

6.1 Watercourse Crossings – Impact

6.1.1 The assessment presented in the following sections considers the impact of the proposed water crossings on flow and water levels in the watercourse and the resulting impact on sensitive receptors in the vicinity of the crossing.

6.1.2 The potential impact of the water crossings on the wider floodplain due to changes in peak flood flows, time to peak flow and flood volumes are considered within the floodplain assessment (Section 6.2).

6.1.3 Construction and operational impacts are assessed separately.

Watercourse Crossings - Construction Impacts

6.1.4 The construction of the Proposed Scheme will include the upgrade, replacement, extension and/ or new watercourse crossings. The majority of the culverts will be

constructed offline from the existing culverts which will maintain flows of the watercourses during construction. Minor local watercourse diversions at the inlets and outlets will also be necessary to allow offline construction.

6.1.5 Should it be required to construct crossings online then the watercourse will be temporarily diverted through a temporary channel and/or pumped, which could result in flows being:

- Conveyed more effectively downstream increasing the flood risk to the site and third parties; or
- Water backing up due to insufficient capacity resulting in washout to the construction area.

6.1.6 Materials and plant equipment stored on site could result in the blockage to existing structures and localised flooding to the site and sensitive receptors.

6.1.7 Excavation and construction works on the site could lead to blockage and or severance of surface water that could lead to localised flooding to the site and sensitive receptors.

6.1.8 During construction, localised ground-raising could result in displacement of floodwater and changes to the surface water runoff pathways increasing the flood risk to the surrounding area.

6.1.9 During construction, movement of materials on site including the creation of stockpiles could alter flow pathways and displace flood water.

6.1.10 The operation of plant may result in compaction of soils, which may reduce the infiltration capacity. This could result in an increase in surface water runoff leading to localised flooding and runoff into the receiving watercourse.

6.1.11 The magnitude of impact of flood risk associated with the construction of the Proposed Scheme will consider the duration, time of year and construction sequencing in addition to the factors given in Section 2.3. Any impacts are likely to be temporary and mitigation will be possible. Once construction details are known flood risk impacts should be assessed and any mitigation agreed with SEPA. Table 6.1 provides an overview of the potential construction activities that impact on flood risk and typical mitigation measures.

Table 6-1: Watercourse Crossings - Construction Impacts

Activity	Timing of Measure	Description of Measure	Purpose of Measure
Flood Risk	Pre-Construction & Construction	In relation to flood risk the Contractor will implement the following mitigation measures during construction: • the Flood Response Plan will set out mitigation measures to be implemented when working within the functional floodplain (defined here as the 0.5% AEP (200-year) flood extent); • plant and materials will be stored in areas outside the functional floodplain where practicable, with the aim for temporary construction works to be resistant or resilient to flooding impacts, to minimise/prevent movement or damage during potential flooding events. Where this is not possible, agreement will be required with the EnvCoW; • where practicable, haul routes will be located out of the functional floodplain. When in the floodplain stockpiling of material must be carefully controlled with limits to the extent of stockpiling within an area to prevent compartmentalisation of the floodplain and stockpiles should be away from water feature banks (not within 10m of the water feature banks). This is in order to limit floodplain encroachment, associated increased flood risk and sediment entering the water feature.	To reduce the risk of flooding impacts on construction works.
Runoff and Surface Water Drainage	Pre-Construction & Construction	The Contractor will implement appropriate controls for construction site runoff: • installation of temporary drainage systems/SuDS systems (or equivalent) including pre-earthworks drainage to increase storage capacity potential for surface water runoff; • treatment facilities to be scheduled for construction early in the programme to control the rate of flow before water is discharged into a receiving watercourse; • temporary drainage systems will be implemented to alleviate localised surface water flood risk and prevent obstruction of existing surface runoff pathways	To implement appropriate controls for site runoff and sedimentation and reduce impacts on the water environment and the risk of flooding as a result of increased runoff rates.
In-channel works	Pre-Construction & Construction	In relation to in-channel working the Contractor will implement the following mitigation measures: • compliance with SEPA regulations in relation to in channel works; • undertaking in-channel works during low flow periods (i.e. when flows are at or below the mean average) as far as practicable; • minimise length of channel disturbed and size of working corridor;	To reduce impacts on frequency, depth, extent and duration of flooding.

Activity	Timing of Measure	Description of Measure	Purpose of Measure
		• limit the amount of removal of the vegetated riparian corridor and woodland area retaining vegetated buffer zone wherever possible; and • limit the amount of tracking along the side of watercourses and avoid creation of new flow paths between exposed areas and new or existing channels.	
Channel realignment	Construction	Where channel realignment is proposed the following mitigation measures will be implemented by the Contractor: • once a new channel is constructed, the flow should, where practicable, be diverted from the existing channel to the new course under normal/low flow conditions. In addition, diverting flow to a new channel should be timed to avoid forecast heavy rainfall events at the location and higher up in the catchment. The optimum time for constructing a new channel, where practicable, is in the spring and early summer months to allow vegetation establishment to help stabilise the new channel banks.	To reduce impacts on frequency, depth, extent and duration of flooding.
General site activities	Construction	The placement of site compounds and the storage of construction material and equipment should be outside of natural flow paths to prevent severance of flow pathways and displacement of flood water.	To reduce impacts on frequency, depth, extent and duration of flooding.

Watercourse crossings - Operational Impacts

6.1.12 The design process for the watercourse crossings is complex, taking account of a range of design criteria and constraints to develop the most appropriate crossing for each watercourse. The primary technical standards driving the design of culverts are DMRB HA107/04 Design of Outfall and Culvert Details (2004) and the CIRIA Culvert design and operation guide (C689) (2010). However, in addition to these technical standards, other drivers that influence the culvert design include:

- **Flood risk** - In the event that a culvert is either extended (based on current geometry) or replaced, the impact on flood sensitive receptors may change by either retaining more water on the upstream side of the A9 or by passing more water through the culvert. Extending a culvert in the absence of any other change may increase flood levels upstream, while replacing an existing culvert with a larger one will increase the flow downstream, possibly reducing water level upstream and increasing water level downstream.
- **Maintenance requirements** - Maintenance of culverts to meet DMRB standards (as defined by HA107/04) requires consideration of a minimum culvert size. This culvert may be larger than the culvert size required from a hydraulic perspective, in which case increasing the culvert size may have an impact on flood sensitive receptors downstream.
- **Ecological considerations** - When designing new culverts, consideration is given to the provision of adequate integrated mammal passage, which if required will influence culvert size. In addition, consideration is given to maintaining a natural bed level within the culvert barrel by burying the culvert invert such that the culvert is sized to carry both flood flow and river bed sediment.
- **Geomorphological considerations** - When increasing the size of a culvert there is the potential for influencing sediment transport which occurs during a flood, thereby impacting on either erosion or sedimentation in the vicinity of the culvert, both upstream and downstream.
- **Highway drainage design** - The culvert design, in terms of both gradient and cross-section, needs to be considered so that it does not conflict with the proposed scheme, i.e. the proposed road structure and drainage system.

6.1.13 For all areas, these influencing factors need to be considered together on a case-by-case basis to develop the most appropriate culvert design for each crossing. This design process is iterative, such that the final design meets the fundamental design standard, which is that the proposed scheme remains free from flooding in the 0.5% AEP (200-year) design flood event plus an allowance for climate change (increase in flow of 20%), and freeboard (typically between 300mm and 600mm depending upon culvert dimensions). In this context freeboard is defined as the difference between the proposed scheme road level and the peak water level during the 0.5% AEP (200-year) plus climate change event.

6.1.14 The design approach for the watercourse crossings, which takes account of the culvert design guidance, allows for a degree of flexibility and engineering judgement to be applied to the culvert design, to take into account the various influencing factors outlined above. The final designs for the watercourse crossings included within this FRA are all compliant with this guidance, with a focus on design considerations set out in CIRIA C689 and DMRB HA107/04.

6.1.15 The results of the 1D hydraulic modelling confirmed that all the proposed structures under the main A9 alignment pass the 0.5% AEP flow with 20% allowance for climate

change and an appropriate freeboard. The minimum freeboard allowance is 600mm for structures larger than 1.2m high and 300mm for smaller openings.

6.1.16 The magnitude of the impact is based on the capacity of the existing structure (given in Table 4-2) to reflect the change in downstream flow when the culvert is replaced. For watercourses where no structure currently exists the magnitude has been set as negligible on the basis that all new structures have the capacity to convey the 0.5% AEP plus climate change.

6.1.17 The assessed impacts for each watercourse are given in Table 6-2 below.

Table 6-2: Watercourse Crossings - Operational Impacts

Watercourse	Existing Structure ID	New Structure ID	Catchment ID	Sensitivity	0.5% Peak Flow (m^3/s)	Existing Capacity (m^3/s / AEP)	Magnitude	Significance
Allt an Fhearna	-	A9 1090 S	DS-WS-038	Medium	32.43	-	Negligible	Neutral
Allt Chriochaidh	A9 1100	A9 1100	DS-WS-037	Low	6.60	20.9 / >0.1%	Negligible	Neutral
Allt Chriochaidh	-	A9 1100 S	DS-WS-037	Low	6.60	-	Negligible	Neutral
Caochan Ruadh	A9 1100 C70	A9 1100 C70	DS-WS-036	Low	5.02	5.42 / 0.5%	Moderate	Slight
Ballinluig Burn	A9 1100 C10	A9 1110 C10	DS-WS-035	Low	2.26	9.1 / >0.1%	Negligible	Neutral
Allt na Criche (Lynwilg)	A9 1130	A9 1130	DS-WS-034	High	14.95	83.7 / >0.1%	Negligible	Neutral
Loch Puladdern	A9 1150 C7	A9 1150 C7	DS-WS-033	Low	4.97	0.3 / <50%	Moderate	Slight
Unnamed Drain	A9 1150 C92	A9 1150 C92		High	0.82	0.99 / 0.5%	Negligible	Neutral
Aviemore Burn	A9 1150 C95	A9 1150 C95	DS-WS-030	High	15.32	8.05 / 10%	Moderate	Moderate / Large
The Shieling / Easter Aviemore Burn	A9 1150 C11	A9 1160 C14	DS-WS-029	Low	1.76	0.89 / 10%	Moderate	Slight
Unnamed Drain	A9 1170 C4	A9 1170 C4		Low	0.14	1.78 / <50%	Moderate	Slight
Unnamed Drain	A9 1170 C6	A9 1170 C6	DS-WS-019	Low	5.49	0.124 / <50%	Moderate	Slight
Unnamed Drain	-	A9 1170 C6 S	DS-WS-019	Low	5.49	-	Negligible	Neutral
Allt na Criche (Granish)	-	A9 1170 C12 S	DS-WS-028	High	8.35	-	Negligible	Neutral
Allt na Criche (Granish)	A9 1170 C12	A9 1170 C12	DS-WS-028	Very High	8.35	1.44 / <50%	Major	Very Large
Avielochan Burn	3689 A9 1170 C20	A9 1170 C20	DS-WS-025	High	4.14	1.43 / 50%	Moderate	Moderate / Large

Watercourse	Existing Structure ID	New Structure ID	Catchment ID	Sensitivity	0.5% Peak Flow (m^3/s)	Existing Capacity (m^3/s / AEP)	Magnitude	Significance
Avielochan Burn	-	A9 1170 C20 S	DS-WS-025	High	4.14	-	Negligible	Neutral
Avielochan Burn North	3688 A9 1170 C23	A9 1170 C23	DS-WS-024	Very High	1.75	0.9 / 10%	Moderate	Moderate / Large
Unnamed Drain	-	Drain 8		High	2.76		Minor	Slight
Allt Cnapach	-	A9 1170 C50	DS-WS-020	High	3.98	3.17 / 1%	Moderate	Moderate / Large
Allt Cnapach	-	A9 1170 C50 S	DS-WS-020	High	3.98	-	Negligible	Neutral
Unnamed Drain	A9 1170 C53	A9 1170 C53	DS-WS-019	Low	0.4	0.65 / >0.5%	Negligible	Neutral
Feith Mhor	A9 1170 C75	A9 1170 C75	DS-WS-016	High	6.2	4.74 / 2%	Moderate	Moderate / Large
Feith Mhor	-	A9 1170 C75 S	DS-WS-016	High	6.2	-	Negligible	Neutral
Unnamed Drain	A9 1170 C77	A9 1170 C77	DS-WS-015	High	1.4	2.69 / 0.1%	Negligible	Neutral
Unnamed Drain	-	A9 1170 C77 S		High	1.4	-	Negligible	Neutral
Unnamed Drain	-	Drain 14		Low	0.07	0.16 / >0.1%	Negligible	Neutral
Unnamed Drain	-	Drain 14 S		Low	0.07	-	Negligible	Neutral
Unnamed Drain	A9 1170 C81	A9 1170 C81	DS-WS-014	High	0.02	0.19 / >0.1%	Negligible	Neutral
Unnamed Drain	-	A9 1170 C81 S		High	0.02	-	Negligible	Neutral
Unnamed Drain	-	Drain 16		High	0.47	0.15 / 50%	Minor	Slight
River Dulnain	A9 1190	A9 1190	DS-WS-010	Medium	245	5550 / >0.1%	Minor	Slight
River Dulnain		A9 1190S	DS-WS-010	Medium	245	5550 / >0.1%	Minor	Slight
Allt nan Ceatharnach	A9 1200	A9 1200	DS-WS-009	Medium	34.84	3765 / >0.1%	Minor	Slight

Watercourse	Existing Structure ID	New Structure ID	Catchment ID	Sensitivity	0.5% Peak Flow (m^3/s)	Existing Capacity (m^3/s / AEP)	Magnitude	Significance
Allt nan Ceatharnach		A9 1200S	DS-WS-009	Medium	34.84	3765 / >0.1%	Minor	Slight
Unnamed Drain	-	Drain 18		Medium	1.6	1.22 / 1%	Minor	Slight
Slochd Mhuic	A9 1206 F			Low	7.6	9.0 / >0.1%	Negligible	Neutral
Slochd Mhuic	A9 1210 C31	A9 1210 C31	DS-WS-003	Low	7.6	10.35 / >0.1%	Negligible	Neutral
Unnamed tributary of Slochd Mhuic	3649 A9 1210 C39	A9 1210 C39	DS-WS-002	Low	7.6	7.6 / 0.5%	Moderate	Slight
Slochd Mhuic	A9 1207 F			Low	7.6	10.0 / >0.1%	Negligible	Neutral
Slochd Mhuic	A9 1208 F			Low	7.6	3.5 / 20%	Negligible	Neutral
Slochd Mhuic	A9 1210 C45	A9 1210 C45	DS-WS-002	High	7.6	2.7 / 50%	Moderate	Moderate Large / Large
Slochd Mhuic	3648 A9 1210 C46	A9 1210 C46	DS-WS-002	Low	7.6	3.53 / 20%	Moderate	Slight
Slochd Mhuic	A9 1209 F			Low	7.6	3.0 / 20%	Negligible	Neutral

6.1.18 The only watercourse crossing which has the potential to have a Major magnitude of impact on peak flows downstream of the structure is the A9 1170 C12 Allt na Criche at Granish

6.1.19 In addition to Major impacts there are 11 watercourse crossings with a Moderate impact and a further 4 with Minor impacts. For each watercourse the significance of the impact varies depending on the receptor.

6.1.20 There is one structure that is considered to have a Very Large impact significance which is A9 1170 C12 Allt na Criche (Granish). Six structures are considered to have a Moderate / Large significance and nine with a Slight significance.

A9 1150 C7 Loch Puladdern

6.1.21 Downstream receptors of the Loch Puladdern overflow is land with classification capable of producing a narrow range of crops and is considered to have low sensitivity. The proposed structure is larger than the existing and has a moderate impact giving a slight significance of impact overall.

A9 1150 C95 Aviemore Burn

6.1.22 Downstream receptors of Carn Elrig View (A9 1150 C95) are the residential and non-residential properties including Aanside, Millside house, Croftside, Grampian Way, and the town of Aviemore. Historical flooding information indicates that Craig-na-Gower Avenue and the former Aviemore Primary School, flooded in February 1990. The proposed structure is similar to the existing and has a moderate impact giving a moderate/large significance of impact overall. Mitigation through constriction of the A9 structure is required to address the impact here and is considered further in Section 6.2.12 and in Annex 11.3a.

A9 1150 C11 Easter Shieling

Downstream receptors are restricted to agricultural land in the immediate vicinity of the channel. Whilst the proposed structure is considered to have a moderate impact magnitude the receptors are of a low sensitivity receptor giving a slight significance of impact overall.

A9 1170 C12 Allt na Criche, Granish

6.1.23 The immediate downstream receptor of the Allt na Criche (DS-WC-022) is forestry land, which is considered to be of Medium Sensitivity with a Large significance of impact. The B9152 would be considered to have a High sensitivity, however there is no evidence of historical flooding at either location. The A9 is included as a Very High sensitive receptor. Just less than 1.2km downstream of the A9 culvert crossing A9 1170 C12 is the Highland main line railway which has been included in the assessment as a precaution given it is Very High Sensitive receptor. Mitigation measures are required to address the impact here and is considered further in Section 7 and in Annex 11.3a.

A9 1170 C20 Avielochan

6.1.24 The A95 road is 284m downstream of the A9 1170 C20 and has a sensitivity of Very High. Vegetation is mixed woodland and there are no flood risk receptors between the A9 and the A95. There are a number of holiday cottages and caravans situated around the loch downstream of the A95. Mitigation through constriction of the A9 structure is required to address the impact here and is considered further in Annex 11.3a.

A9 1170 C50 Allt Cnapach

6.1.25 Downstream of A9 1170 C50 is the A95. The sensitivity of this receptor is High and increasing flow conveyance could increase the flood risk to the road. The significance of the impact is considered to be Moderate/Large. Mitigation through constriction of the A9 structure is required to address the impact here and is considered further in Annex 11.3a.

A9 1170 C75 Feith Mhor

6.1.26 Downstream of A9 1170 C75 is the Highland Main Line railway. The sensitivity of this receptor is High and increasing flow conveyance could increase the flood risk to the railway. The significance of the impact is considered to be Moderate/Large and further assessment and mitigation has been considered to address the impact and is considered further in Section 7 and in Annex 11.3a

A9 1210 C45 Slochd Mhuic

6.1.27 The immediate downstream receptors of A9 1210 C45 is the National Cycle Network (NCN) route 7 and the Highland Main Line railway. Increases in culvert capacity could increase flow conveyance upstream of these assets. This is considered to be a High sensitivity receptor with an associated Moderate Large/ Large impact significance. At this location the Slochd Mhuic is to be diverted to mitigate the impact and is considered further in Annex 11.3a.

6.2 Floodplain - Impact

6.2.1 The 1D/2D hydraulic models were used to determine the impact of the Proposed Scheme on the 0.5% AEP floodplain. The modified topography and new watercourse crossings were included in the models and the impact assessed using the method given in Section 2.3.

6.2.2 The impacts have been assessed separately for the construction and operation phases and are presented in the following sections.

Floodplain – Construction Impact

6.2.3 During construction, localised ground-raising could result in displacement of floodwater and changes to the surface water runoff pathways increasing the flood risk to the surrounding area.

6.2.4 During construction, movement of materials on site including the creation of stockpiles could alter flow pathways and displace flood water.

6.2.5 The operation of plant may result in compaction of soils, which may reduce the infiltration capacity. This could result in an increase in surface water runoff leading to localised flooding and runoff into the receiving watercourse.

6.2.6 The magnitude of impact of flood risk associated with the construction of the Proposed Scheme will consider the duration, time of year and construction sequencing in addition to the factors given in Section 2.3. Any impacts are likely to be temporary and mitigation will be possible. Once construction details are known flood risk impacts should be assessed and any mitigation agreed with SEPA.

Floodplain – Operational Impact

6.2.7 The operational impact on floodplains have been assessed using the method set out in Section 2.3. The hydrology and hydraulic modelling, which were used to determine the magnitude of the impact on the 0.5% AEP floodplain, are described in detail in Annex 11.3a.

6.2.8 The 1D/2D hydraulic model results were processed to give the magnitude of the impact for each of the receptors given in Table 4-3. The magnitude and receptor sensitivity are combined to give the impact.

6.2.9 The results are given in Table 6-3 below. Table 6.2 includes the Proposed Scheme as a receptor in addition to those identified in Table 4-3.

Table 6-3: Floodplain Receptor Impact Assessment

Floodplain	Description	Receptors	Location (NGR)	Sensitivity	Magnitude	Impact
Allt an Fhearna / Loch Alvie	There is existing flood risk to the B9152 to the South-east shore of Loch Alvie and access roads to North east shore of Loch Alvie for a 0.5% AEP event. The proposed scheme includes improvements to the existing access roads on the North-east shore of Loch Alvie and a new SuDS access road across the Allt an Fhearna to the North West of Loch Alvie.	A9	285410 809200	Very High	Negligible	Neutral
		Access Road on North East shore of Loch Alvie	287300 810090	Medium	Negligible	Neutral
		SuDS Access Road and agricultural land / woodland / SSSI	285670 809370	Medium	Moderate	Moderate
		B9152	286860 809160	High	Negligible	Neutral
		Residential & Non-Residential Properties	286700 809100	High	Negligible	Neutral
Allt na Criche (Lynwilg)	The 0.5% AEP is contained within the channel and no flood plain is displaced by the earthworks for the new bridge crossing. The Proposed Scheme also includes two SUDS ponds located upstream of the A9 1130 crossing and either side of the watercourse. The ponds and their access tracks are above the 0.5% AEP flood level.	A9	288370 810610	Very High	Negligible	Neutral
		Agricultural land	288412 810661	Medium	Negligible	Neutral
		Grassland	288384 810593	Low	Negligible	Neutral
		B9152	288398 810575	High	Negligible	Neutral
		Highland Main Line railway	288416 810559	Very High	Negligible	Neutral
Aviemore South	At Aviemore South, the A9 1150 C92 and A9 1150 C92 along with the Milton Sheep Creep access will be replaced. The proposed A9 1150 C95 will be a portal frame 2.5 x 2.5 m of 32m in length with 600 mm mammal ledges included. The A9 1150 C92 will be replaced with a 1.2 m box culvert, 44m in length. The Milton Sheep Creep will be replaced with a 2.0 m box culvert, 34 in length and will be a dry culvert used only for flood relief, mammal passage and	A9	289326 813856	Very High	Negligible	Neutral
		Grassland area between the existing A9 and Carn Elrig, north of DS-WC-014. Land Classification as grassland with limited potential. A9 road embankment retains water upstream of Aviemore.	289317 813889	Low	Negligible	Neutral
		Aviemore Burn downstream of DS-WC-014, residential properties.	289394 813871	High	Negligible	Neutral
		Residential Properties at Strathspey Avenue	289375 813705	High	Negligible	Neutral

Floodplain	Description	Receptors	Location (NGR)	Sensitivity	Magnitude	Impact
	access. The proposed earthworks of the A9 do not encroach on the existing floodplain.	Aviemore Burn at Strathspey Avenue	289459 813646	High	Negligible	Neutral
Aviemore North Easter Shieling	At Aviemore North / Easter Shieling the earthworks for the proposed widening encroach on the existing flood risk upstream of the A9. The two new Suds ponds are located outside of the 0.5% AEP flood outline but the SuDS access track crosses the existing floodplain.	A9	289330 813850	Very High	Negligible	Neutral
		Woodland and Scrub	289410 814170	Low	Negligible	Neutral
Allt na Criche (Granish)	The Proposed Scheme includes a grade separated junction (GSJ), underpasses on the main alignment (A9 1170) and junction (A9 1171), replacement of the culverts A9 1170 C6 and A9 1170 C12, four SUDS ponds and associated tracks. The junction is located outside of the 0.5% AEP flood outline but the earthworks for the mainline dualling and the access tracks do encroach on the 0.5% AEP flood outline.	Forestry downstream of DS-WC-022	290140 815672	Medium	Major Beneficial	Large Benefit
		Mixed woodland and rough grassland west of the A9 and north of the bifurcation channel	289806 815072	Medium	Major	Large
		Rough grassland west of the A9 and south of the bifurcation channel	289787 815027	Medium	Major	Large
		B9152 road to the east of Granish	289930 814718	High	Minor Beneficial	Slight / Moderate Benefit
		Non-coniferous woodland downstream of Granish underpass	289763 814641	Low	Moderate	Slight
		B9152 north of Granish Farm.	289883 814593	High	Negligible	Neutral
		Highland Main Line railway downstream of the B9152	290224 814224	Very High	Major Beneficial	Very Large Benefit
Avielochan	At Avielochan, the A9 is to be widened and the levels of the road will be slightly higher than what they are currently. The culvert A9 1170 C12 is to be replaced with a 1.8 x 1.2m box and A9 1170	A95	290470 816403	Very High	Minor Beneficial	Moderate Benefit
		Forestry Commission Land	289926 816387	Medium	Minor	Slight
		Grassland and scrub	290269 816371	Low	Minor	Neutral

Floodplain	Description	Receptors	Location (NGR)	Sensitivity	Magnitude	Impact
	C20S by a 1.2 x 1.2m box. The existing flood risk to the A9 and A95 are reduced as a result of the scheme and no mitigation is required.	Avie Lochan non-residential lochside properties	290595 816446	High	Minor Beneficial	Slight / Moderate Benefit
Allt Cnapach	At Allt Cnapach, the A9 is to be widened and there is a new access track and SuDS pond. Levels of the road will be slightly higher than what they are currently. The culvert A9 1170 C50 is to be replaced with a 1.25 x 1.2m box. Flooding is not predicted to the A9 and the SuDS pond is outside of the 0.5% AEP flood outline	A9	291040 818510	Very High	Negligible	Neutral
		Highland Main Line Railway	291096 818513	Very High	Negligible	Neutral
		Grassland	291062 818466	Low	Minor	Neutral
Feith Mhor	The proposed scheme in the vicinity of Feith Mhor includes enlarged embankments, new junction, replacement water crossings, SuDS ponds and access tracks to SuDS. The proposed earthworks encroach on the existing floodplain.	A9	290763 820734	Very High	Negligible	Neutral
		Forestry Commission Land Upstream of the A9 DS-WC-039	290687 820841	Medium	Negligible	Neutral
		Forestry Commission Land Upstream of the DS-WC-036 A9 Crossing	290712 820712	Medium	Major	Large
		Forestry Commission Land Between the Highland Main Line railway and A9	290808 820873	Medium	Moderate	Moderate
		Highland Main Line railway embankment	290825 820931	Very High	Moderate	Large/ Very Large
		Downstream of the Highland Railway	290878 820896	Medium	Minor	Slight
River Dulnain	For the River Dulnain, the proposed scheme includes an additional single span bridge on the downstream side and new SuDS pond and access tracks to SuDS. The proposed earthworks do not encroach on the existing floodplain.	A9	289668 822549	Very High	Negligible	Neutral
		Agricultural Land	289630 822530	Medium	Negligible	Neutral
		A9	289119 823152	Very High	Negligible	Neutral

Floodplain	Description	Receptors	Location (NGR)	Sensitivity	Magnitude	Impact
Allt nan Ceatharnach	For the Allt nan Ceatharnach, the proposed scheme includes an additional single span bridge on the downstream side and new SuDS pond and access tracks to SuDS. The proposed earthworks do not encroach on the existing floodplain.	Agricultural Land	289150 822580	Medium	Negligible	Neutral
Bogbain Burn	At Bogbain Burn, the scheme includes a grade separated junction (GSJ) to connect the A938 with the dualled A9, an auxiliary junction connects the southbound GSJ loop with the U2400. A SUDS pond is located between the GSJ and the railway. The earthworks for the southern loop of the GSJ confine the floodplain between the scheme and the railway causing floodplain levels to rise.	Grassland and Scrub	287840 824160	Low	Minor	Neutral
		Highland Main Line railway	287804 824140	Very High	Minor	Moderate
		A938	288170 824050	Very High	Moderate	Large
Slochd Mhuic	At Slochd Mhuic, widening of the southbound carriageway and the diversion of Allt Slochd Mhuic alongside the carriageway at higher elevation before cascading into an underpass to join the existing channel.	Grassland and Scrub	284350 824210	Low	Negligible	Neutral
		A9	283500 825670	Very High	Negligible	Neutral
		National Cycle Network track	283590 825510	High	Negligible	Neutral

6.2.10 There is no floodplain loss at Allt na Criche (Lynwilg), The Shieling/ Aviemore Burn North, River Dulnain, Allt nan Ceatharnach, and Slochd Mhuic and no impact on flood risk to sensitive receptors. Therefore, the Proposed Scheme passes the Sequential Tests 1 and 2 at these locations and no further assessment is required

6.2.11 The Proposed Scheme increases flood levels at Allt an Fhearna in the vicinity of the new SuDS access track and would impact on medium sensitivity receptors of agricultural and woodland areas along with the SSSI. The Proposed Scheme therefore fails Test 2 and Sequential Test 3 has been applied.

6.2.12 At Aviemore Burn South, the encroachment of the scheme has very little impact on available floodplain storage at the site. In total there is approximately 68m^3 of floodplain loss. Any shortening of watercourse channels immediately downstream of the A9 is replaced by increasing proposed culvert lengths, all of which have capacity matching or exceeding the existing channel capacity lost. The A9 crossing structure has been optimised to manage flows downstream whilst ensuring any increased water levels are contained within the channel upstream so as not to increase flood risk to upstream properties. The result is that there are some beneficial impacts of a reduction in 1-2mm on flood risk areas for the 0.5% AEP event within the residential area with only a minimal 2mm increase further downstream. Results show that water levels are within 10 mm of baseline conditions downstream of the A9 for all AEP events. The embedded mitigation included as part of the scheme design at Aviemore South results in a negligible impact, and as such, compensatory floodplain storage or further scheme mitigation measures are not considered necessary at this site and it was not therefore necessary to apply Sequential Test 3.

6.2.13 At Allt na Criche (Granish) the GSJ is located outside of the 0.5% AEP flood outline but the earthworks for the mainline dualling and the farm and SUDS access tracks do encroach on the 0.5% AEP floodplain causing a shallow depth of flooding on the A9, a Very High sensitivity receptor. Sequential Test 3 has therefore been applied.

6.2.14 At Avielochan the raised level of the A9 and the under-sized structure at A9 1170 C12 ensure that downstream receptors are not impacted by the scheme. The proposed main alignment culvert A9 1170 C23 has been sized to ensure that flood risk to the Very High sensitive receptor does not increase. The culverts were included in the floodplain assessment for this area to assess the impact of loss of floodplain storage and to ensure that the risk to all receptors remains unchanged. It was not therefore necessary to apply Sequential Test 3. The SuDS pond lies outside of the 0.5% AEP floodplain.

6.2.15 The proposed scheme earthworks at Feith Mhor encroaches on the floodplain between the A9 and the Highland Main Line railway which would impact on Forestry Commission land (medium sensitivity receptor) and the railway embankment (high sensitivity receptor). The Proposed Scheme therefore fails Test 2 and Sequential Test 3 has been applied.

6.2.16 At Allt Cnapach, constraining the size of structure at A9 1170 C50 ensures that downstream receptors are not impacted by the scheme. It was not therefore necessary to apply Sequential Test 3.

6.2.17 The proposed scheme earthworks at the A938 junction encroaches on the Bogbain Burn floodplain between the A938 and the Highland Main Line railway which would impact on scrub (low sensitivity receptor) and the A938 itself (high sensitivity receptor). The Proposed Scheme therefore fails Test 2 and Sequential Test 3 has been applied.

6.2.18 The results of the Sequential Test 3 assessment and the proposed actions are given in Section 7.3 as operational mitigation measures.

7. Mitigation

7.1 Construction Mitigation Measures

7.1.1 A Schedule of Environmental Commitments will be incorporated into the works construction documents and the appointed Contractor will be obliged to adhere to these requirements throughout the contract period. The construction commitments will be addressed through the Construction Environmental Management Plan (CEMP). Details of these commitments are given in Chapter 21. The sections below highlight those that relate to flood risk.

7.1.2 Standard S1 is for the Contractor to prepare a Construction Environmental Management Plan (CEMP) to set out how they intend to operate the construction site, including construction-related mitigation measures. The relevant section(s) of the CEMP will be in place prior to the start of construction work.

7.1.3 The CEMP will include a Flood Response Plan and should be listed on the SEPA flood warning register. The flood warning service monitors rainfall and river levels 24 hours a day and uses this information to forecast the possibility of flooding.

7.1.4 The Flood Response Plan will be prepared and submitted to Transport Scotland for approval before construction work commences and will include the following:

- how the flood warning should be provided and disseminated;
- what will be done to protect the critical infrastructure of the development and how easily damaged items will be relocated;
- the availability of staff and time taken to respond to a flood warning;
- the use of high level refuges for staff within the plant;
- the time needed to evacuate the site;
- provision of safe access to and from the development;
- the ability to maintain key operations during a flood event; and
- expected time taken to re-establish normal operation following a flood event.

7.1.5 The Contractor will implement Mitigation Item W2 during construction in relation to flood risk. These measures include:

- In relation to flood risk the Contractor will implement the following mitigation measures during construction:
- the Flood Response Plan (as part of the CEMP) will set out the following mitigation measures to be implemented when working within the functional floodplain (defined here as the 0.5% AEP (200-year) flood extent):
  - routinely check the MET office Weather Warnings and the SEPA Floodline alert service for potential storm events (or snow melt), flood alerts and warnings relevant to the area of the construction works.
  - during periods of heavy rainfall or extended periods of wet weather (in the immediate locality or wider river catchment) river levels will be monitored using, for example, SEPA Water Level Data when available or visual inspection of water features. The Contractor will assess any change from base flow condition and be familiar with the normal dry weather flow conditions for the water feature, and be familiar with the likely hydrological response of the water feature to heavy rainfall

(in terms of time to peak, likely flood extents) and windows of opportunity to respond should river levels rise.

- should flooding be predicted, works close or within the water features should be immediately withdrawn (if practicable) from high risk areas (defined as: within the channel or within the bankfull channel zone - usually the 50% (2-year) AEP flood extent). Works should retreat to above the 10% AEP (10-year) flood extent) with monitoring and alerts for further mobilisation outside the functional floodplain should river levels continue to rise.

- plant and materials will be stored in areas outside the functional floodplain where practicable, with the aim for temporary construction works to be resistant or resilient to flooding impacts, to minimise/prevent movement or damage during potential flooding events. Where this is not possible, agreement will be required with the EnvCoW;
- temporary drainage systems will be implemented to alleviate localised surface water flood risk and prevent obstruction of existing surface runoff pathways; and
- where practicable, haul routes will be located out of the functional floodplain. When in the floodplain stockpiling of material must be carefully controlled with limits to the extent of stockpiling within an area to prevent compartmentalisation of the floodplain and stockpiles should be away from water feature banks (not within 10m of the water feature banks). This is in order to limit floodplain encroachment, associated increased flood risk and sediment entering the water feature.

7.2 Operational Mitigation Measures - Watercourse Crossings

General

7.2.1 In relation to culverts the Contractor will implement the mitigation measures set out in Mitigation Item W15 within Chapter 21: Schedule of Environmental Commitments. In particular, detailed design has included embedded mitigation of flood risk impacts through appropriate hydraulic design of culvert structures. Flood risk has been assessed against the 0.5%AEP (200-year) plus an allowance for climate change design flood event. Where widening of the proposed scheme footprint would lead to loss of existing floodplain storage volume embedded mitigation as part of detailed design shall mitigate this through for example provision of compensatory storage. Any embedded mitigation in the form of flood storage is proposed following discussion with the landowner. Where culvert extension is not practicable or presents adverse impact on the water environment, appropriately designed replacement culverts shall be installed.

7.2.2 The impact of the new crossings identified in Section 6.1 which affect Aviemore Burn South, Allt na Criche (Granish), Avielochan, Feith Mhor are addressed in the floodplain mitigation measures (Section 7.3).

7.2.3 There are no other significant impacts on flood risk resulting from the replacement and new watercourse crossings that require mitigation.

7.3 Operational Mitigation Measures - Floodplain

7.3.1 There is no floodplain loss at Allt na Criche (Lynwilg), River Dulnain, Allt nan Ceatharnach and Slochd Mhuic and no impact on flood risk to sensitive receptors. Therefore, the Proposed Scheme passes the Sequential Tests 1 and 2 at these locations and no further assessment was required for mitigation measures.

7.3.2 The Sequential Test 3 has been applied to four floodplain areas: Allt an Fhearna / Loch Alvie, Allt na Criche (Granish), Feith Mhor and Bogbain Burn.

7.3.3 The floodplain for the 0.5% AEP and 0.5% AEP with climate change events along with the impacts on flood depth (impact magnitude) are shown in Figures A11.3.10 and A11.3.11.

Allt an Fhearna and Loch Alvie

7.3.4 The proposed scheme at Loch Alvie was developed based on a wide range of constraints including flood risk, ecology (SSSI and Ancient Woodland) and the interests of the landowner.

7.3.5 The SuDS access road as part of the proposed scheme crosses the floodplain to the North West of Loch Alvie resulting in a potential loss of floodplain of 336 m^3 and modification of the hydraulic links between the floodplains due to barrier to flow from the raised SuDS access road. This road is required to cross the floodplain to enable it tie-in to the nominated access point from the existing track. The elevation of the road surface has been kept to a minimum and, for the majority of the tracks length, is lower than the culvert soffit level. Optimisation of the alignment of the access track has been undertaken as part of the design process to minimise the impact on the SSSI, Ancient Woodland and flood risk.

7.3.6 Providing direct compensation storage for loss of floodplain would require excavation of Ancient Woodland and SSSI land adjacent to the Allt na Fhearna and was therefore rejected given the indirect impacts and the lack of high sensitive flood risk receptors in this area. The defacto online storage behind the raised access track is considered to have the least potential detrimental impact on the environment and additional flood risk mitigation is not proposed at this location.

7.3.7 The defacto online storage increases water levels upstream of the side road crossing. However, the impact at this location is minor with no sensitive flood receptors. The increase in flood water level is experienced in an area of riparian woodland and no ecological or landscape concern has been identified by the relevant environmental specialists.

Allt na Criche (Granish)

7.3.8 The proposed scheme at Granish is to raise the right bank of the bifurcation channel by a height of approximately 0.5m over the length of approximately 115m. The embankment eliminates the flooding of A9 when the bifurcation channel overtops. It leads to a greater proportion of the 0.5% AEP flow being held in the bifurcation channel and spilling onto the left floodplain of the bifurcation channel. The embankment ensures that there is neutral or better impact on downstream receptors.

7.3.9 The embankment leads to an increase in flood depths over the floodplain west of the A9. No sensitive receptors or constraints (e.g. environmental designations) were identified in this area which is already largely within the 0.5% AEP floodplain.

7.3.10 Providing direct compensation storage would require a volume of up to 20,000 m^3 to be excavated and was therefore rejected given the extensive indirect impacts and the lack of high sensitive flood risk receptors in this area. Indirect impacts include the removal of ancient woodland and associated landscape; the need to dispose of the excavated material either as fill or waste; and the impacts on the current land use (and access) are significant given the limited space for storage between the Allt na Criche and Bifurcation channel

7.3.11 The use of upstream storage (including natural flood management) was assessed. However, this approach would require substantial land acquisition and a sensitivity analysis showed that a reduction of more than 30% in runoff is required to eliminate the flooding of the A9. This option was also therefore rejected.

Feith Mhor

South

7.3.12 The encroachment of the southernmost scheme crossing on the existing floodplain causes a loss of floodplain storage of approximately 5150m^3 for the 0.5% AEP event, between the A9 and the railway, and an increase in flood levels greater than the appropriate threshold of 10mm for all AEP events simulated. The railway is considered a very high sensitivity asset, and in order to mitigate against the increased flood levels, mitigation measures were deemed necessary

7.3.13 Two mitigation measures were considered at the site, the first involved providing like-for-like floodplain compensation between the railway and the A9. This would involve excavating into the side of existing sloping topography and would be highly constrained between the A9 and the railway. Due to the sensitivities involved with large amounts of excavation in such close proximity to the railway, this option was not progressed any further.

7.3.14 The second, preferred option, would involve the attenuation and storage of flood water upstream of the A9. The benefit of storing water upstream of the A9 is that it works with the existing processes of the watercourse and the natural topography of the area without having to undertake large amounts of excavation.

7.3.15 The southern channel of Feith Mhor Burn provides approximately four times more flow than the northern channel, and when water backs up and spills out of bank behind culvert FEITH06_us it is naturally directed northwards towards the northern channel and culvert FEITH20_us. Retaining water upstream of the A9 requires blocking off the flow path between the southern and northern channel. By blocking this flow route, water accumulates in a natural low point located between the two culvert crossings, thus reducing the amount of flow passing beneath the A9 and reducing flood levels between the A9 and the railway.

7.3.16 To simulate this in the modelling, a bund has been set to a level of 260.3 m AOD parallel to the right bank of the northern channel, which prevents water from overflowing into the northern channel in events up to and including the 0.5% AEP. Additionally, a storage area has been defined within the natural low point in topography, with ground levels at the base of the proposed storage area set to 258.5 m AOD (the lowest point of existing topography). This provides up to 1.8m of storage depth before water overtops the bund. The total available storage behind the A9, up to the 260.3 m AOD contour, is approximately 7400 m^3

7.3.17 Mitigation measures at the site have been designed to ensure that water levels are within 10 mm of baseline conditions between the A9 and the railway for all AEP events. Water levels do increase upstream of the A9, however, there are no sensitive flood risk receptors in this area and these increases are considered to be offset by the benefits of ensuring there is a neutral impact to the railway asset.

North

7.3.18 The encroachment of the scheme and access track C14 on the existing floodplain causes a loss of floodplain storage of approximately 230m^3 for the 0.5% AEP event. The

majority of this loss is associated with the elevated C14 access track. Despite this loss, flood levels in close proximity to the railway have decreased in all AEP events, which is caused by water becoming impounded behind the C14 access track and the incorporated culvert controlling the flow of water that is directed towards the railway.

7.3.19 As a result, flow volume has been redistributed across the floodplain with isolated areas of increase/decrease in levels. Due to the improvement (decrease) in levels in close proximity to the railway, and the increase in levels located away from any sensitive flood risk receptors, compensatory floodplain storage is not considered necessary at this northern portion of the Feith Mhor site.

Bogbain Burn

7.3.20 The proposed alignment encroaches onto the 0.5% AEP floodplain of Bogbain Burn and approximately 2500 m^3 of floodplain is lost. An assessment was undertaken to include flood compensation storage mitigation in the proposed scheme. The sequential approach was fully adopted at this location to ensure that the flood risk assessment informed the junction layout.

7.3.21 The GSJ and auxillary junction to the U2400 have been moved as far off the floodplain as possible resulting in the connection to the U2400 unclassified road on the southbound compact loop requiring a Departure from DMRB standards.

7.3.22 The drainage network was modified to minimise the loss of floodplain by moving SuDS basins off the floodplain between the railway and the A9 (although one has had to remain) together with a below ground tank attenuation road drainage.

7.3.23 The viability of a flood storage basin was assessed as being technically unviable due to:

- Excavation in the floodplain between the GSJ and the railway is constrained by the need to locate a buried tank to attenuate road drainage here.
- The location of a flood storage basin on the floodplain will further constrain flood flows and cause water levels on the floodplain to increase significantly;
- Locating flood storage on the north side of the railway would require a culvert to be bored through the railway embankment at high cost as well as additional land purchase.

7.3.24 The scheme displaces water onto the floodplain between the A938 and the railway leading to increased flood depths on the A938 in the underpass under the railway. The mitigation involves an increase in height (410mm) to the right bank upstream of the railway crossing (313.20 mAOD) compared to 312.79 mAOD) to control the volume of spill onto the floodplain between the A9 and the railway.

7.3.25 This mitigation leads to increased flows in the burn between the railway bridge and the A938 which dissipate downstream of the A938. There are only minor differences in the extent of the floodplain of the Bogbain Burn and depths north of the railway increase (A11.3.10). The increased flows are limited to the 775m reach between the railway bridge and A938 as flood flows recombine downstream of this point.

7.3.26 The impact of increasing flows, water levels and velocities in the vicinity of the railway bridge has been assessed in terms of geomorphological impact. There is some scour evident on the left bank downstream of the railway bridge on a bend, which may be slightly exacerbated if more water is kept in the channel through the mitigation measures put in place. If mitigation is required to alleviate the pressure on the bend (and bed), the

right bank will be pulled back (reprofiled) to take the pressure off the left bank. A site visit should be carried out prior to any detailed design to confirm this assessment.

7.3.27 The track along the northern (away from railway) side of the watercourse and the watercourse have been included in the CPO boundary such that scour protection could be installed should it be required following the more detailed assessment and detailed design.

8. Residual Risk

8.1 Watercourse Crossings

8.1.1 The residual risk associated with the new watercourse crossings are given in Table 8-1.

Table 8-1: Residual Risk - Watercourse Crossings

Watercourse	Proposed Structure ID	Sensitivity	Potential Impact		Proposed mitigation	Residual Impact	
			Magnitude	Significance		Magnitude	Significance
Allt an Fhearna	A9 1090 S	Medium	Negligible	Neutral	None	Negligible	Neutral
Allt Chriochaidh	A9 1100 S	Low	Negligible	Neutral	None	Negligible	Neutral
Allt Chriochaidh	A9 1100	Low	Negligible	Neutral	None	Negligible	Neutral
Caochan Ruadh	A9 1100 C70	Low	Negligible	Neutral	None	Negligible	Neutral
Ballinluig Burn	A9 1110 C10	Low	Negligible	Neutral	None	Negligible	Neutral
Allt na Criche (Lynwilg)	A9 1130	High	Negligible	Neutral	None	Negligible	Neutral
Loch Puladdern	A9 1150 C7	Low	Moderate	Slight	None	Moderate	Slight
Unnamed Drain	A9 1150 C92	High	Negligible	Neutral	None	Negligible	Neutral
Aviemore Burn	A9 1150 C95	High	Moderate	Moderate / Large	See Floodplain assessment		
The Shieling / Easter Aviemore Burn	A9 1160 C14	Low	Moderate	Slight	See Floodplain assessment		
Unnamed Drain	A9 1170 C4	Low	Negligible	Neutral	None	Negligible	Neutral
Unnamed Drain	A9 1170 C6	Low	Negligible	Neutral	None	Negligible	Neutral
Unnamed Drain	A9 1170 C6 S	Low	Negligible	Neutral	None	Negligible	Neutral
Allt na Criche (Granish)	A9 1170 C12 S	Very High	Negligible	Neutral	See Floodplain assessment		
Allt na Criche (Granish)	A9 1170 C12	Very High	Major	Very Large	See Floodplain assessment		
Avielochan Burn	A9 1170 C20	High	Moderate	Moderate / Large	See Floodplain assessment		
Avielochan Burn	A9 1170 C20 S	High	Negligible	Neutral	See Floodplain assessment		
Avielochan Burn North	A9 1170 C23	High	Moderate	Moderate / Large	See Floodplain assessment		
Unnamed Drain	Drain 8	Low	Negligible	Neutral	None	Negligible	Neutral

Watercourse	Proposed Structure ID	Sensitivity	Potential Impact		Proposed mitigation	Residual Impact	
			Magnitude	Significance		Magnitude	Significance
Allt Cnapach	A9 1170 C50	High	Moderate	Moderate / Large	None	Negligible	Neutral
Allt Cnapach	A9 1170 C50 S	High	Negligible	Neutral	None	Negligible	Neutral
Unnamed Drain	A9 1170 C53	Low	Negligible	Neutral	None	Negligible	Neutral
Unnamed Drain	Drain 9	Low	Negligible	Neutral	None	Negligible	Neutral
Unnamed Drain	Drain 10	Low	Negligible	Neutral	None	Negligible	Neutral
Feith Mhor	A9 1170 C75 S	High	Negligible	Neutral	See Floodplain assessment		
Feith Mhor	A9 1170 C75	High	Moderate	Moderate / Large	See Floodplain assessment		
Unnamed Drain	A9 1170 C77	High	Negligible	Neutral	See Floodplain assessment		
Unnamed Drain	A9 1170 C77 S	High	Negligible	Neutral	See Floodplain assessment		
Unnamed Drain	Drain 14	Low	Negligible	Neutral	See Floodplain assessment		
Unnamed Drain	Drain 14 S	Low	Negligible	Neutral	See Floodplain assessment		
Unnamed Drain	A9 1170 C81	High	Negligible	Neutral	None	Negligible	Neutral
Unnamed Drain	A9 1170 C81 S	High	Negligible	Neutral	None	Negligible	Neutral
Unnamed Drain	Drain 16	High	Negligible	Neutral	None	Negligible	Neutral
River Dulnain	A9 1190	Medium	Negligible	Neutral	None	Negligible	Neutral
Allt nan Ceatharnach	A9 1200	Medium	Negligible	Neutral	None	Negligible	Neutral
Unnamed Drain	Drain 18	Medium	Negligible	Neutral	None	Negligible	Neutral
Unnamed tributary of Slochd Mhuic	A9 1210 C39	Low	Moderate	Slight	None	Negligible	Neutral
Slochd Mhuic	A9 1210 C46	Low	Moderate	Slight	None	Negligible	Neutral

8.2 Floodplain Assessments

8.2.1 The proposed mitigation of a flood bund at Allt na Criche (Granish), storage upstream of the A9 at Feith Mhor and raised right bank at Bogbain are included as embedded mitigation within the proposed scheme as outlined in Table 8-2. This embedded mitigation within the scheme has been proposed through discussion with landowners and land will be safeguarded for mitigation.

8.2.2 The residual risk associated with the Proposed Scheme are given in Table 8-2.

Table 8-2: Residual Risk – Floodplain Assessment

Floodplain	Receptors	Sensitivity	No Mitigation		Proposed Mitigation	With Mitigation	
			Magnitude	Significance		Magnitude	Significance
Allt an Fhearna / Loch Alvie	A9	Very High	Negligible	Neutral	None, the increased flood depth associated with the SuDS access track is to the woodland area which is comprised of ancient woodland and SSSI designation. The only technical viable solution to reduce flood depths is to provide compensatory storage which would result in a loss of woodland and SSSI encroachment. Due to the potential detrimental impact on the environment, mitigation is proposed through de facto online storage behind the access track which increases flood depths in an area of riparian woodland. No ecological or landscape concern has been identified by the relevant environmental specialists	Negligible	Neutral
	Access Road on North East shore of Loch Alvie	Medium	Negligible	Neutral		Negligible	Neutral
	SuDS Access Road and agricultural land / woodland	Medium	Moderate	Moderate		Moderate	Moderate
	B9152	High	Negligible	Neutral		Negligible	Neutral
	Residential & Non Residential Properties	High	Negligible	Neutral		Negligible	Neutral
Allt na Criche (Lynwilg)	A9	Very High	Negligible	Neutral	None	Negligible	Neutral
	Agricultural land	Medium	Negligible	Neutral		Negligible	Neutral
	Grassland	Low	Negligible	Neutral		Negligible	Neutral
	B9152	High	Negligible	Neutral		Negligible	Neutral
	Highland Main Line railway	Very High	Negligible	Neutral		Negligible	Neutral
	A9	Very High	Negligible	Neutral	None	Negligible	Neutral

Floodplain	Receptors	Sensitivity	No Mitigation		Proposed Mitigation	With Mitigation	
			Magnitude	Significance		Magnitude	Significance
Aviemore South	Grassland area between the existing A9 and Carn Elrig, north of DS-WC-014.	Low	Negligible	Neutral		Negligible	Neutral
	Aviemore Burn downstream of DS-WC-014, residential properties.	High	Negligible	Neutral		Negligible	Neutral
	Residential Properties at Strathspey Avenue	High	Negligible	Neutral		Negligible	Neutral
	Aviemore Burn at Strathspey Avenue	High	Negligible	Neutral		Negligible	Neutral
Aviemore North Easter Shieling	A9	Very High	Negligible	Neutral	None	Negligible	Neutral
	Woodland and Scrub	Low	Negligible	Neutral		Negligible	Neutral
Allt na Criche (Granish)	Forestry downstream of DS-WC-022	Medium	Major Beneficial	Large Benefit	Approximately 115m long bund along the right bank of the bifurcation channel of between 0.5 and 1m in height. The mitigation measure eliminates the flooding of A9 and compensates for the lost 0.5% AEP floodplain storage by increasing the depth of flood water west of the A9.	Major Beneficial	Large Benefit
	Mixed woodland and rough grassland west of the A9 and north of the bifurcation channel	Low[1]	Major	Large		Major	Slight
	Rough grassland west of the A9 and south of the bifurcation channel	Medium	Major	Large		Major Beneficial	Large / Very Large Benefit
	B9152 road to the east of Granish	High	Minor Beneficial	Slight / Moderate Benefit		Minor Beneficial	Slight / Moderate Benefit
	Non-coniferous woodland downstream of Granish underpass	Low	Moderate	Slight		Negligible	Neutral
	B9152 north of Granish Farm.	High	Negligible	Neutral		Minor Beneficial	Slight / Moderate Benefit

Floodplain	Receptors	Sensitivity	No Mitigation		Proposed Mitigation	With Mitigation	
			Magnitude	Significance		Magnitude	Significance
	Highland Main Line railway downstream of the B9152	Very High	Major Beneficial	Very Large Benefit	1 The sensitivity of the receptor west of the A9 has been reduced to Low with mitigation to reflect that this area is used for upstream flood displacement.	Major Beneficial	Very Large Benefit
Avielochan	A95	Very High	Major Beneficial	Very Large Benefit	None	Major Beneficial	Very Large Benefit
	Forestry Commission Land	Medium	Minor Beneficial	Slight Benefit		Minor Beneficial	Slight Benefit
	Grassland and scrub	Low	Minor Beneficial	Neutral		Minor Beneficial	Neutral
	Avie Lochan non-residential lochside properties	High	Minor Beneficial	Slight / Moderate Benefit		Minor Beneficial	Slight / Moderate Benefit
	Highland Mainline Railway	Very High	Negligible	Neutral		Negligible	Neutral
Feith Mhor	A9	Very High	Negligible	Neutral	Retaining water upstream of the A9 by blocking off the flow path between the southern and northern channel. Ground levels of the base of the proposed storage area have been set to 258.5 mAOD to provide additional storage 1 The sensitivity of the receptor west of the A9 has been reduced to Low with mitigation to reflect that this area is now mitigation.	Negligible	Neutral
	Forestry Commission Land Upstream of the A9 DS-WC-039	Medium/ Low[1]	Negligible	Neutral		Major	Slight / Moderate
	Forestry Commission Land Upstream of the DS-WC-036 A9 Crossing	Medium/ Low[1]	Major	Large		Major	Slight / Moderate
	Forestry Commission Land Between the Highland Main Line railway and A9	Medium	Moderate	Moderate		Negligible	Neutral
	Highland Main Line railway embankment	Very High	Moderate	Large/ Very Large		Negligible	Neutral
	Downstream of the Highland Railway	Medium	Minor	Slight		Minor	Slight
River Dulnain	Agricultural Land	Medium	Negligible	Neutral	None	Negligible	Neutral

Floodplain	Receptors	Sensitivity	No Mitigation		Proposed Mitigation	With Mitigation	
			Magnitude	Significance		Magnitude	Significance
Allt nan Ceatharnach	Agricultural Land	Medium	Negligible	Neutral	None	Negligible	Neutral
Allt Cnapach	Highland Main Line railway	Very High	Negligible	Neutral	None	Negligible	Neutral
	Grassland	Low	Minor	Neutral		Minor	Neutral
Bogbain Burn	Grassland and Scrub	Low	Minor	Neutral	Mitigation involves an increase in height (410mm) to the right bank upstream of the railway crossing (313.20mAOD compared to 312.79mAOD) to control the volume of spill onto the floodplain between the A9 and the railway.	Minor	Neutral
	Highland Main Line railway	Very High	Minor	Moderate		Negligible	Neutral
	A938	Very High	Moderate	Large		Negligible	Neutral
Slochd Mhuic	Grassland and Scrub	Low	Minor	Neutral	None	Minor	Neutral

9. Conclusion

9.1.1 The PFRA concluded that the focus of the FRA should be on the potential impact of new or replacement watercourse crossings and the loss or displacement of floodplain storage on the flood risk of sensitive receptors (including the A9 as a receptor of Very High sensitivity).

9.1.2 A methodology has been developed to classify the sensitivity of a receptor, the magnitude of the impact and so assess the significance of the impact. The method was used in the PFRA to screen for significant impacts which have been assessed in more detail in the FRA.

9.1.3 The results of the impact assessment given in Section 6 show that the Proposed Scheme will have at least a slight impact on the flood risk associated with 16 watercourses and 10 floodplain locations.

9.1.4 A more detailed assessment of the watercourse crossings established that mitigation measures are not required at Allt na Criche (Lynwilg), Aviemore South, The Shieling/ Aviemore Burn North, Avielochan Burn, River Dulnain, Allt nan Ceatharnach, Allt Cnapach and Slochd Mhuic. The impacts in the vicinity of Allt an Fhearna and Loch Alvie, Allt na Criche (Granish), Feith Mhor and Bogbain Burn are addressed as a part of the floodplain assessments at those locations.

9.1.5 At Allt an Fhearna and Loch Alvie there is loss of floodplain and modification of the hydraulic links between the floodplains due to barrier to flow from the raised SuDS access road. Providing direct compensation storage would require excavation of Ancient Woodland and SSSI land adjacent to the Allt an Fhearna and was therefore rejected given the indirect impacts and the lack of high sensitive flood risk receptors in this area. The defacto online storage behind the raised access track is considered to have the least potential detrimental impact on the environment and additional flood risk mitigation is not proposed at this location. The increase in flood water level is experienced in an area of riparian woodland and no ecological or landscape concern has been identified by the relevant environmental specialists.

9.1.6 The Proposed Scheme crosses the floodplain at Feith Mhor leading to a displacement of floodplain storage. Retaining water upstream of the A9 requires blocking off the flow path between the southern and northern channel. By blocking this flow route, water accumulates in a natural low point located between the two culvert crossings, thus reducing the amount of flow passing beneath the A9 and reducing flood levels between the A9 and the railway. Additionally, ground levels of the base of the proposed storage area have been set to 258.5 mAOD to provide additional storage. Mitigation measures at the site have been designed to ensure that water levels are within 10 mm of baseline conditions between the A9 and the railway for all AEP events. Water levels do increase upstream of the A9, however, there are no sensitive receptors in this area and these increases are considered to be offset by the benefits of ensuring there is a neutral impact to the railway asset.

9.1.7 The proposed scheme at Granish is to raise the right bank of the bifurcation channel by a height of approximately 0.5m over the length of approximately 115m. The embankment eliminates the flooding of the A9 and also ensures that there is a neutral or better impact on downstream receptors.

9.1.8 The GSJ and auxillary junction to the U2400 have been moved as far off the floodplain of Bogbain Burn as possible resulting in the connection to the U2400 unclassified road on the southbound compact loop requiring a Departure from DMRB standards. The

scheme displaces water onto the floodplain between the A938 and the railway leading to increased flood depths on the A938 in the underpass under the railway. The mitigation involves an increase in height (410mm) to the right bank upstream of the railway crossing (313.20 mAOD) compared to 312.79 mAOD) to control the volume of spill onto the floodplain between the A9 and the railway. This mitigation leads to increased flows in the burn between the railway culvert and the A938 which dissipate downstream of the A938. The impact of increasing flows, water levels and velocities in the vicinity of the railway culvert has been assessed in terms of geomorphological impact. There is some scour evident on the left bank downstream of the railway bridge on a bend, which may be slightly exacerbated if more water is kept in the channel through the mitigation measures put in place. The track along the northern (away from railway) side of the watercourse and the watercourse have been included in the CPO boundary such that scour protection could be installed should it be required following the more detailed assessment and detailed design.

9.1.9 With the implementation of mitigation set out in Section 7, no significant impacts from the Proposed Scheme have been identified for almost all potential receptors, the exception being increased flood risk at the Allt an Fhearna watercourse.

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