Appendix A13.2 Flood Risk Assessment

Contents

A13.2: Flood Risk Assessment

1 Introduction

Purpose

1.1 This appendix provides detailed information on the Flood Risk Assessment (FRA) relevant to Chapter 13 (Road Drainage and the Water Environment).

1.2 The A96 Dualling Inverness to Nairn (including Nairn Bypass) Scheme comprises the provision of approximately 31km of new dual carriageway, achieved through offline construction (hereafter referred to as the proposed Scheme). The existing A96 single carriageway would be de-trunked and reclassified as a local road to maintain local access. Due to the size and layout of the proposed Scheme, there are a number of flood risks, which may place the road and its users at risk of flooding. The proposed Scheme also has the potential to impact the level of flood risk elsewhere.

1.3 A FRA is required to demonstrate that the proposed Scheme design meets the requirements of national and local planning policy and is considered appropriate from a flood risk perspective. As well as fluvial and coastal flooding, the FRA also considers flood risk from other sources, including surface water (pluvial), sewer and water mains, groundwater, land drainage and artificial drainage and failure of water retaining infrastructure.

1.4 The guiding principle adopted with regard to flood risk and flood risk management is that the proposed Scheme is developed such that the impact on the flood risk is neutral, taking cognisance of environmental, engineering and economic constraints. Any development could alter existing processes, and the focus of the measurement of impact is on those sensitive receptors, which are hydrologically impacted by the proposed Scheme. These sensitive receptors include the proposed Scheme itself, properties, infrastructure, and ecologically important areas. Higher value agricultural land has also been considered but given the location of the proposed Scheme some impact is unavoidable.

1.5 The purpose of the FRA is to document the assessments undertaken to investigate baseline flood risk, identify potential flood risk impacts associated with the proposed Scheme and, where necessary, develop appropriate flood mitigation/flood management measures.

Context

1.6 The proposed Scheme starts east of the roundabout for Inverness Retail and Business Park, approximately 850m east of Raigmore Interchange, and continues approximately 31km east and ends at Hardmuir, 3.5km to the east of Auldearn. The study area runs between the Moray Firth to the north and the rolling Drummossie Muir hills to the south.

1.7 The proposed Scheme would also incorporate:

- 22 watercourse crossings;
- provision of shared use paths suitable for Non-Motorised Users (NMU), approximately 30km in length;
- six grade separated junctions;
- 24 principal structures including a crossing of the River Nairn and three structures over the Aberdeen to Inverness Railway Line;
- local road diversions and provision of new private means of access; and
- utility diversions including major diversions for SGN (previously Scotia Gas Network) and CLH Pipeline Systems (CLH-PS).

1.8 The land within the vicinity of the existing A96 Aberdeen – Inverness Trunk Road is generally flat and low-lying in nature. This is also the case moving in a northerly direction from the carriageway, towards the coastline of the Moray Firth. To the south of the existing A96, the land gradually rises towards Drummossie Muir.

1.9 The land within the study area is principally agricultural and comprises open fields used for both grazing and crops. However, there are several industrial estates, communities and settlements located within the study area that the proposed Scheme could affect.

1.10 Parts of the existing and proposed A96 route corridor are at risk of flooding (according to SEPA flood maps) and the proposed Scheme has the potential to alter baseline hydrological regimes and flood mechanisms, which may result in undesirable ecological, social and economic impacts. Flood risk therefore presents one of many challenges to the proposed Scheme.

Approach

1.11 The FRA has been developed with consideration of the following requirements:

- the Design Manual for Roads and Bridges (DMRB) Volume 11, Section 3, Part 10 (HD45/09) (Highways Agency, Scottish Government, Welsh Assembly Government and The Department for Regional Development Northern Ireland 2009a)
- Scottish Environment Protection Agency (SEPA) Technical Flood Risk Guidance for Stakeholders (SEPA 2015b); and
- Scottish Planning Policy (SPP) (Scottish Government 2014).

1.12 SPP provides a statement on the Scottish Government's policy on nationally important land use planning issues such as flood risk. One of the key principles of the guidance is to avoid development in areas at risk of flooding. Given the scale of the proposed Scheme, it is unavoidable to develop the proposed Scheme outside of those areas currently at risk of flooding. Consequently, SPP recognises that essential infrastructure, such as the A96 Aberdeen – Inverness Trunk Road, can be built in areas considered to be at risk of flooding. In accordance with SEPA, areas of high risk of flooding are defined as those with 0.5% Annual Exceedance Probability (AEP) (200-year). Developments will only be permitted in areas at high risk if it is designed and constructed to remain operational during times of flood and not impede water flow.

1.13 In accordance with the DMRB, the proposed Scheme development is currently at DMRB Stage 3 'Detailed Assessment'. Table 1 illustrates the development of the FRA within the context of the DMRB staged assessment. It also illustrates the links between how the DMRB staged assessment requirements relate to SEPA's technical requirements, as a statutory consultee to planning authorities, where a risk of flooding exists.

1.14 As shown in Table 1, there is considerable agreement between the DMRB assessment requirements and FRA technical requirements recommended by SEPA.

1.15 The following SEPA requirements have been considered for this FRA:

- assess the proposed Scheme as a sensitive receptor to flood risk;
- assess the proposed Scheme as a potential source of change in flood risk to sensitive receptors;
- assessment of the existing flood risk should include establishing the flood mechanism;
- assess all sources of flood risk; and
- design locally appropriate flood mitigation measures to achieve acceptable level of change in flood risk.

Table 1: DMRB Assessment Stages

Stage	Assessment	To Support	Alignment with the requirements of SEPA Technical Flood Risk Guidance for Stakeholders
DMRB 1 Scoping Assessment	The 'Scoping Assessment' uses readily available information to highlight potential sources of flood risk and identify and establish areas and flood sources that require further detailed assessment. This includes high-risk sources of flooding including rivers, small watercourses and existing A96 water crossings.	Scoping of DMRB 2 'Simple Assessment'.	Identification of sources and types of flooding.

Stage	Assessment	To Support	Alignment with the requirements of SEPA Technical Flood Risk Guidance for Stakeholders
DMRB 2 Simple Assessment	The 'Simple Assessment' aims to assess and compare flood hazards between alternative alignment route options by providing a description of the baseline conditions, identifying receptors sensitive to flooding, assessing the impacts of the route options and assessing the importance of the impact i.e. magnitude of the impact against the sensitivity of the receptor.	Selection of a preferred route option and supporting the 'Stage 2 Environmental Report'.	Assessment of design flows. Identification of the plan extents of flooding. Describe the proposed structure/changes and impacts on predicted water level. Assessment of climate change impacts.
DMRB 3 Detailed Assessment	'Detailed Assessment' will focus on potential effects of the preferred route option and where necessary consider appropriate flood mitigation measures to achieve a neutral flood risk.	Alignment design and supporting the 'Environmental Statement'.	Provide details of proposed flood mitigation measures. Provide an assessment of any displaced flood water on sensitive receptors. Provide reference to any other impact on the river environment.

Flooding Sources

1.16 Consideration has been given to the following sources of flooding within the proposed Scheme area:

- **Fluvial:** Flooding originating from a watercourse. See Section 3 (Fluvial Flood Risk).
- **Surface Water (pluvial):** Flooding resulting from high intensity rainfall saturating the drainage system (either natural or man-made) with excess water travelling overland and ponding in local topographic depressions. This also includes consideration of the impact of the new road drainage system on surface water flood risk. See Section 4 (Surface Water Flood Risk).
- **Sewer and Water Mains:** Flooding due to surcharging of man-made drainage systems. A review has been undertaken to identify where sewers and water mains are located local to the proposed Scheme. The proposed Scheme would not result in additional flow being discharged into the existing sewer or mains network, therefore the risk of flooding is unlikely to change and consequently this source of flooding has not been considered further.
- **Groundwater:** Flooding due to elevated ground water table. See Section 5 (Groundwater Flood Risk).
- **Land drains and artificial drainage:** Failure of land drainage infrastructure such as drains, channels and outflow pipes is most commonly the result of obstructions, poor maintenance and/or blockages. For the proposed Scheme, a like for like replacement would be undertaken where this infrastructure is affected. Therefore, there is no change in flood risk and this has not been considered further.
- **Failure of water retaining infrastructure:** Flooding due to the collapse and/or failure of man-made water retaining feature such as a dam, water supply reservoirs, canals, flood defences, underground conduits, and water treatment tanks or pumping stations. There are no known man-made water retaining infrastructure structures located within the area; hence this risk is considered to be low and has not been considered further.
- **Coastal:** Flooding originating from the sea where water levels exceed the normal tidal range and flood onto the low-lying areas that define the coastline. The proposed Scheme does not traverse areas considered to be at risk of coastal flooding and would not increase the risk of coastal flooding. Therefore this risk has not been considered further.
- **Construction risks:** Construction phase risks are outlined in Section 6 (Construction Flood Risks).

2 Study Area

Location

2.1 With the exception of the more urban areas around Culloden, Balloch and Nairn, the majority of land within the study area is characterised by a farming landscape interspersed with forests and small urban settlements. The route crosses the hydrological catchment area relating to the River Nairn.

2.2 The study area is situated within generally flat terrain with occasional high points along the route. The corridor encompasses a gently undulating topography of the Moray Lowlands.

2.3 The study area is shown on Diagram 1. The extent of the study area is indicated by the red boundary.

Flood Risk

2.4 The study area for flood risk principally comprises the land adjacent to the proposed Scheme; however, the impacts of the proposed Scheme on flood risk may be felt a significant distance away from the proposed Scheme itself. Consequently, the study area extends to include all areas where flood risk is altered as a result of the proposed works associated with the proposed Scheme. This would include any watercourse, surface water and groundwater catchments that may be impacted due to the proposed Scheme.

2.5 The proposed Scheme crosses six principal watercourses and 16 minor watercourses, as listed in Annex A13.2.A (Watercourses in the Study Area).

History of Flooding

2.6 The Highland Council has provided a history of flooding records local to the study area. Records that lie within 100m of the proposed Scheme have been listed in Table 2 and shown on Diagram 1.

Table 2 : History of flooding

Source	Description
Map 1: Inverness to Newton	
Fluvial	Roadside drainage was damaged due to water flowing down the embankment in Stratton on 20 January 2012.
Fluvial	Significant flooding occurred due to pinch points on Kenneth's Black Well in Milton of Culloden on 8 September 2002.
Fluvial	Cairnlaw Burn reported to have washed away part of the railway line in Milton.
Fluvial	Two incidences occurred in Milton of Culloden where gardens and fields flooded.
Fluvial	The existing culvert along Fiddler's Burn surcharged resulting in flooding to the field upstream.
Fluvial	Two incidences occurred in Tornagrain Wood where the ditch and forest flooded.
Surface water	One incidence occurred on 7 September 2002 in Culloden where extreme localised rainfall flooded roads, gardens, houses and commercial premises.
Surface water	One incidence in Milton where ponding in west of field occurred due to field drains surcharging and flash (pluvial) flooding .
Surface water	There is a record of occasional surface water runoff flooding the existing A96 in Kerrowaird.
Groundwater	There is a record of a high water table in Allanfearn, which has caused flooding with heavy rainfall.
Unknown	An incidence of flooding from an unknown source within Newton of Petty.
Map 2: Newton to Gollanfield	
Fluvial	Flood risk within Tornagrain Wood has been advised by The Highland Council. This record lies along the proposed Scheme.
Fluvial	Within Drumine, it is recorded that the watercourse cannot cope with the existing A96 drainage.
Fluvial	Flood risk is advised within the area of Culblair.
Surface water	Residents stated that flooding occurred in Gollanfield three years ago (2013).
Groundwater	Two incidences occurred within Milton of Gollanfield, where the ground was wet and unable to drain away.
Groundwater	There is a record of a high water table in the area of Gollanfield.

Source	Description
Unknown	Two incidences from an unknown source occurred within Mid Coul.
Map 3: Gollanfield to Nairn	
Fluvial	Two incidences occurred in Drumdivan, related to Alton Burn flooding.
Fluvial	One incidence occurred in Broadley where fields and a property flooded from the River Nairn.
Surface water	One incidence of surface water flooding occurred in Drumdivan.
Surface water	The existing A96 road has flooded due to a blocked filter drain in Blackcastle.
Ground water	There is a spring near a property, which has caused flooding in Blackcastle.
Groundwater	There is a history of boggy land within the woodland of Crook.
Map 4: Nairn to Auldearn	
Fluvial	There are three incidences along Auldearn Burn, downstream of Mill of Boath.
Groundwater	Two incidences regarding a seasonal spring, which ponds to about 4ft of water in the winter within the area of Courage.
Groundwater	There is a history of boggy land within Hardmuir.
Unknown	Flooding from unknown source to Mill of Boath in Auldearn on 1 July 1997.

Infrastructure

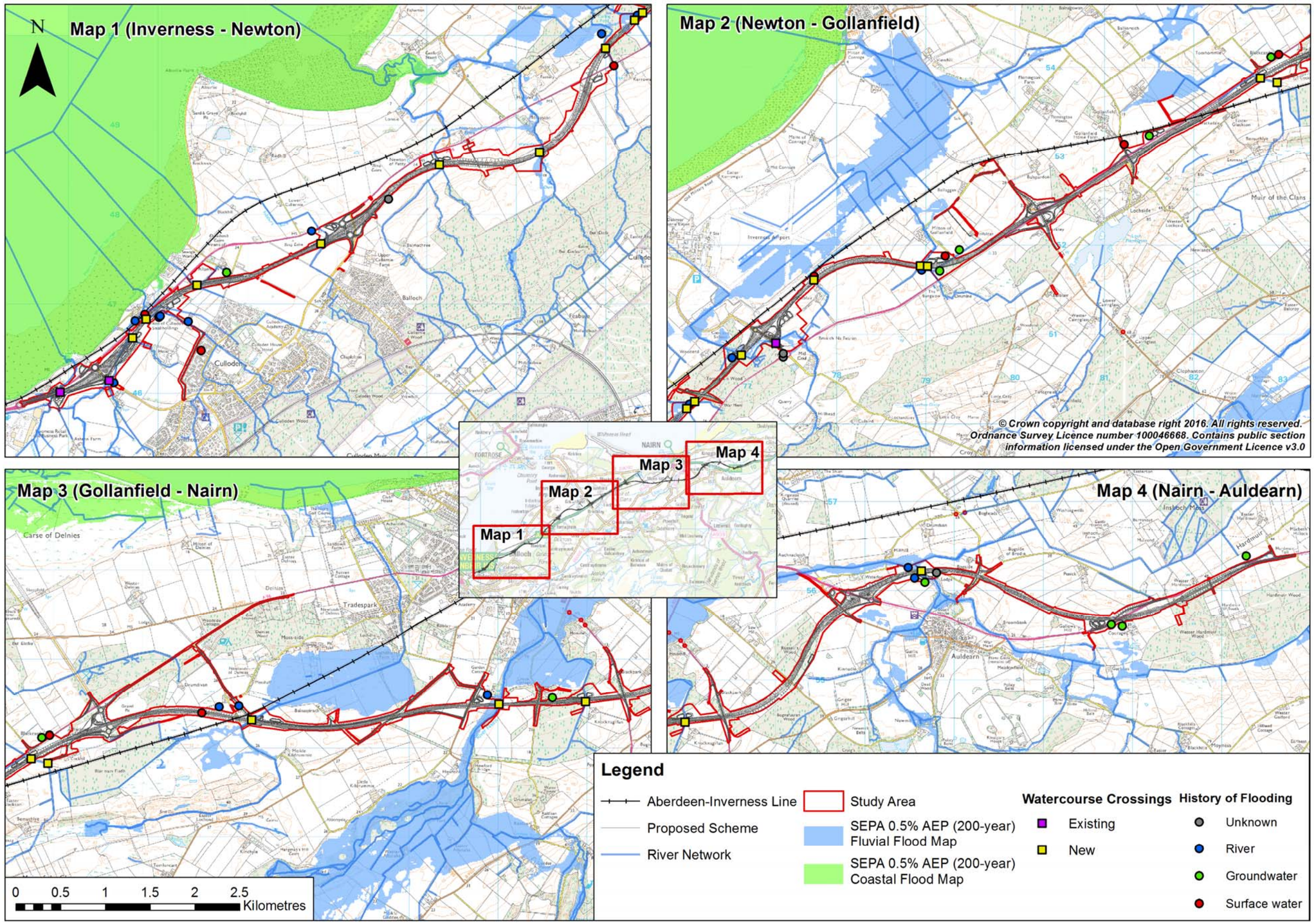
2.7 The Aberdeen to Inverness Railway Line, within the study area, is predominantly a single track rail line, with a short section of double track line at Nairn Station. The Aberdeen to Inverness Railway Line is in close proximity to the proposed Scheme in several locations and passes under the dual carriageway at Gollanfield and under the dual carriageway and a side road at Moss-Side.

Environmental Designations

2.8 There are international and national designations within the study area, these are outlined below. Refer to Chapter 11 (Habitats and Biodiversity) for further details.

- Two Sites of Special Scientific Interest (SSSI):
  - Longman and Castle Stuart Bays; and
  - Kildrummie Kames.
- Two Special Protection Areas (SPA):
  - Loch Flemington; and
  - Inner Moray Firth.

Diagram 1: Study Area



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3 Fluvial Flood Risk

Categorisation of Watercourse Significance

3.1 The methodology to evaluate fluvial flood risk varies according to the significance of the watercourse. Principal watercourses are rivers, which have the potential to pose the most significant flood risks within the study area, whereas minor watercourses are those with localised or less significant flood risk potential.

3.2 Table A1 (Annex A13.2.A: Watercourses in the Study Area) lists all the watercourses within the study area as having potential to be impacted by the proposed Scheme. This includes six principal watercourses and 16 minor watercourses.

Principal Watercourses

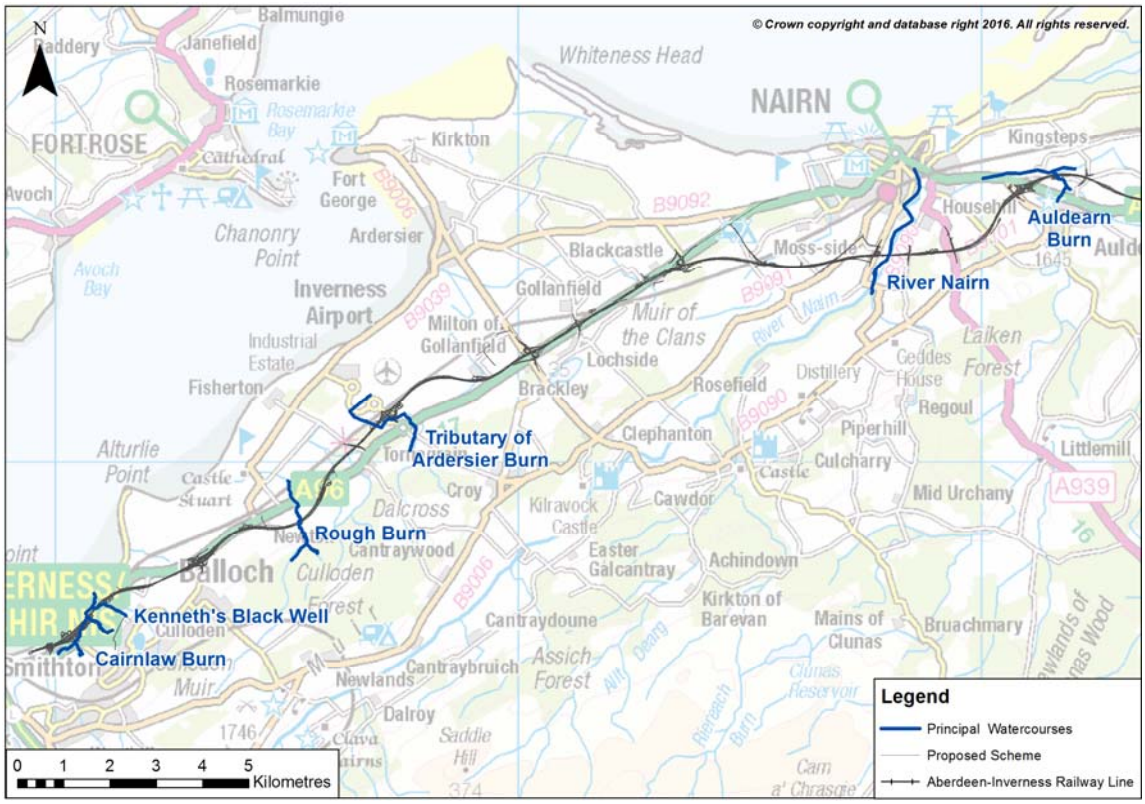
3.3 Due to the size, significance and hydraulic complexity, hydraulic numerical modelling has been undertaken on the following watercourses to develop an understanding of fluvial flood risk for both the baseline, 'with-scheme' and 'with-mitigation' scenarios:

- Cairnlaw Burn;
- Kenneth's Black Well;
- Tributary of Ardersier Burn;
- Rough Burn;
- River Nairn; and
- Auldearn Burn.

3.4 As Kenneth's Black Well is a tributary to Cairnlaw Burn, they have been included in one numerical model.

3.5 Diagram 2 shows the location of these principal watercourses.

Diagram 2: Location of Principal Watercourses



3.6 Five numerical models have been developed to assess the principal watercourses. Each of the models adopt a linked one-dimensional (1D)/two-dimensional (2D) technique, where the river channel is represented as a 1D component using Flood Modeller software and it is linked dynamically to the flood plain, which is represented in 2D, using TUFLOW software.

3.7 The models have been used to simulate the 0.5% AEP (200-year) design event including an allowance for climate change, with the predicted peak water level within the modelled river reach extracted and comparison made between the baseline and 'with-scheme' case.

3.8 The predicted peak flow associated with the 0.5% AEP (200-year) event has been increased by 20% to allow for climate change impacts, which is commensurate with SEPA recommendations (SEPA 2015b).

3.9 To assess the impact of the proposed Scheme on fluvial flood risk, the baseline models have been modified to represent the route of the proposed Scheme. The updates are broadly categorised as follows:

- representation of the proposed Scheme alignment including embankment and cuttings on the existing ground topography;
- modifications to baseline channel structures - hydraulic structures in the river channel updated in their length and cross section according to the proposed Scheme; and
- inclusion of new river structures.

3.10 Table 3 illustrates the criteria used to define fluvial flood risk.

Table 3: Categorisation of difference in flood depths, principal watercourse assessment

Potential flood impact		Criteria	Flood risk
	Major Adverse	Results in loss of attribute and/or quality and integrity of the attribute.	Increase in peak flood level 0.5% AEP (200-year) > 100 mm
	Moderate Adverse	Results in effect on integrity of attribute, or loss of part of attribute.	Increase in peak flood level 0.5% AEP (200-year) 50 - 100 mm
	Minor Adverse	Results in some measurable change in attributes quality or vulnerability.	Increase in peak flood level 0.5% AEP (200-year) 10 - 50mm
	Negligible Adverse	Results in effect on attribute, but of insufficient magnitude to affect the use or integrity.	Increase in peak flood level 0.5% AEP (200-year) 1 – 10mm
	Negligible	Results in effect on attribute, but of insufficient magnitude to affect the use or integrity.	Negligible change in peak flood level 0.5% AEP (200-year) +/- 1 mm
	Negligible Beneficial	Results in effect on attribute, but of insufficient magnitude to affect the use or integrity.	Reduction in peak flood level 0.5% AEP (200-year) 1 – 10mm
	Minor Beneficial	Results in some beneficial effect on attribute or a reduced risk of negative effect occurring.	Reduction in peak flood level 0.5% AEP (200-year) 10 - 50mm
	Moderate Beneficial	Results in moderate improvement of attribute quality.	Reduction in peak flood level 0.5% AEP (200-year) 50 - 100mm
	Major Beneficial	Results in major improvement of attribute quality.	Reduction in peak flood level 0.5% AEP (200-year) >100mm

3.11 In the context of the DMRB Stage 3 design, it is considered that 'negligible' potential flood impact equates to 'neutral' impact. This also recognises that post DMRB Stage 3, further detailed design would be undertaken. Therefore, this FRA refers to the current outline design stage of DMRB Stage 3.

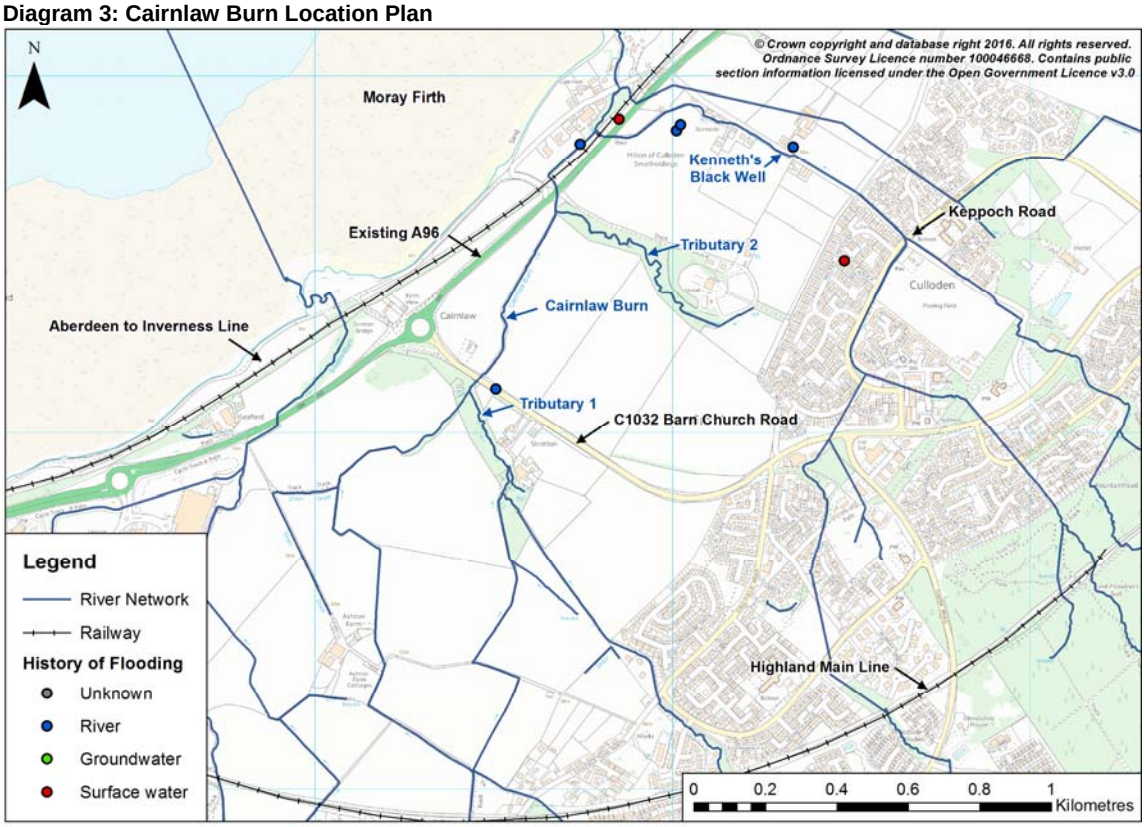
3.12 The following sections assess the flood risk for the baseline, 'with-scheme' and 'with-mitigation' scenarios for the 0.5% AEP (200-year) plus an allowance for climate change (+CC) design flood event. For this assessment baseline represents the existing situation, the 'with-scheme' scenario represents the initial design of the proposed Scheme, without any further mitigation and the 'with-mitigation' case represents the proposed Scheme with further mitigation included. For further information on the modelling results, refer to the hydraulic modelling reports in Annexes A13.2.B to A13.2.F.

3.13 This FRA makes reference to Surface Water Features (SWF) as defined within paragraph 13.1.4 of Chapter 13 (Road Drainage and the Water Environment). These have been identified as a result of their potential to be impacted by the proposed Scheme in relation to hydrology, flood risk, fluvial geomorphology or water quality.

Cairnlaw Burn (SWF03)

3.14 Cairnlaw Burn flows in a north-easterly direction, towards the Moray Firth, as shown on Diagram 3. Within the study area, there are three tributaries (Tributary 1, Tributary 2 and Kenneth's Black Well) each have been represented within the numerical model.

Diagram 3: Cairnlaw Burn Location Plan



3.15 The main reach of the Cairnlaw Burn rises to the south of Westhill at an approximate elevation of 170m. It passes through a moderately steep urbanised section around Cradlehall before passing under the Highland Main Line. Thereafter, the gradient lessens and the reach passes through farmland and under C1032 Barn Church Road before passing under the existing A96 and Aberdeen to Inverness Railway Line at Milton, where it joins the Moray Firth. The total catchment area is 12km^2 to the confluence with the estuary.

3.16 Tributary 1 joins the main reach just upstream of C1032 Barn Church Road. The headwaters are at a similar elevation to the main reach, and flows through an urbanised section between Westhill and Smithton before passing under the Highland Main Line and through agricultural land and woodland before reaching the confluence with the Cairnlaw Burn.

3.17 Tributary 2 is a short watercourse, rising near Caulfield Road on the northern edge of Culloden, fed by a combination of a natural spring and field drains. It meanders through woodland to the confluence with the Cairnlaw Burn just upstream of the crossing of the existing A96.

3.18 Kenneth's Black Well (SWF06) is a more significant watercourse, which has a number of tributaries, which all combine to the south of Keppoch Road. The headwaters of these tributaries rise at Culloden Muir, pass through Culloden Wood and through the urbanised areas of Culloden and the west of Smithton. Past development in these areas has introduced a number of culverts and realignments, which may have changed the historic connectivity. The area was subject to flooding in 2002 and 2011, which is being addressed through the Smithton and Culloden Flood Protection Scheme. This Flood Protection Scheme will address the flood risk in areas upstream of the interaction with the proposed Scheme. It should also reduce downstream flows in the lower section of Kenneth's Black Well,

however at this stage the benefits associated with the proposed Smithton and Culloden Flood Prevention Scheme have not be incorporated within this FRA. This approach has been followed as a precautionary measure so that the FRA considers a scenario where the proposed Flood Defence Scheme does not progress.

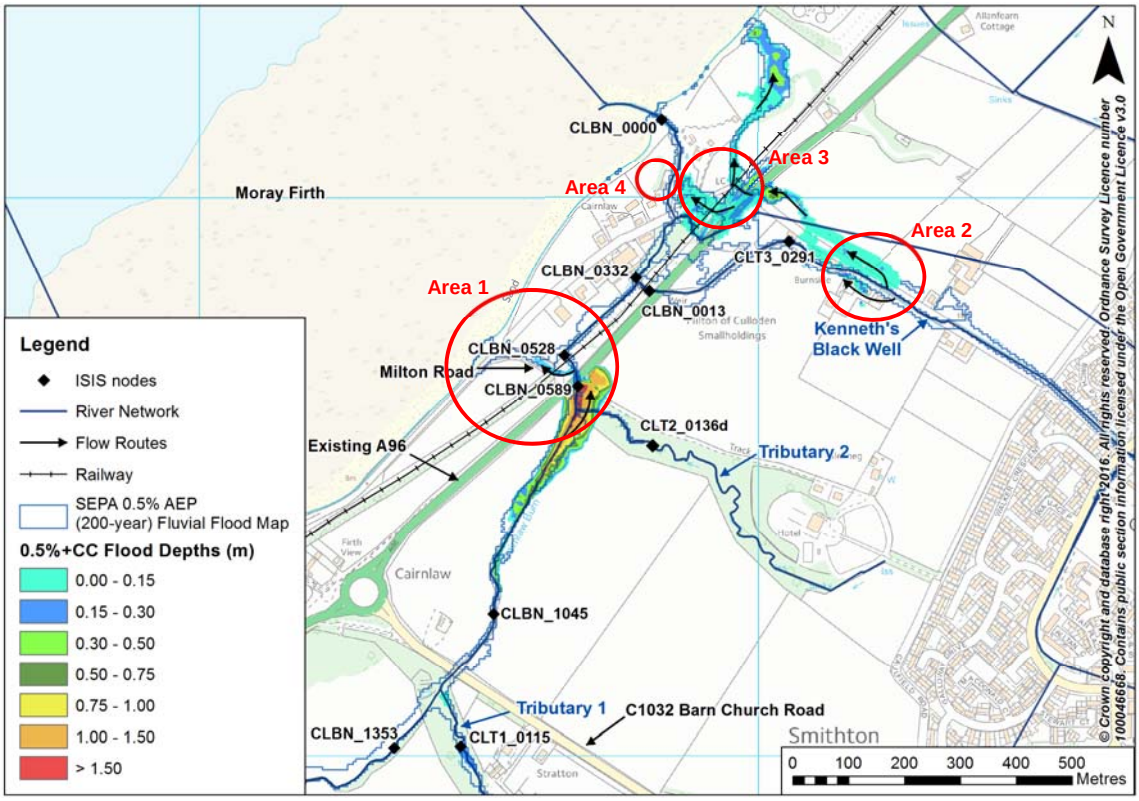
3.19 The history of flooding for this area has been provided by The Highland Council and the records are outlined below and shown on Diagram 3.

- Two incidences of surface water flooding have been recorded:
  - one event refers to ponding of water due to unmaintained field drains and flash flooding in close proximity to the Aberdeen to Inverness Railway Line; and
  - one event refers to extreme localised rainfall which caused roads, gardens, houses and commercial premises to flood within Culloden.
- Five incidences of fluvial flooding have been recorded:
  - two incidences refer to gardens and fields flooding along Kenneth's Black Well;
  - one event suggests that there are a number of pinch points along Kenneth's Black Well;
  - one incident refers to Cairnlaw Burn washing away part of the Aberdeen to Inverness Railway Line in a flood; and
  - one event suggests that roadside drainage along C1032 Barn Church Road was damaged from water flowing down a nearby embankment.

Baseline Flood Risk

3.20 As Carinlaw Burn has been identified as a principal watercourse, a hydraulic model was constructed in order to understand the baseline flood risk. The model includes the three tributaries that flow into the burn within the study area. The results of the modelling are shown on Diagram 4.

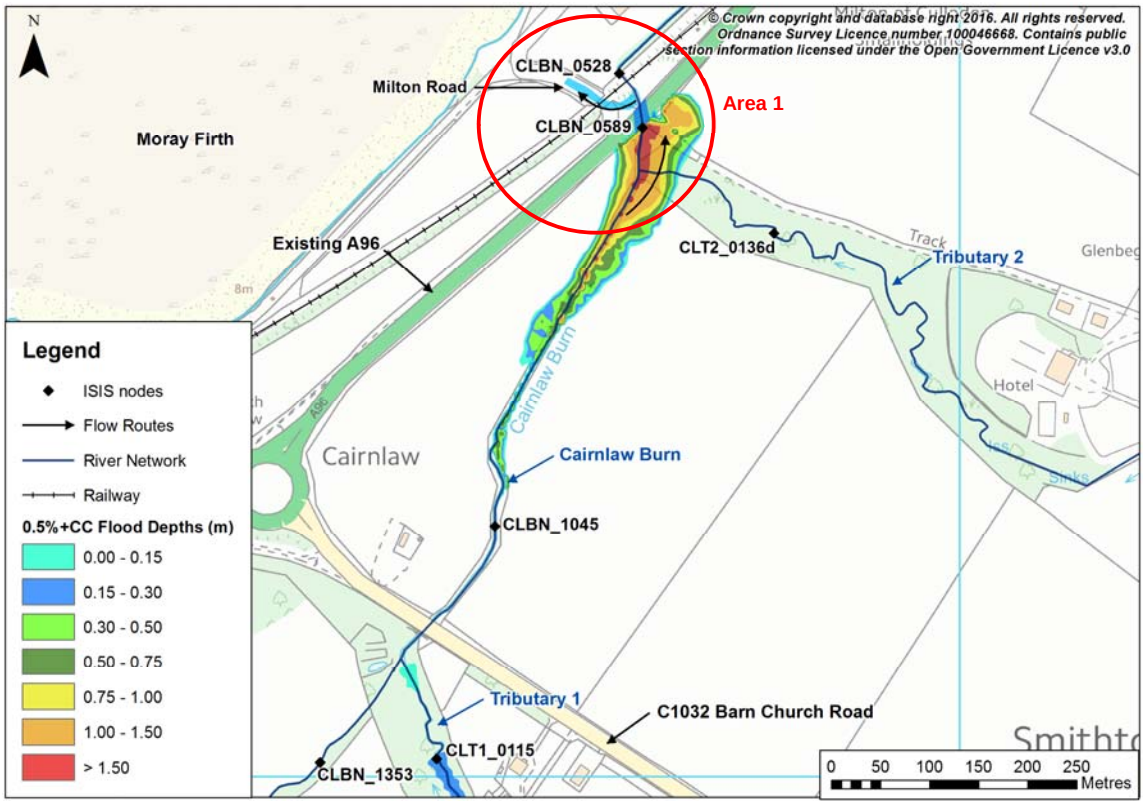
Diagram 4: Cairnlaw Burn Baseline



3.21 The model predicts that downstream of C1032 Barn Church Road, Cairnlaw Burn begins to overtop its banks during the 50% AEP (2-year) flood event due to restricted channel capacity. When the burn reaches the existing A96 culvert, water begins to back up due to the culvert constriction during the 10% AEP (10-year) flood event. At this location, highlighted as Area 1 on Diagram 4 (Model Node: CLBN_0589), there is an existing twin arch culvert, each culvert barrel is 1.5m wide and 1.1m high.

3.22 Diagram 5 shows the baseline flood risk at the existing A96 in more detail.

Diagram 5: Cairnlaw Burn Baseline (Area 1)



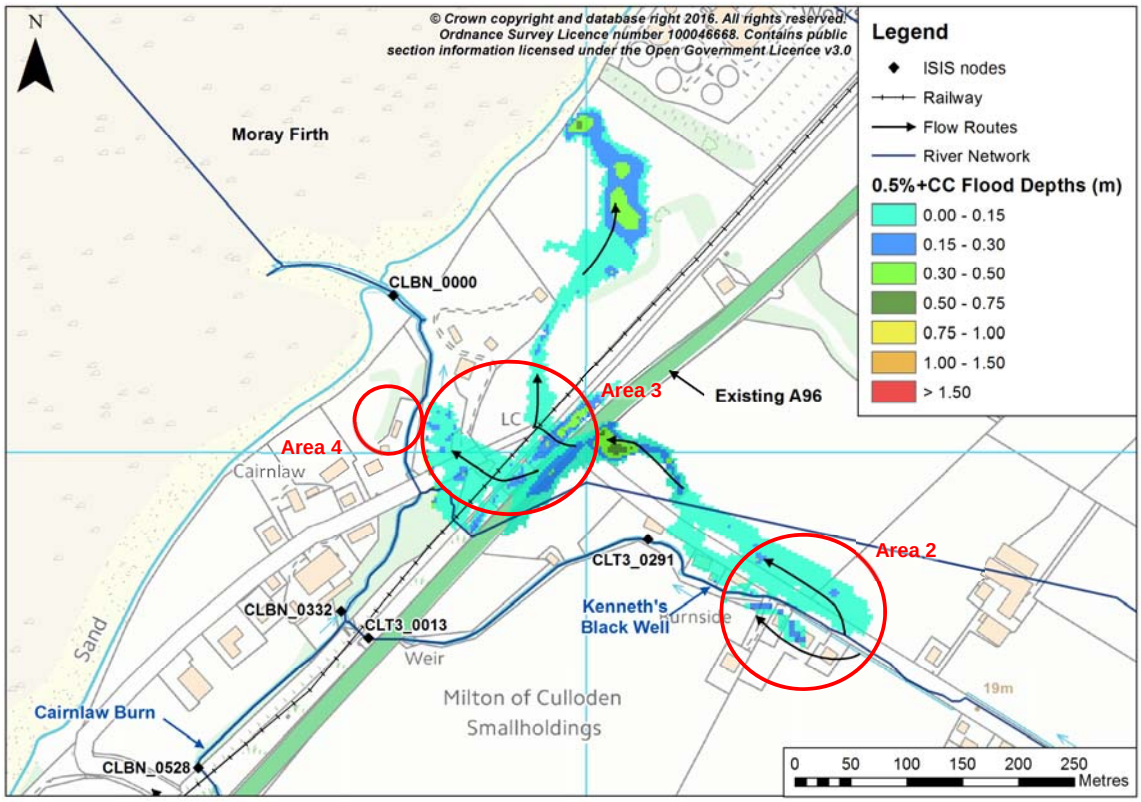
3.23 The twin arch culvert represents a hydraulic constraint and water overtops both the left and right bank. There are no flood sensitive receptors upstream of the existing A96 culvert, that lie within the modelled flood extent. The land in this location is a mixture of woodland and agricultural land. The culvert also causes water to back up and overtop the existing A96 (onset of flooding occurs during the 0.5% AEP (200-year flood event)). In addition, the railway culvert downstream of this point, becomes surcharged and results in water overtopping the left bank between the existing A96 and the Aberdeen to Inverness Railway Line (onset of flooding occurs during the 0.5% AEP (200-year)+CC design flood event).

3.24 Once water has overtopped the left bank, it flows down Milton Road and towards the Moray Firth.

3.25 The baseline flood risk associated with the tributaries of Cairnlaw Burn indicate that Tributaries 1 and 2 are considered to be a low flood risk. The design flood flow is contained within the wider river valley of Tributary 1 and no properties are affected. Tributary 2 remains completely in channel until its confluence with Cairnlaw Burn.

3.26 However, along Kenneth's Black Well, water overtops both the left bank and right bank. The area of flood risk is shown as Area 2 on Diagram 4 and shown in more detail on Diagram 6.

Diagram 6: Cairnlaw Burn Baseline (Areas 2, 3 and 4)



3.27 The model indicates that flooding associated with Kenneth's Black Well occurs due to the presence of culverted driveways providing access to local properties. The driveways cross the channel and restrict flows along the watercourse, resulting in elevated water level and flooding.

3.28 The flooding on the left bank results in flooding of residential properties before flood flows re-enter the watercourse approximately 70m downstream.

3.29 The flooding on the right bank flows overland across agricultural land towards the existing A96 (Area 3). At this location, floodwater overtop the existing A96 and the Aberdeen to Inverness Railway Line before diverging into separate flow paths. Part of the flow goes north-east to the Moray Firth and part re-enters the Cairnlaw Burn.

3.30 Before the Cairnlaw Burn discharges to the Moray Firth, there is a property located on the left bank (Area 4). Due to the proximity of the property to Cairnlaw Burn, this property has been used to assess the impact of the proposed Scheme with regards to downstream flood risk impact. The threshold level for the property is 1.02m above the predicted peak water level and hence this property is not at risk of flooding during the 0.5% AEP (200-year) +CC design flood event..

3.31 The analysis undertaken indicates that there are number of sensitive receptors at risk of flooding in the baseline situation for the 0.5% AEP (200-year) + CC design flood event. These receptors include the existing A96, properties at Burnside and the Aberdeen to Inverness Railway Line.

'With-Scheme' Flood Risk (No Mitigation)

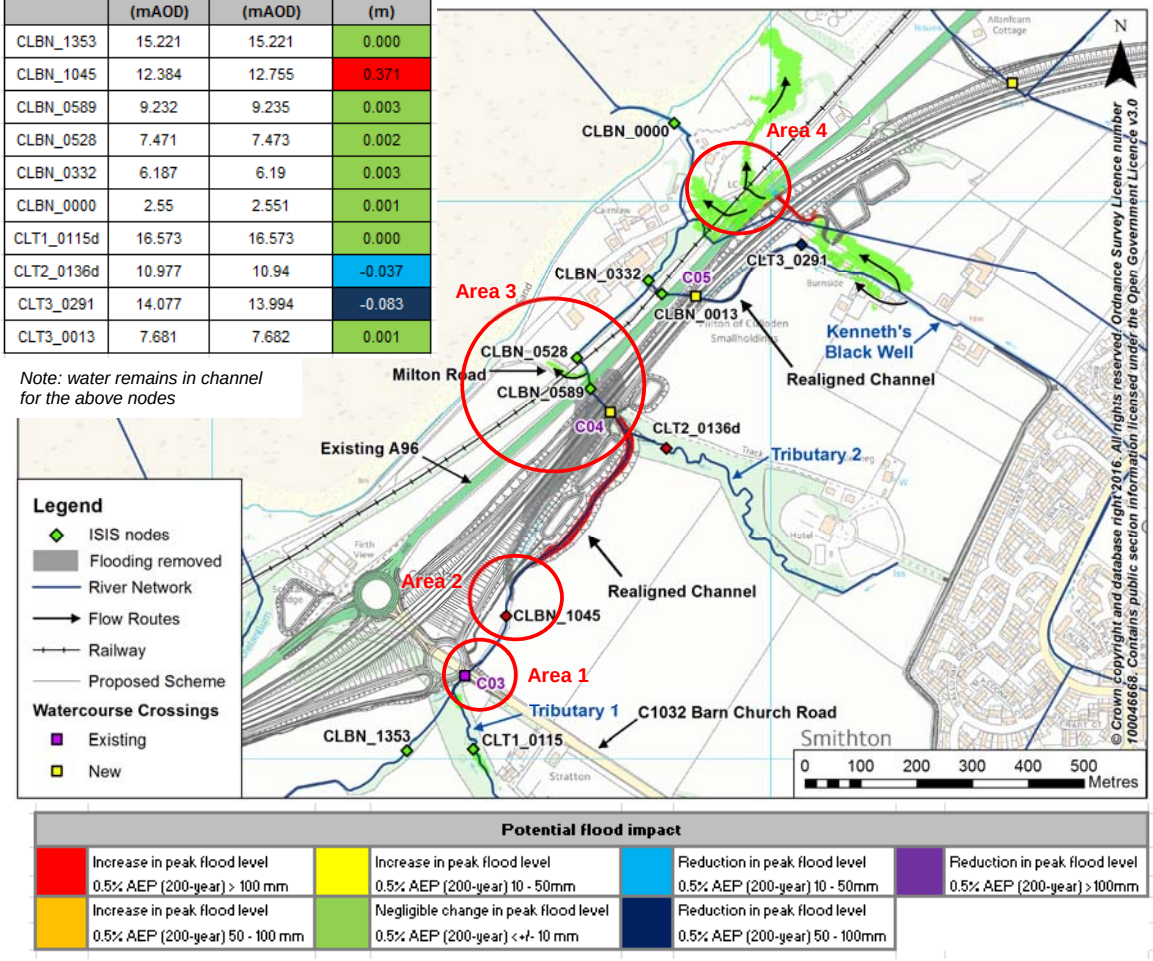
3.32 The proposed Scheme would cross the Cairnlaw Burn, and its tributaries, at a number of locations. But modelling indicates that the proposed Scheme would not be at risk of flooding in the 0.5% AEP (200-year)+CC design event. However, a number of changes to the channel and associated structures would be needed to accommodate the proposed Scheme. These changes could have several hydraulic impacts and peak flood levels could be affected at a number of locations.

3.33 Diagram 7 shows the water depth difference results for the 'with scheme' scenario compared to the 'baseline' for Cairnlaw Burn. The key impacts are discussed in more detail below.

Diagram 7: Cairnlaw Burn 'With-Scheme'

Model node	Baseline water level (mAOD)	With-Scheme water level (mAOD)	Change in water level (m)
CLBN_1353	15.221	15.221	0.000
CLBN_1045	12.384	12.755	0.371
CLBN_0589	9.232	9.235	0.003
CLBN_0528	7.471	7.473	0.002
CLBN_0332	6.187	6.19	0.003
CLBN_0000	2.55	2.551	0.001
CLT1_0115d	16.573	16.573	0.000
CLT2_0136d	10.977	10.94	-0.037
CLT3_0291	14.077	13.994	-0.083
CLT3_0013	7.681	7.682	0.001

Note: water remains in channel for the above nodes



3.34 At the point of the first crossing, shown as Area 1 on Diagram 7, the existing culvert (C03) under C1032 Barn Church Road, would be retained and extended by 23m. During the 0.5% AEP (200-year)+CC design flood event, the culvert will pass a peak flow of 7.6m^3/s. Modelling indicates that this would have a negligible impact on upstream flood risk.

3.35 Area 2 (on Diagram 7) is a location where the hydraulic model indicates an increase in flood depths of 0.37m (Model Node CLBN_1045). The increase in water depth is caused by a realignment of the channel to accommodate the proposed Scheme. The realignment would alter the length of the channel and hence the channel gradient. This impact would be regarded as a major adverse impact, however, the realigned channel will be designed to retain the design flood event in-channel with appropriate freeboard i.e. no out-of-bank flow will occur. Therefore, no further mitigation is at this location.

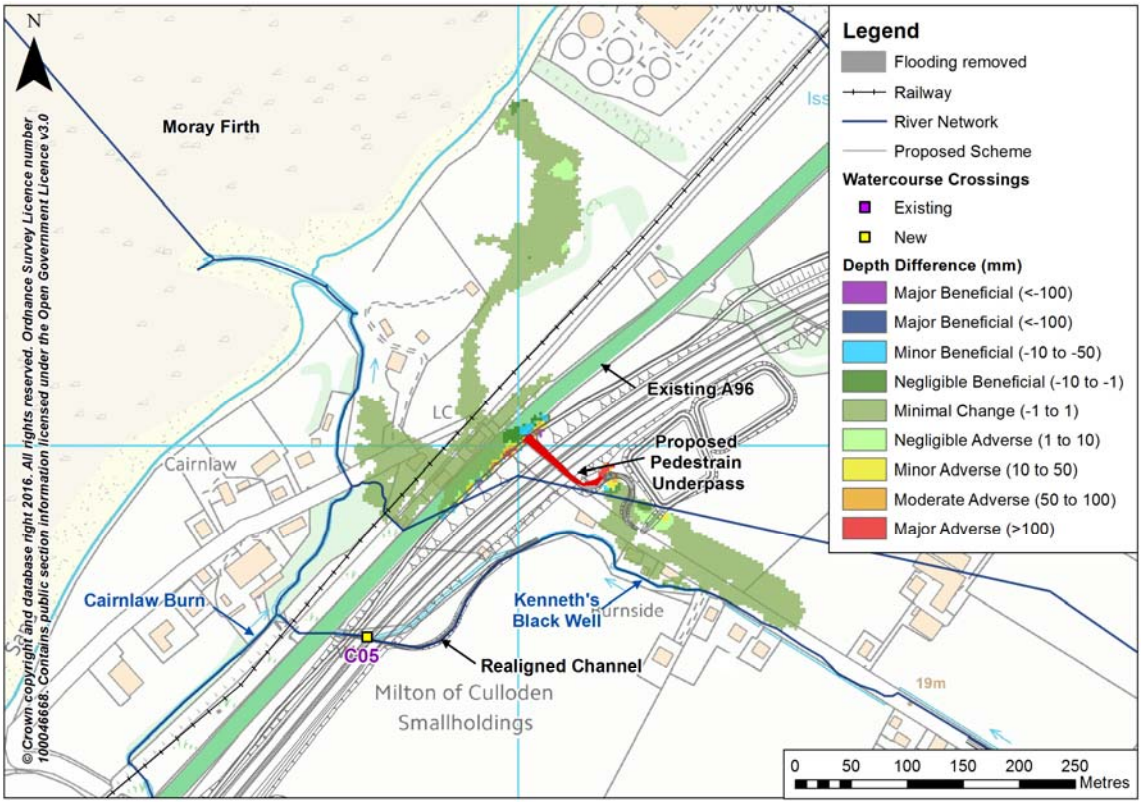
3.36 The proposed Scheme would also remove an area of existing flood plain associated with Area 3. The loss of flood plain storage has been calculated as 2,500m^3. However, the proposed realignment of the channel at this location would include a large increase in channel capacity and the model predicted that the design flow would remain in-channel.

3.37 With the proposed Scheme in place, the water level overtopping of the existing A96, shown as Area 3 on Diagram 7, increases by 0.003m. The peak water level would also slightly increase levels upstream of the Aberdeen to Inverness Railway Line and flood depths along the Milton Road would increase by 0.007m. Both of these impacts are considered to be negligible and hence no mitigation measures are considered necessary.

3.38 At Area 4, the proposed Scheme would include two detention ponds that form part of the proposed Scheme drainage system. These detention ponds would be raised features with earth embankments containing the retained water and both would be sited outside of the 0.5% AEP (200-year)+CC flood envelope. In addition the proposed access track to them would be constructed at existing ground level and hence not affect flood flow paths.

3.39 A proposed NMU underpass (PS24 Milton of Culloden NMU Underpass) at this location would pass under the proposed Scheme. As shown on Diagram 8, the proposed path could act as a new flood flow path during a flood event thereby affecting the use of the underpass for pedestrian access.

Diagram 8: Cairnlaw Burn 'With-Scheme' (Kenneth's Black Well)



3.40 Downstream of the proposed Scheme, a negligible impact on water level is predicted when compared to the baseline scenario, as seen on Diagram 8.

3.41 It is concluded that in general the proposed Scheme would have a negligible flood risk impact, however the use of the proposed pedestrian underpass could be compromised due to flooding and this is considered to be undesirable, hence consideration has been given to provide mitigation measures that remove this flood risk for the design flood event.

3.42 It is also recognised that some of the properties at Burnside are at risk of flooding for the existing case, but this flood risk is not predicted to change due to the proposed Scheme.

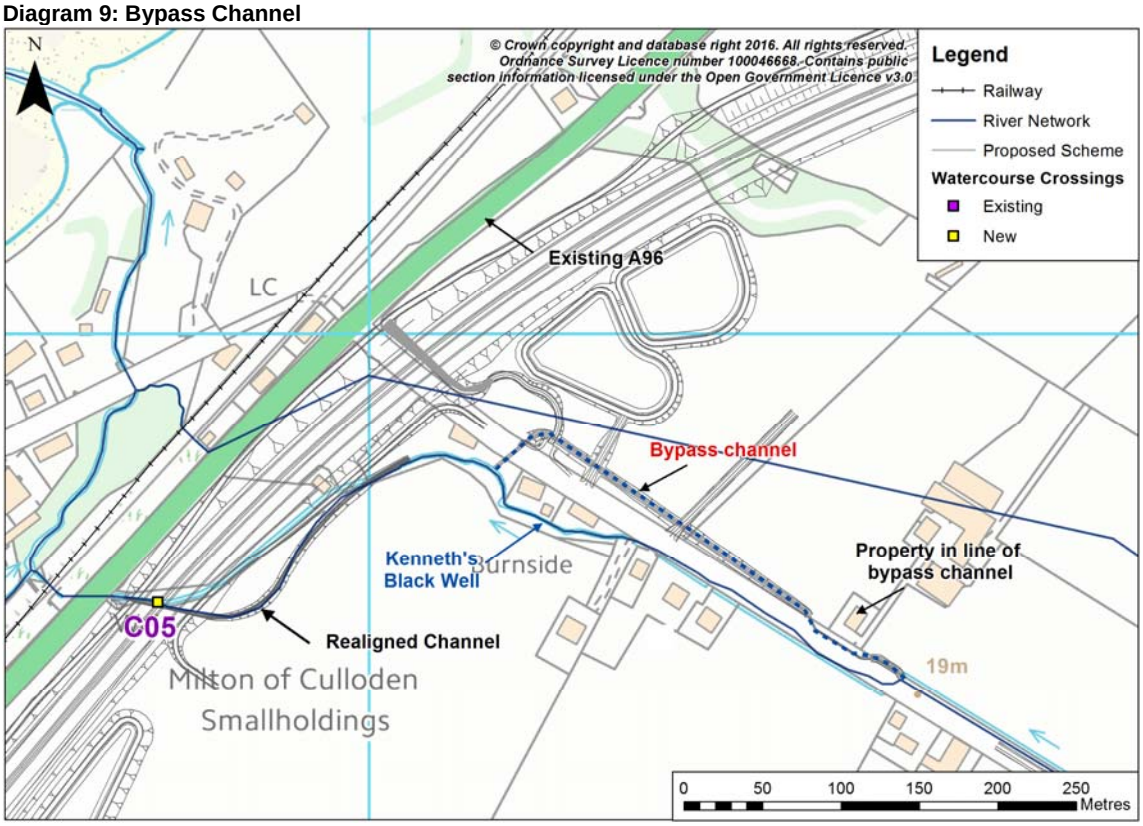
'With Mitigation' Flood Risk

3.43 Two options were investigated in order to mitigate the flood risk associated with the proposed NMU underpass. These are:

- **Option 1:** Increase existing channel conveyance capacity along Kenneth's Black Well by replacing existing driveway culverts together with increasing the sectional area of the channel at this location.
- **Option 2:** Provision of a new flood bypass channel located on the right hand side (looking north) of the access road to alleviate flow within the existing channel.

3.44 Option 1 was discounted as it would involve significant disruption to the residents, increase the footprint of the channel within each private property and would also require the removal of a significant number of mature trees lining the existing channel. In order to avoid these social and ecological impacts Option 2, the flood bypass channel, was considered further. A conceptual design for this option is shown on Diagram 9.

Diagram 9: Bypass Channel

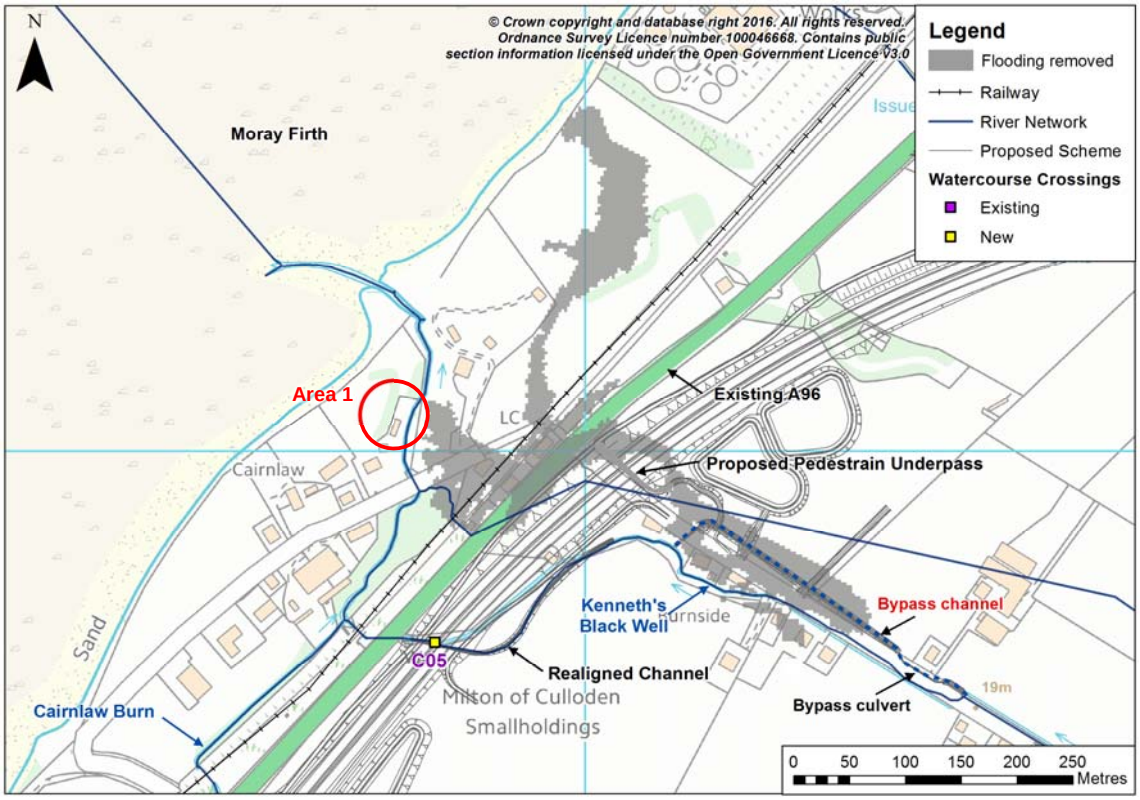


3.45 The proposed flood bypass channel would be designed to convey approximately 60% of the 0.5% AEP (200-year) +CC peak design flow. A new short section of culvert under an existing local access road would also be required to limit the impact on a property that lies within the line of the proposed channel.

3.46 The flood bypass channel would drain back into Kenneth's Black Well, downstream of the existing channel constraint, which results in the baseline flooding.

3.47 Diagram 10 shows the predicted flood extent associated with the design event for the 'with-mitigation' scenario for Kenneth's Black Well.

Diagram 10: Cairnlaw Burn 'With-Mitigation' (Kenneth's Black Well)



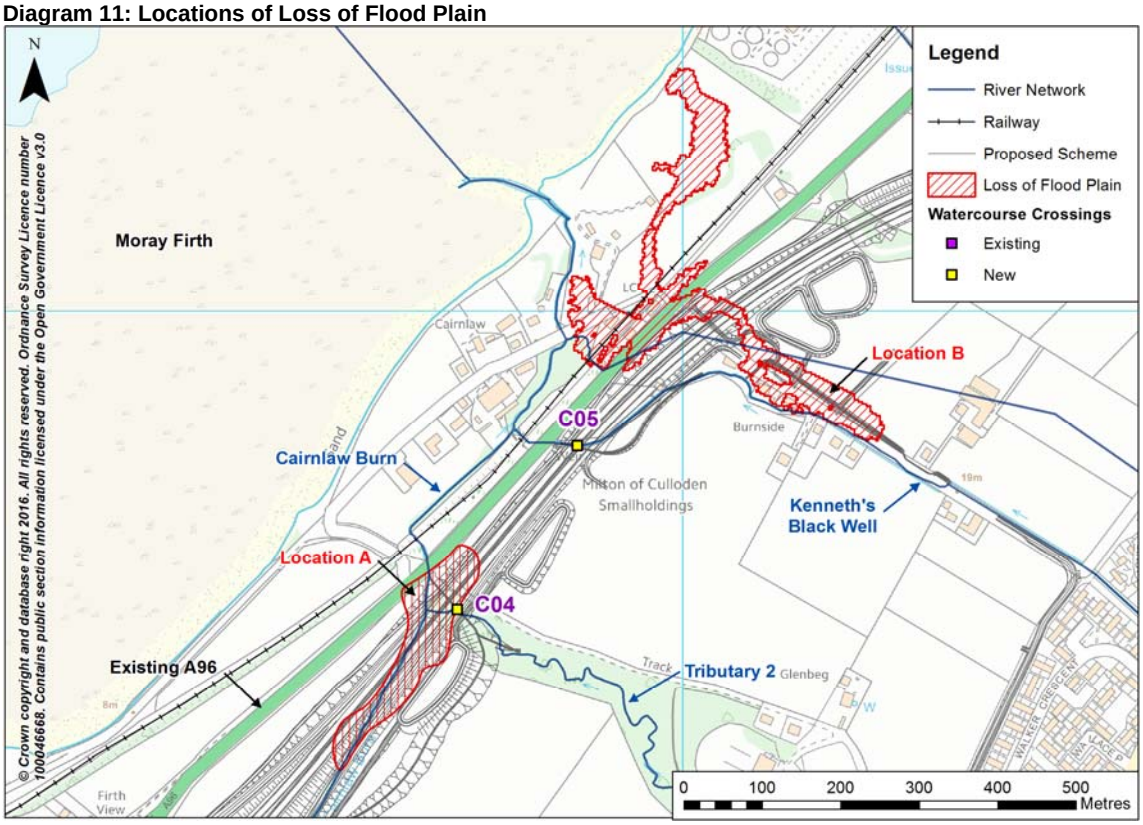
3.48 Modelling of the flood bypass channel option indicates that there would be no flooding to the proposed PS24 Milton of Culloden NMU underpass or to the residential properties at Burnside in the 0.5% AEP (200-year)+CC design flood event. This would be considered to be a significant benefit of the proposed Scheme in relation to flood risk at this location (Diagram 10).

3.49 However, the removal of flood plain on Kenneth's Black Well would result in an increase in peak flow compared to the baseline situation, downstream of the bypass channel discharge point. The size of the proposed Scheme culvert along Kenneth's Black Well (C05) would be 3.0m wide by 2.0m high and would pass a peak flow of 6.30m^3/s in the 0.5% AEP (200-year)+CC event, compared to the baseline pass forward flow of 5.34m^3/s.

3.50 This increase in peak flow would increase peak water level downstream in the Cairnlaw Burn, however the model predicts that 0.5% AEP (200-year) +CC design flood event water level would remain in-channel. At the location of the nearest downstream property (Area 1 on Diagram 10), the available freeboard between predicted water level and property threshold level is predicted to increase by 0.05m from the 'baseline' case.

3.51 The proposed Scheme would include the loss of flood plain storage at Locations A and B as shown on Diagram 11. The volume lost at Location A would be 2,500m^3 and at Location B it would be 2,900m^3.

Diagram 11: Locations of Loss of Flood Plain

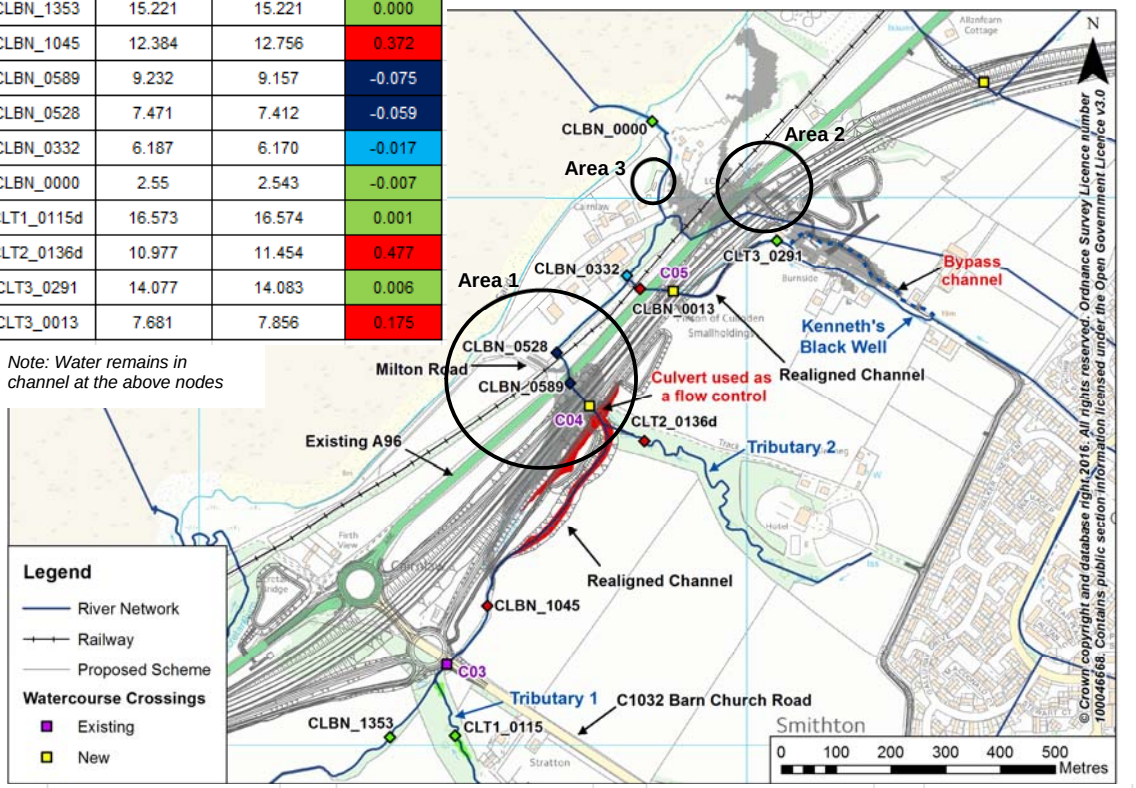


3.52 In order to achieve a neutral downstream flood risk impact, it is necessary to restrict the peak flow of flood water through culvert C04 from 8.7m^3/s to 7.3m^3/s. This could result in culvert C04 being surcharged during the design flood event which could require the design of additional operational features to manage the flow of water at this location. Upstream of culvert C04, the peak volume of flood water stored during the design flood event will increase from 5,400m^3 to 8,000m^3 and this will be contained within the newly formed diverted watercourse.

Diagram 12: **Cairnlaw Burn 'With-Mitigation'**

Model node	Baseline water level (mAOD)	With-Mitigation water level (mAOD)	Change in water level (m)
CLBN_1353	15.221	15.221	0.000
CLBN_1045	12.384	12.756	0.372
CLBN_0589	9.232	9.157	-0.075
CLBN_0528	7.471	7.412	-0.059
CLBN_0332	6.187	6.170	-0.017
CLBN_0000	2.55	2.543	-0.007
CLT1_0115d	16.573	16.574	0.001
CLT2_0136d	10.977	11.454	0.477
CLT3_0291	14.077	14.083	0.006
CLT3_0013	7.681	7.856	0.175

Note: Water remains in channel at the above nodes



Potential flood impact			
Increase in peak flood level 0.5% AEP (200-year) > 100 mm	Increase in peak flood level 0.5% AEP (200-year) 10 - 50mm	Reduction in peak flood level 0.5% AEP (200-year) 10 - 50mm	Reduction in peak flood level 0.5% AEP (200-year) >100mm
Increase in peak flood level 0.5% AEP (200-year) 50 - 100 mm	Negligible change in peak flood level 0.5% AEP (200-year) <+/- 10 mm	Reduction in peak flood level 0.5% AEP (200-year) 50 - 100mm	

3.53 By controlling the flows upstream of culvert C04, the water level exceeds the level of the access track to the ponds and the ponds themselves, as shown by the major adverse area in Diagram 12. This occurs in flood events greater than 0.5% AEP (200-year) and the main carriageway is above the 0.5% AEP (200-year)+CC maximum water level by approximately 3m. As the track is for maintenance purposes only it would not be used during a significant flood event, therefore the impact on flood risk is considered minimal. The inundation of the ponds at greater than the 1 % AEP (100-year) +CC event is unlikely to affect their performance in respect of the protection of water quality and the access track would not be used during time of significant flooding.

3.54 The effect of this flood storage would be to marginally lower water levels along the downstream reaches of the Cairnlaw Burn. At the location of the property located on the left bank (Area 3), water levels would be reduced by 0.05m even after including the additional flows from Kenneth's Black Well.

3.55 The upstream impacts of online flood storage at this location would be that water levels in Tributary 2 increase by 0.477m, as indicated on Diagram 12. However, the water level remains in channel during the 0.5% AEP (200-year)+CC design flood event and given that there are no sensitive flood receptors located along the lower section of this reach, no further mitigation measures are considered necessary.

3.56 With the mitigation measures in place, the proposed Scheme would result in the management of flood flows within the study area and at the location of flood sensitive receptors, the flood risk would be unchanged against the 'baseline' case.

3.57 For the purposes of the DMRB Stage 3 Assessment, the significance of impact for both Cairnlaw Burn (SWF03) and Kenneth Black Well (SWF06) has been assessed against the flood impact to the property located in the downstream reaches of Cairnlaw Burn. For both watercourses, the sensitivity has been assessed as very high, however the magnitude of the impact measured at the closest property to Cairnlaw Burn is negligible and hence the impact significance is considered to be Neutral.

Blockage assessment

3.58 In order to assess residual risk of culvert blockage, model simulations of 50% and 90% have been applied to the dual carriageway culvert C04 and Kenneth's Black Well culvert C05 for the 0.5% AEP (200-year)+CC flood event. Culvert C04 would be 1.5m wide by 1.25m high, whereas culvert C05 would be 3.8m wide by 1.7m high.

3.59 The results of the 50% blockage scenario show an increase in water level of approximately 1.1m upstream of culvert C04, compared with the 'with-mitigation' scenario. The increase in water level propagates upstream 520m from the culvert. Due to the increase in water levels, out-of-bank flow reaches the detention pond on the right bank and the extent increases slightly on the left bank.

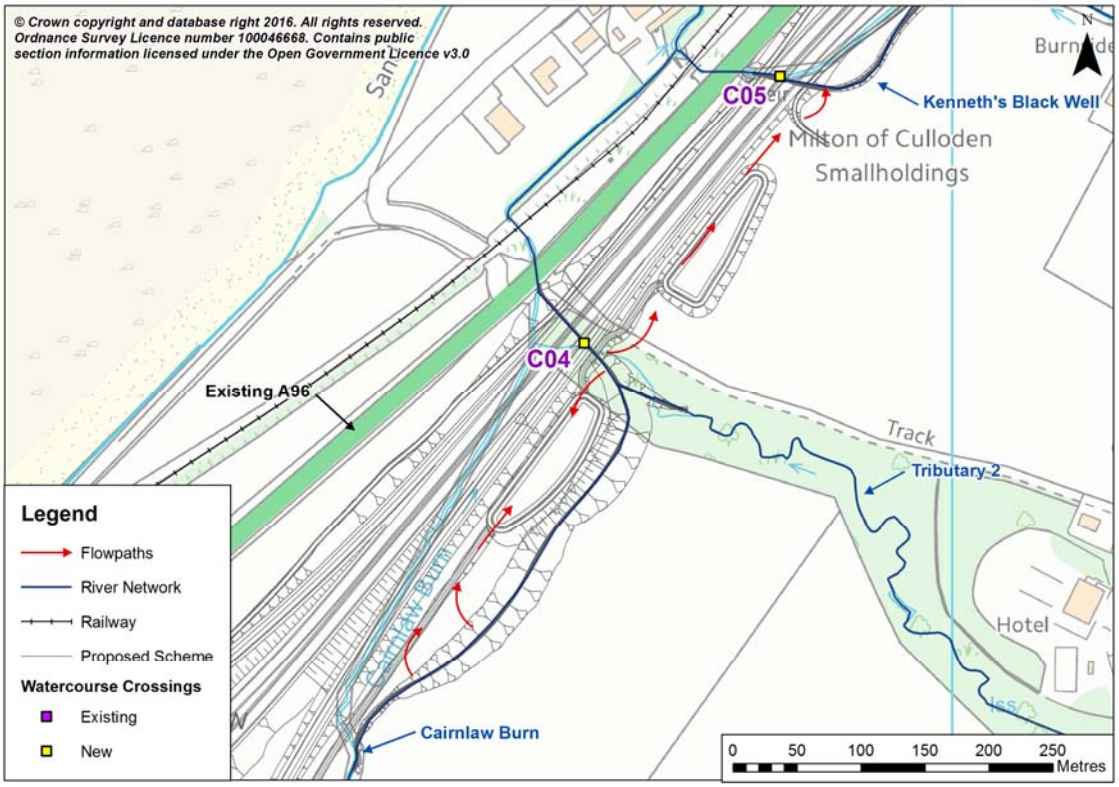
3.60 On Tributary 2, an increase in water level propagates approximately 98m upstream. However, the increases in water level are contained in-channel.

3.61 A 90% blockage of culvert C04 would result in water levels increasing by 1.4m compared to the 'with-mitigation' scenario. This change in water level propagates 520m upstream. The increase in water level forces water to overtop the right bank immediately upstream of the culvert, flow along the toe of the proposed embankment to Kenneth's Black Well and enter the watercourse at culvert C05, see Diagram 13.

3.62 Further upstream of culvert C04, the 90% blockage results in water overtopping the left bank. This out-of-bank flow reaches the detention pond and joins the left bank flowpath from immediately upstream of the culvert, as indicated in Diagram 13 below.

3.63 On Tributary 2, the change in water level propagates 117m upstream, however modelling indicates that this does not cause flooding to nearby properties.

Diagram 13: **Cairnlaw Burn Blockage Flow Routes**



3.64 A blockage of 50% on Kenneth's Black Well, culvert C05, results in water level increasing by 0.097m immediately upstream of the culvert and propagates 100m upstream. The increase water level is predicted to remain in-channel.

3.65 Blocking culvert C05 by 90% increases water level by 0.80m immediately upstream of the culvert and this would propagate 130m upstream. This results in water overtopping the left bank, flowing along the toe of the proposed embankment and entering Cairnlaw Burn at culvert C04.

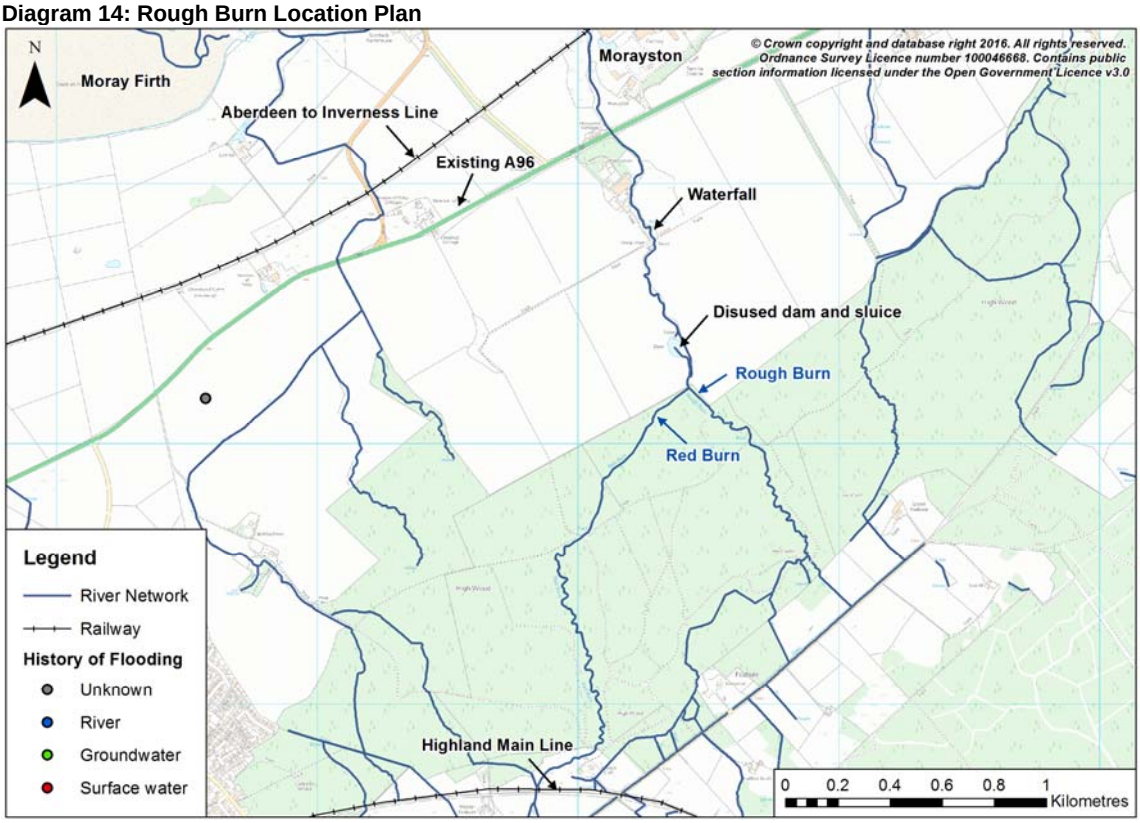
3.66 If the culvert of the bypass channel along Kenneth's Black Well was to become blocked, it is likely to overtop at the driveways along the main channel, as it does in the baseline scenario. The out-of-bank flow would overtop on the road on the right bank and re-enter the bypass channel. Therefore, it is considered that this blockage is unlikely to cause an increase in flood risk.

Rough Burn (SWF12)

3.67 Rough Burn comprises the main watercourse and a single tributary, Red Burn. Rough Burn rises near Feabuie and runs steeply through an incised channel in woodland until its confluence with Red Burn where the gradient becomes less steep and the land use changes to high value agricultural farmland. Passing a disused dam and sluice, the burn drops over a waterfall upstream of Morayston before passing under the existing A96 in an area of much flatter topography. The watercourse passes adjacent to a factory and under the Aberdeen to Inverness Railway Line before entering the Moray Firth further downstream (Diagram 14).

3.68 Red Burn begins on the eastern side of Culloden Muir before passing through a generally flat area of agricultural land around Braehill, under the Highland Main Line and more steeply through Cullernie Wood before its confluence with Rough Burn.

Diagram 14: Rough Burn Location Plan

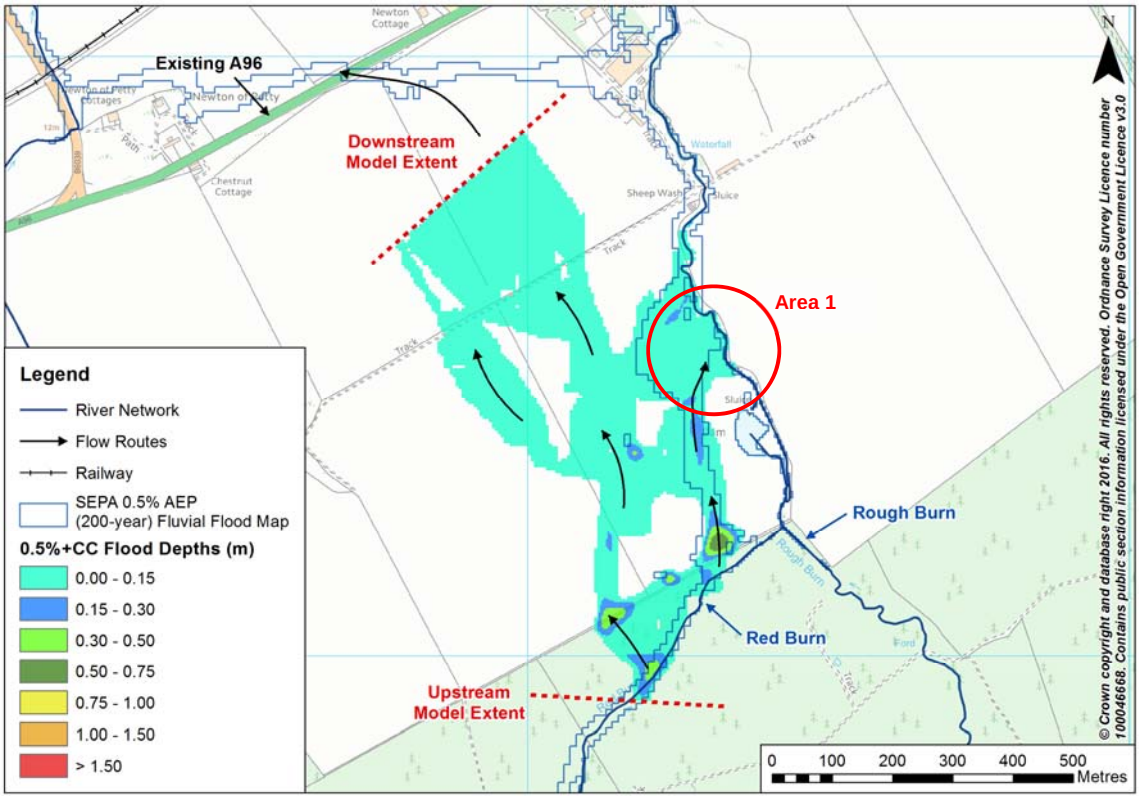


3.69 Consultation with The Highland Council did not indicate any recorded instances of flooding at Rough Burn in the vicinity of the proposed Scheme.

Baseline Flood Risk

3.70 Diagram 15 illustrates the baseline scenario for Rough Burn, based on hydraulic modelling.

Diagram 15: Rough Burn Baseline



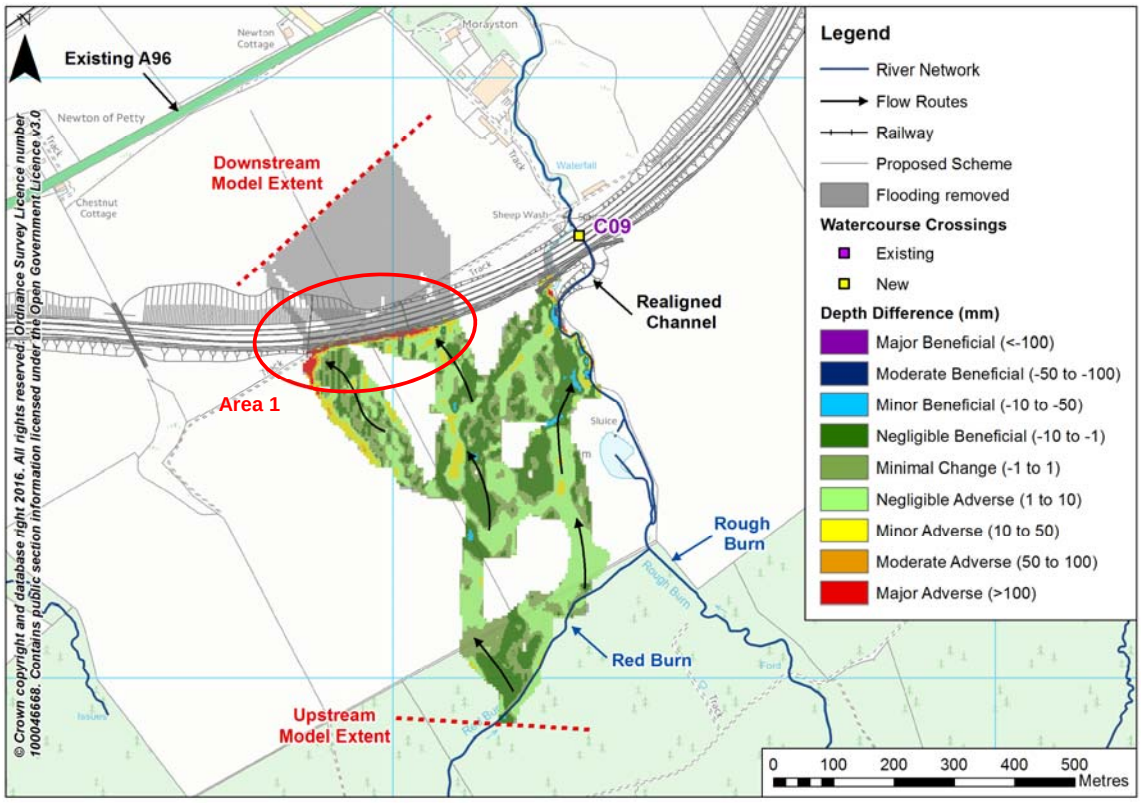
3.71 Upstream of the confluence of Red Burn and Rough Burn, the model predicts that water spills from the Red Burn left bank and flows in a north-westerly direction, over open farmland. However, a portion of this out of bank flow would make its way back into Rough Burn downstream (Area 1). There are no sensitive receptors at risk within the 'baseline' scenario. The land use in this area is agricultural.

3.72 Although the model extent does not include the existing A96 carriageway, it is likely that the existing A96 is at risk of fluvial flooding when the local topography is taken into account. The overland flows would continue in a downhill direction and would likely flow on to the existing A96 and then continue in a westerly direction as indicated by SEPA's flood map (SEPA 2015a).

'With-Scheme' Flood Risk

3.73 The proposed Scheme crosses the Rough Burn and would require a new culvert and realignment of the watercourse to accommodate the crossing. Diagram 16 shows the depth difference results of the 'with-scheme' scenario (without any mitigation) compared to the baseline for Rough Burn.

Diagram 16: Rough Burn 'With-Scheme'



3.74 The proposed Scheme culvert C09 has been designed to freely pass the 0.5% AEP (200-year)+CC design event and designed in accordance with DMRB design guidelines. The proposed culvert is 3m wide by 1.6m high, 65m long and designed to pass a peak flow of 8.3m^3/s during the 0.5% AEP (200-year)+CC design flood event. The channel would also be realigned for a short distance upstream but this would not affect overland flow routes and the geometry of the new channel would match the existing channel upstream. Consequently, flood risk at this location would remain unchanged.

3.75 However, the proposed Scheme would impede overland flood flows originating from Red Burn, and prevent the flow of water to the north of the proposed Scheme, as shown on Diagram 16.

3.76 As seen in Area 1, on Diagram 16, overland flow would pond against the proposed Scheme road embankment and the depth of flooding in this area would increase as a result. The maximum depth of water at this location is 1m, an increase of 0.9m against the 'baseline' case and the extent of flooding would increase slightly. Freeboard between the peak water level and road level at this location is 1m.

3.77 It is considered appropriate to maintain the baseline overland flood flow and as the proposed Scheme severs the flow route in this location, further mitigation is required.

'With-Mitigation' Flood Risk

3.78 The aim of the 'with-mitigation' scenario is to avoid the impounding of water against the proposed Scheme as a result of overland flows originating from Red Burn.

3.79 To mitigate this risk and to maintain the flow paths present in the baseline situation, two 1m circular flood relief culverts are proposed at the locations shown on Diagram 17.

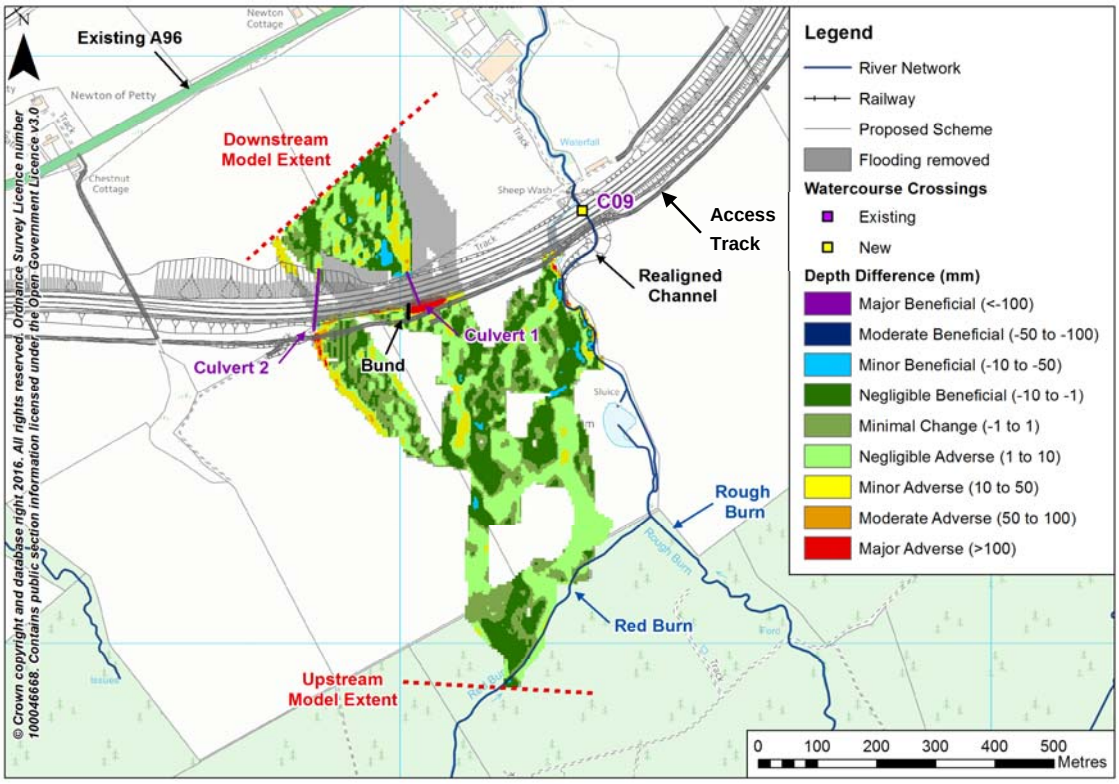
3.80 Culvert 1 (see Diagram 17) would also include a 15m long, 1.6m high earth bund to train the flow of water into Culvert 1 and to prevent floodwater flowing to the west along the toe of the road embankment.

3.81 During the 0.5% AEP (200-year)+CC design flood event, both relief culverts would be operating at free flowing. At Culvert 1, the proposed road level is 0.9m above the soffit of the culvert and the depth of water upstream of the culvert is 0.78m. Consequently, there is approximately 1.1m freeboard between the road level and peak flood water level. Culvert 2 has approximately 4m freeboard between the road level and peak water level. The proposed road embankment would be designed to withstand this impounding of water.

3.82 A track runs south of the proposed Scheme to provide access for local landowners. This track will be placed at ground level and will therefore, not affect the flows through the flood relief culverts.

3.83 Diagram 17 shows the depth difference results of the 'with-mitigation' scenario compared to the baseline for the Rough Burn.

Diagram 17: Rough Burn 'With-Mitigation'



3.84 Diagram 17 shows that with mitigation there would be an increase water levels immediately upstream of the culvert inlet, classified as an area of major adverse impact. However, this is highly localised and there are no sensitive receptors in this area. The land use in this location is principally agricultural.

3.85 In general, the upstream extent is very similar to the baseline scenario, although there are also small areas of minor adverse flood impact, which indicates a slight increase in peak flood depths. However, it is likely that the operation of the agricultural land would be unaffected by the predicted small localised increases in water depth and there are no sensitive receptors in this area.

3.86 The downstream extent has changed slightly from the baseline and the pass forward flow has slightly reduced from 1.13m^3/s in the baseline scenario to 1.08m^3/s.

3.87 For the purposes of the DMRB Stage 3 Assessment the significance of impact for the Rough Burn has been assessed against the flood impact to the channel immediately upstream of the proposed Scheme culvert (C09) and also the flooded agricultural land located to the west of the Rough Burn.

3.88 The agricultural land located upstream of the culvert C09 is considered to be of high sensitivity and the magnitude of the impact within the channel upstream of culvert C09 is negligible due to no change in predicted water level. Hence, the significance of impact at this location is considered to be Neutral.

3.89 The flooded agricultural land located to the west of the Rough Burn is considered to be of high sensitivity and in general the magnitude of the impact within the floodplain is negligible. Hence, the significance of impact at this location is considered to be Neutral. However, there are very small localised areas of large impact significance at the entrance to the flood relief culverts, however these small areas are not considered likely to affect the use of the agricultural land and also not affect the operation of the proposed Scheme, therefore no further mitigation measure is required.

Blockage Assessment

3.90 A 50% blockage of culvert C09 would result in no change in flood depths across the flood plain. Immediately upstream of the culvert C09, the in-channel water levels would increase by 0.17m. However, the floodwater is predicted to remain in channel.

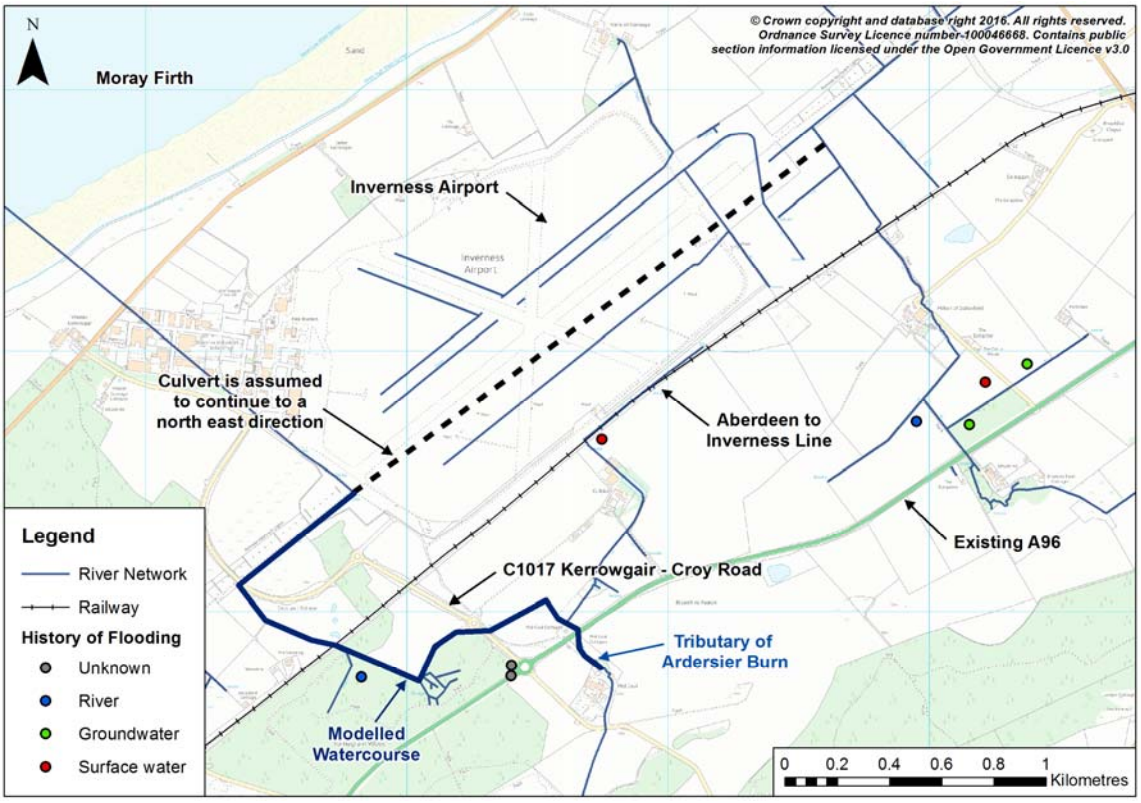
3.91 A 90% blockage of culvert C09 would result in water levels increasing by 1m immediately upstream of the culvert, at the toe of the proposed Scheme, and 4m in channel. The proposed Scheme forces the out-of-bank water to flow in a north-east direction, flowing away from the Rough Burn. This out-of-bank flow would pond in a local depression, 100m to the east, within the agricultural land.

3.92 This change in water levels would marginally increase the risk to the proposed Scheme, as more water would impound against the toe of the road embankment, however there are no other sensitive receptors in this location.

Tributary of Ardersier Burn (SWF16)

3.93 The Tributary of Ardersier Burn originates to the south-west of Dalcross at an elevation of approximately 110m. It runs through a steeply incised valley before passing through woodland, and onto flatter ground around the perimeter of a quarry. It passes under the existing A96 at Mid Coul before crossing under the C1017 Kerrowgair – Croy Road and Aberdeen to Inverness Railway Line. It then enters an area of marshy ground and continues downstream before being culverted beneath Inverness Airport. Downstream of the airport, the watercourse runs through flat agricultural land before its confluence with the Ardersier Burn approximately 400m upstream of its confluence with the Moray Firth (Diagram 18).

Diagram 18: Tributary of Ardersier Burn



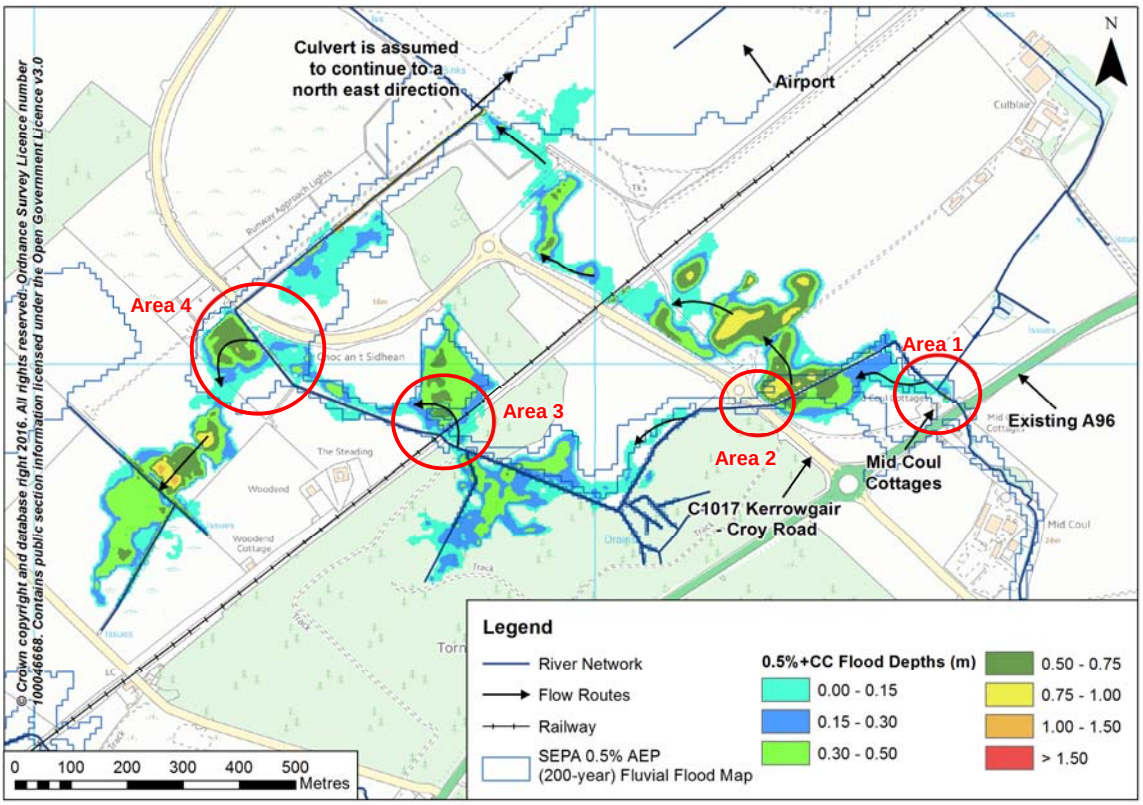
3.94 The history of flooding provided by The Highland Council along the Tributary of Ardersier Burn is outlined below (see Diagram 18).

- two unknown flooding incidences along the existing A96; and
- there is a known risk of fluvial flooding within Tornagrain Wood.

Baseline Flood Risk

3.95 Diagram 19 displays the baseline scenario for the Tributary of Ardersier Burn, based on hydraulic modelling of the 0.5% AEP (200-year)+CC design flood event. Evaluation of the model results indicates that there are number of flooding issues in this area with complex and interrelated flood mechanisms.

Diagram 19: Tributary of Ardersier Burn



3.96 The first area of flooding is at Mid Coul Cottages (Area 1). The existing culvert here does not have the capacity to pass the flood flows and water overtops the left bank.

3.97 The out of bank flows generated travel back towards the channel downstream. However, the culvert under the C1017 Kerrowgair – Croy Road (Area 2) also has insufficient capacity to pass the peak design flow. Consequently, water spills from the channel and flows overland in a north-westerly direction towards Inverness Airport, resulting in inundation of the Aberdeen to Inverness Railway Line, before it re-joins the burn near the airport culvert.

3.98 Downstream of the C1017 Kerrowgair – Croy Road culvert, flood water is predicted to spill out of bank within the Tornagrain Wood area between Area's 2 and 3 on Diagram 19.

3.99 At Area 3, there is further flooding due to the lack of channel capacity immediately upstream of the Aberdeen to Inverness Railway Line culvert, and this subsequently leads to flooding of the railway line and a large area of flooding immediately to the north.

3.100 Before the burn turns 90 degrees towards the airport at Area 4, the left bank overtops and results in flooding of lower lying farmland located further to the south-west.

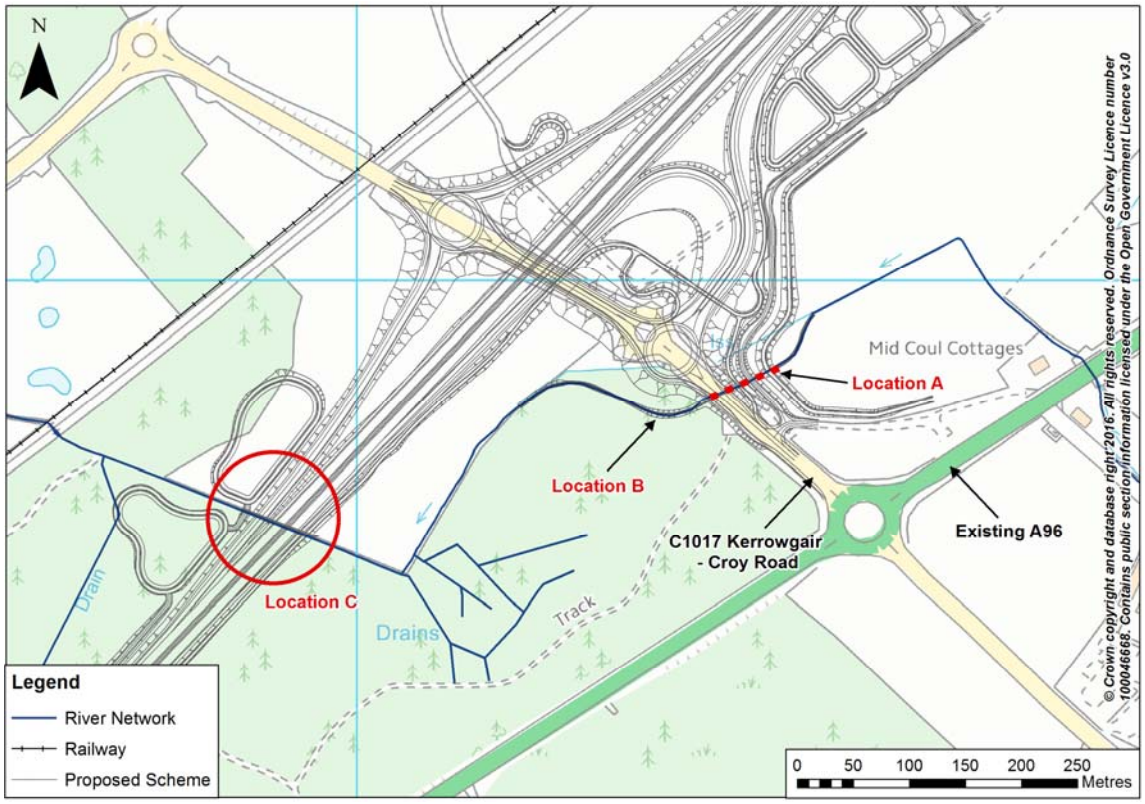
3.101 Due to the extent of flooding, sensitive receptors such as the railway line and the Inverness Airport, are at a risk of flooding.

'With-Scheme' Flood Risk

3.102 The proposed Scheme cuts across the flood plain of the Tributary of Ardersier Burn. The proposed road would be in a cutting throughout much of this area. Consequently, there would be extensive alterations required where the proposed Scheme crosses the watercourse. The proposed alterations

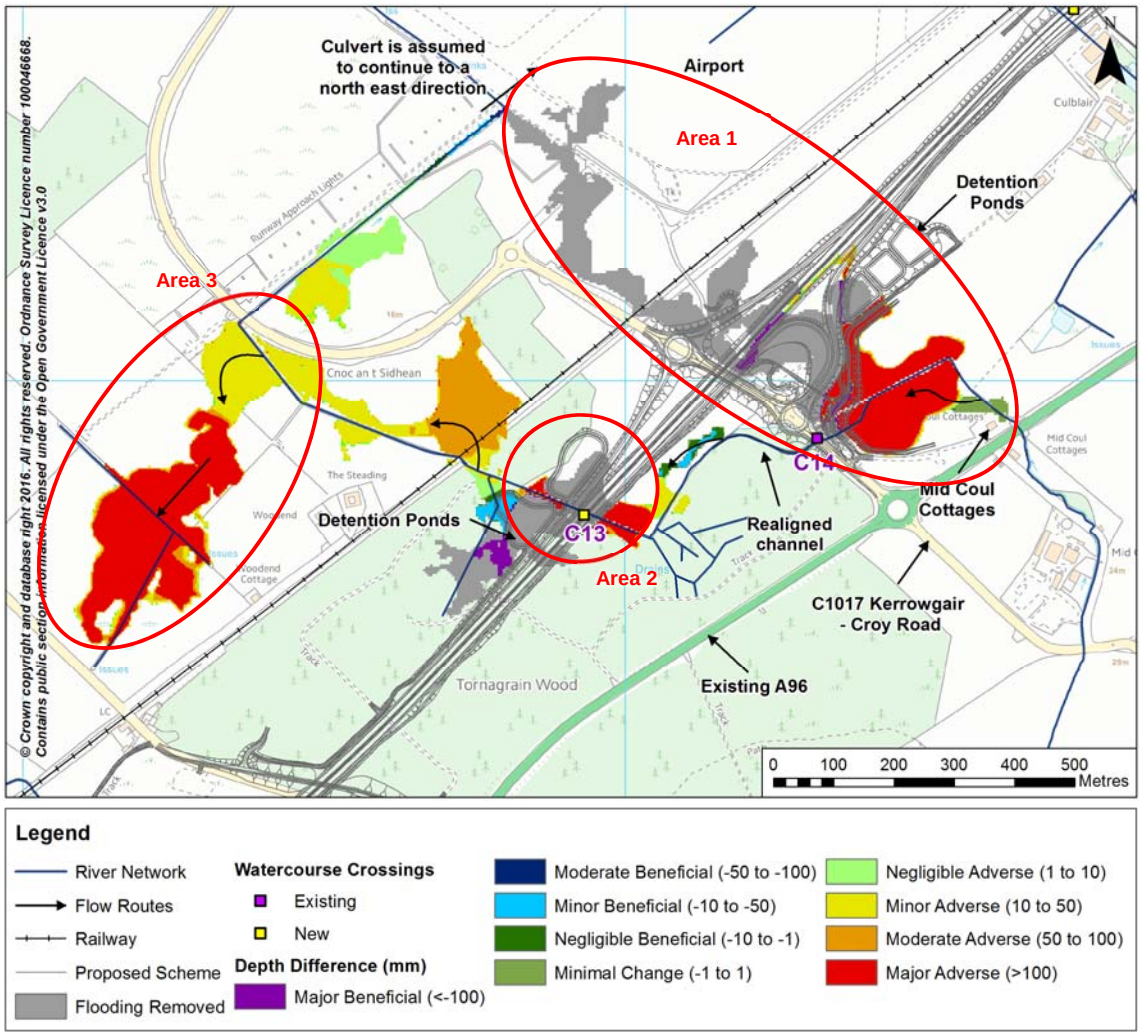
are shown on Diagram 20 and include a realigned culvert at Location A, realignment of the channel at Location B and new culvert at Location C.

Diagram 20: Location of Proposed Alterations at Tributary of Ardersier Burn



3.103 The proposed alterations to the watercourse network could have significant impacts on flood extents and flood mechanisms in the area. These impacts are shown on Diagram 21, which shows the depth difference results of the 'with-scheme' scenario (without any mitigation) compared to the baseline.

Diagram 21: Tributary of Ardersier Burn 'With-Scheme'



3.104 At Area 1, the proposed Scheme crosses the flood plain. The flow path flowing north shown in the baseline situation has been severed and there would be additional ponding upstream of the first proposed culvert (C14), as seen on Diagram 21.

3.105 The increased water levels in this area would put a number of elements of the proposed Scheme at risk of flooding. The elements include the proposed access track to Culblair, the new drainage detention ponds and the shared-use path. There is also a topographic low spot between the ponds and the proposed Scheme, where modelling indicates that there is a risk of flooding onto the dual carriageway of the proposed Scheme. This is considered to be unacceptable.

3.106 In addition, the proposed Scheme also interrupts the flow of water at new culvert C13 downstream (Area 2). Preliminary design suggest that the size of the new culvert at Area 2 would be 2.1m wide by 1.9m high. This culvert would restrict the pass forward flow and hence both upstream flood depth and flood extent would increase as shown on Diagram 21.

3.107 Due to the loss of flood plain in the north and around the location of the detention ponds, water would be displaced. This would result in an increased depth of flooding at the Aberdeen to Inverness Railway Line and an increase in flood extent and depth downstream at Area 3. Pass forward flow to Inverness Airport would also slightly increase from 1.78m^3/s to 1.79m^3/s, which could slightly increase the risk of flooding local to the airport, which is considered to be unacceptable.

3.108 It is concluded that the proposed Scheme increases the pass forward flow to Inverness Airport and also increases the risk of flooding to the Aberdeen to Inverness Railway Line, which is considered unacceptable. Furthermore, elements of the proposed Scheme would also be at risk of flooding. Therefore, mitigation measures have been considered to manage the impact on flood risk.

'With-Mitigation' Flood Risk

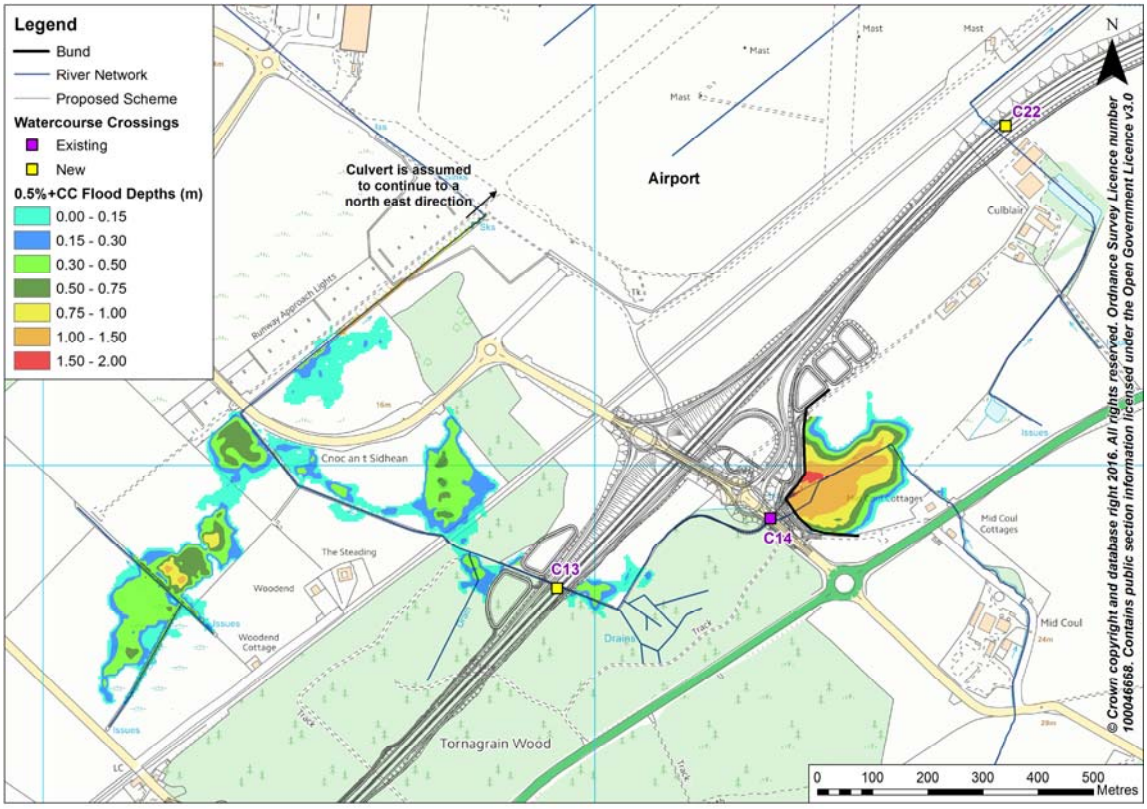
3.109 The principal aims of the 'with-mitigation' scenario are to i) not increase the pass forward flow to the airport culvert; ii) not increase the fluvial flood risk to the Aberdeen to Inverness Railway Line from the baseline scenario, or iii) prevent flooding of the proposed Scheme. A number of options have been considered culminating with a shortlist of three options presented below and identification of the preferred solution.

Option 1: Online Storage at culvert C14

3.110 This option would involve the provision of flood storage restricting flows through culvert C14 and storing the water behind flood embankments. This option would have significant benefits throughout the study area and would effectively manage flood risk to the proposed Scheme.

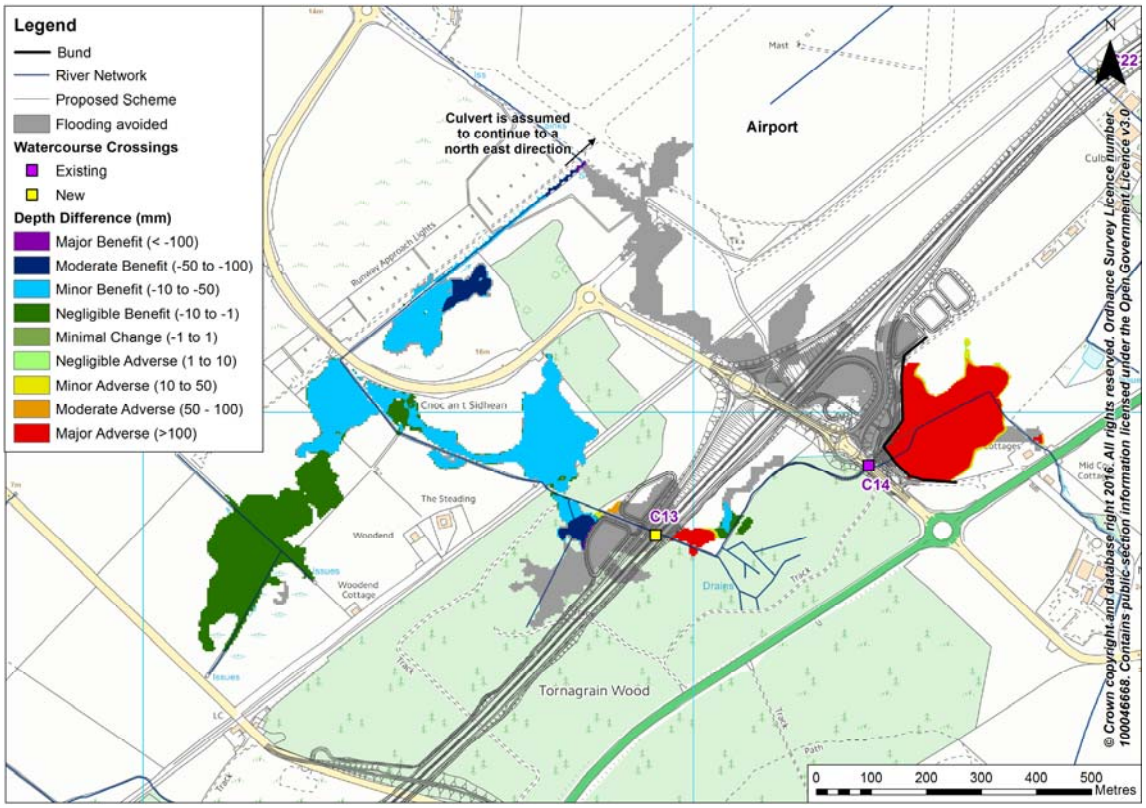
3.111 Diagram 22 illustrates the modelled depths results for Option 1 during the 0.5% AEP (200-year)+CC flood event.

Diagram 22: Option 1 Modelled Depths Results



3.112 Diagram 23 shows the depth difference of Option 1 compared to the baseline modelled results.

Diagram 23: Option 1 Depth Difference



3.113 Option 1 would store ~25,600m^3 of water upstream of culvert C14. Diagram 23 shows that there are wide-scale flood risk benefits throughout the system with this option. These benefits include:

- the removal of the flow path towards Inverness Airport from culvert C14;
- the pass forward flow to Inverness Airport would reduce from 1.78m^3/s to 1.65m^3/s;
- reductions in peak flood levels downstream (apart from upstream of culvert C13, which is discussed in more detail later in this section of the report);
- No flooding to the proposed Scheme for the 0.5% AEP (200-year)+CC flood event and with 0.6m freeboard within culvert C13; and
- reduction in flood risk to existing rail infrastructure.

3.114 The reduction in flood risk is achieved by limiting the peak flows passed forward by sizing culvert C14 so that it becomes a hydraulic flow control structure. The proposed size of this culvert would be 0.95m wide by 1m high and this would limit the peak pass forward flow downstream to 2.4m^3/s. The pass forward flow for the baseline case is 2.5m^3/s.

3.115 Out-of-bank overland flows would be controlled through the construction of flood embankments to create a formal flood storage area. The embankments would be 2.4m high including 0.6m freeboard.

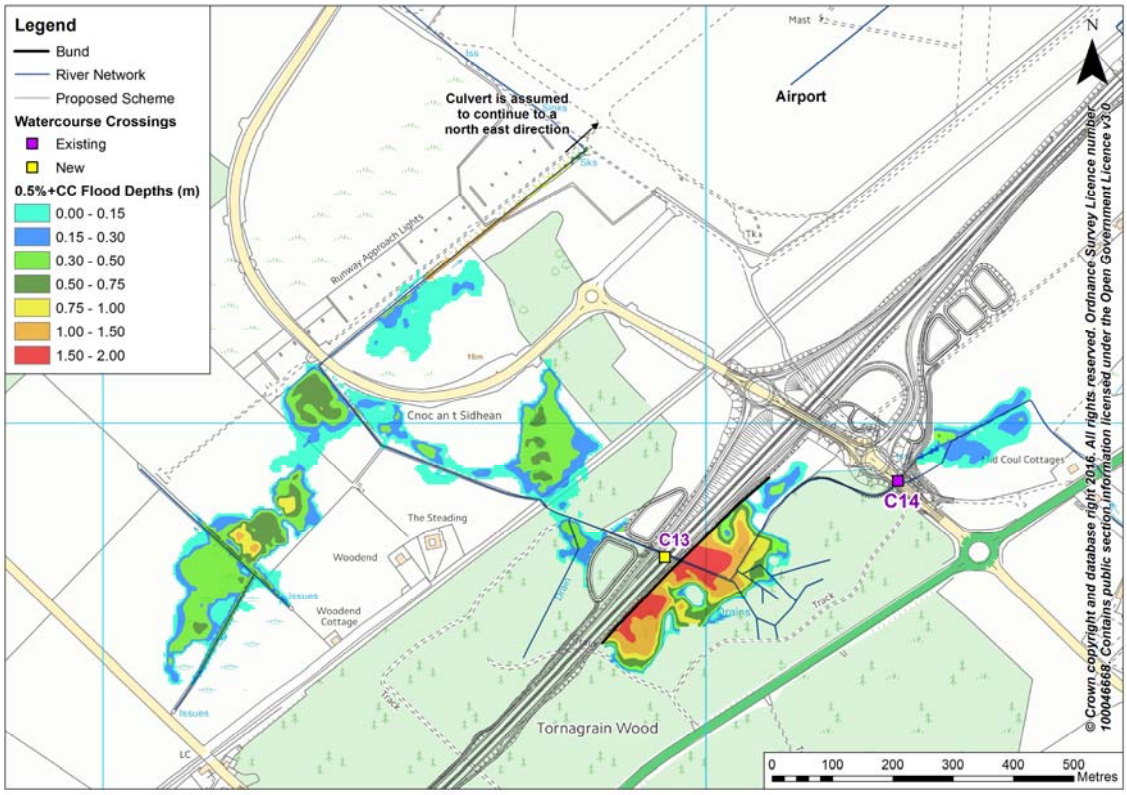
3.116 Due to the proposed Scheme and new culvert at C13, the functional flood plain is severed and water would surcharge against the road, shown as an area of major adverse impact in Diagram 23. However, the proposed Scheme road level is 1m above the peak water level at this location and consequently is not at risk of flooding for the 0.5% AEP (200-year) + CC design event.

Option 2: Online Storage in Tornagrain Wood

3.117 This option would involve increasing the size of culvert C14 to increase the pass forward flow and the provision of flood storage within the channel upstream of culvert C13 in the Tornagrain Wood area. Culvert C13 would control the forward flow of water.

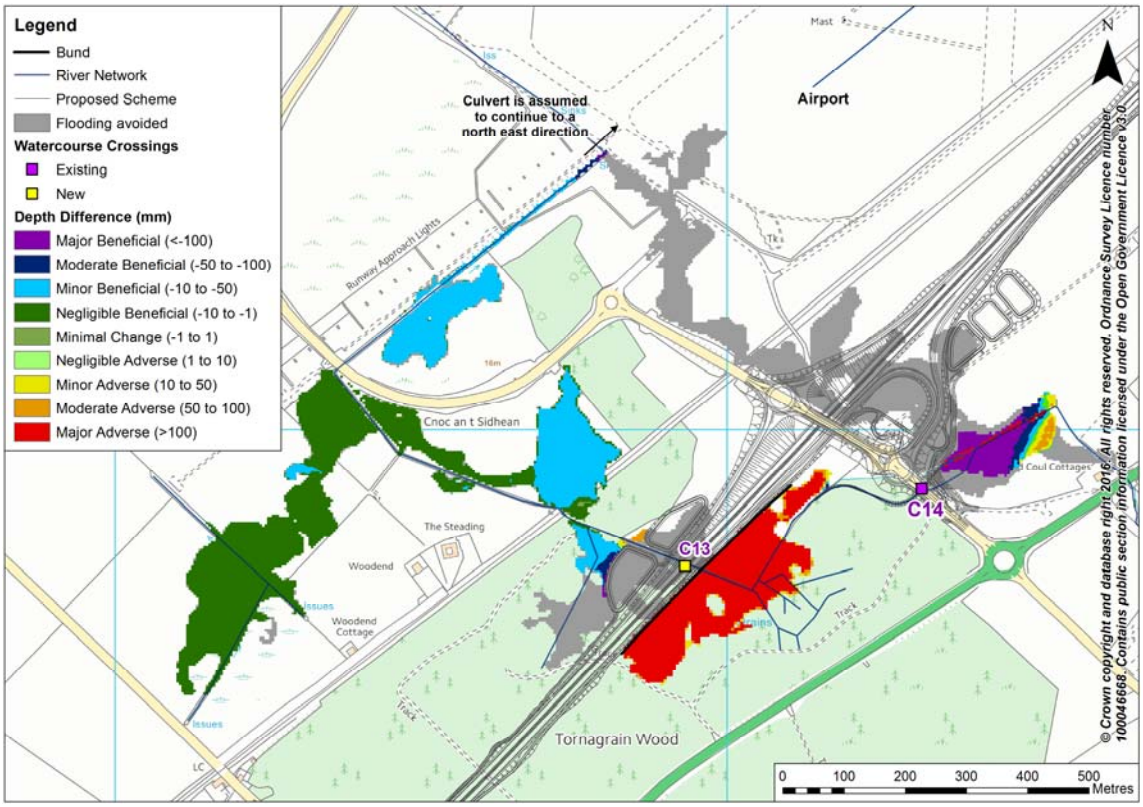
3.118 Diagram 24 illustrates the modelled depths results for Option 2 during the 0.5% AEP (200-year)+CC flood event.

Diagram 24: Option 2 Modelled Depths Results



3.119 Diagram 25 shows the depth difference of Option 2 compared to the baseline modelled results.

Diagram 25: Option 2 Depth Difference



3.120 Option 2 would store ~31,000m^3 of water upstream of culvert C13. Diagram 25 shows that there are wide-scale flood risk benefits throughout the system with this option. These benefits include:

- the removal of the flow path towards Inverness Airport from culvert C14;
- the pass forward flow to Inverness Airport would reduce from 1.78m^3/s to 1.69m^3/s;
- reductions in peak flood levels downstream of culvert C13;
- No flooding to the proposed Scheme for the 0.5% AEP (200-year)+CC flood event and with 0.6m freeboard within culvert C14;
- reduction in water levels and extent upstream of culvert C14; and
- reduction in flood risk to rail infrastructure.

3.121 The reduction in flood risk is achieved by limiting the peak pass forward flow by sizing culvert C13 so that it becomes a hydraulic flow control structure. The proposed size of this culvert would be 1.5m wide by 1m high.

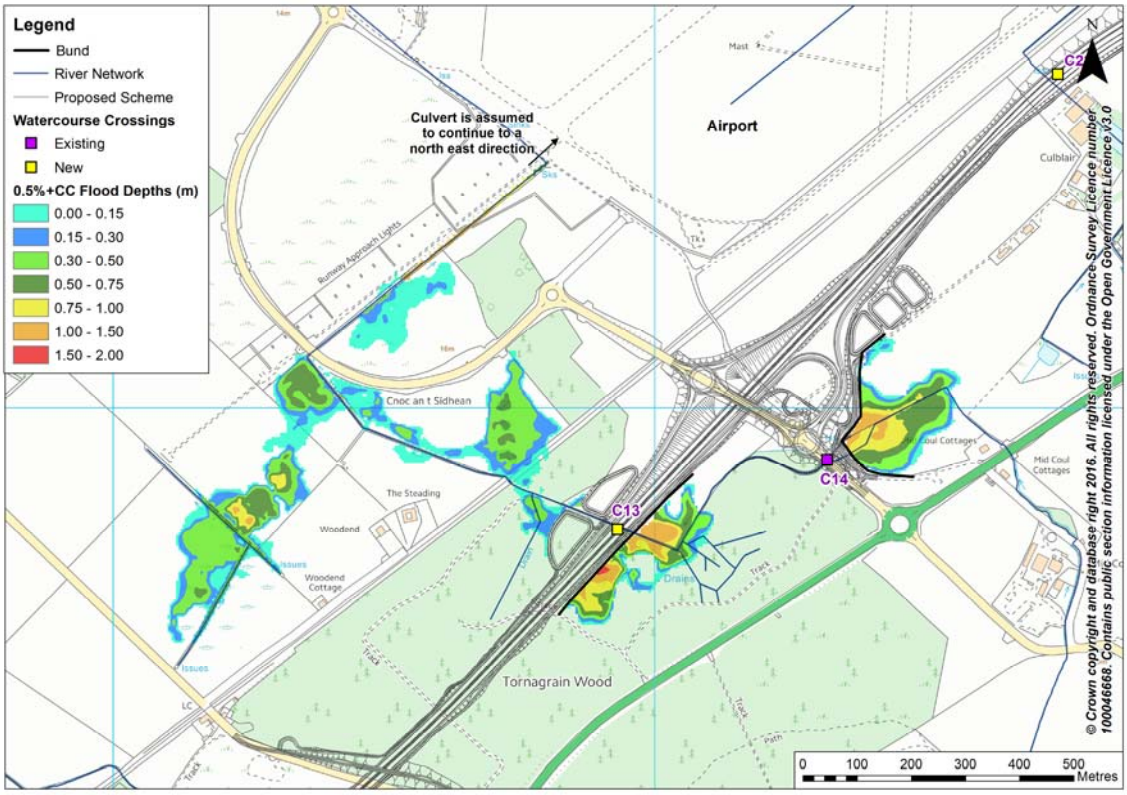
3.122 Out-of-bank overland flows would be controlled through the construction of flood embankments to create a formal flood storage area and to protect the proposed Scheme from flooding. The embankments would be 2.6m high including 0.6m freeboard, and would be parallel to the proposed Scheme, as shown in Diagram 25.

Option 3: Two Online Storage Basins

3.123 This option involves the creation of two separate basins upstream of culvert C13 and culvert C14. Both culverts would act as flow control structures to limit the flows downstream.

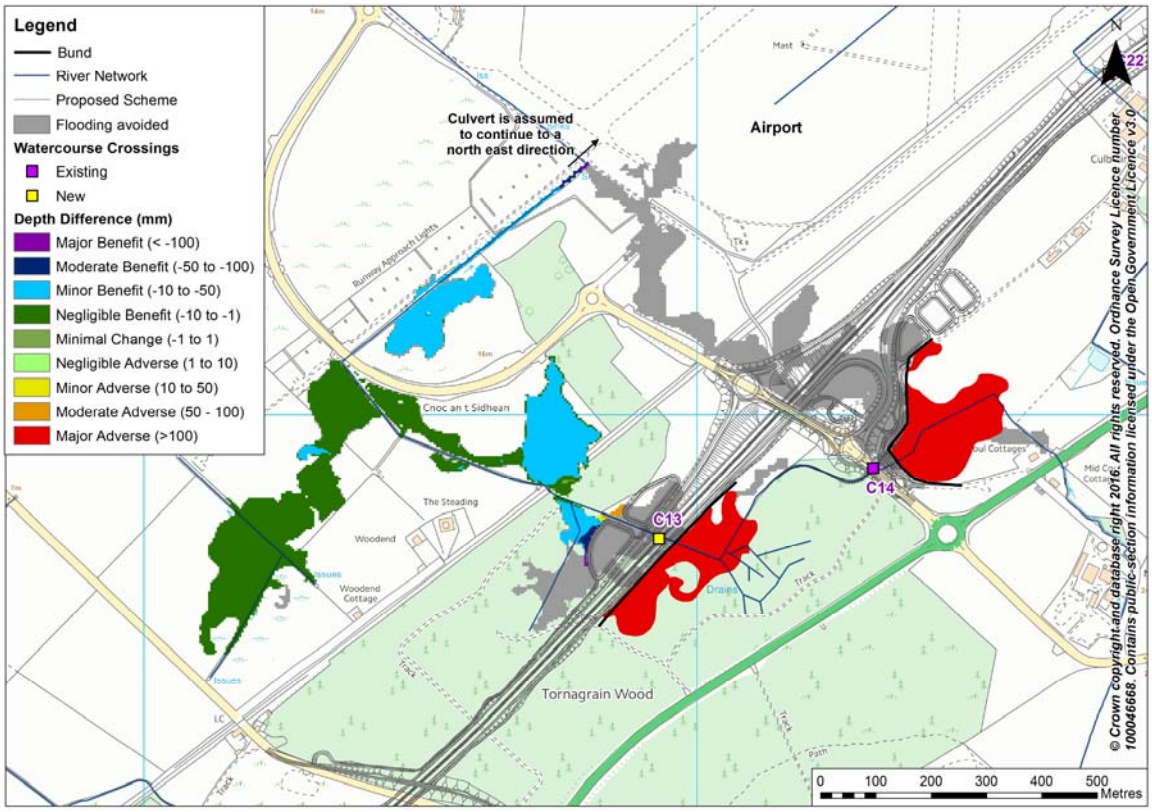
3.124 Diagram 26 illustrates the modelled depths results for Option 3 during the 0.5% AEP (200-year)+CC flood event.

Diagram 26: Option 3 Modelled Depths Results



3.125 Diagram 27 shows the depth difference of Option 3 compared to the baseline modelled results.

Diagram 27: Option 3 Depth Difference



3.126 Option 3 would store 14,500m^3 of water upstream of culvert C13 and 15,500m^3 upstream of culvert C14 (total stored 30,000m^3). Diagram 27 shows that there are wide-scale flood risk benefits throughout the system with this option. These benefits include:

- the removal of the flow path towards Inverness Airport from culvert C14;
- the pass forward flow at Inverness Airport would reduce from 1.78m^3/s to 1.69m^3/s;
- reductions in peak flood levels downstream;
- no flooding to the proposed Scheme for the 0.5% AEP (200-year)+CC flood event
- reduction in flood risk to existing rail infrastructure.

3.127 The reduction in flood risk is achieved by limiting the peak flows passed along from the upper parts of the watercourse. The reduction in flow is realised by sizing both culvert C13 and culvert C14 so that they become hydraulic flow control structures. The proposed size of both culverts would be 1.5m wide by 1m high.

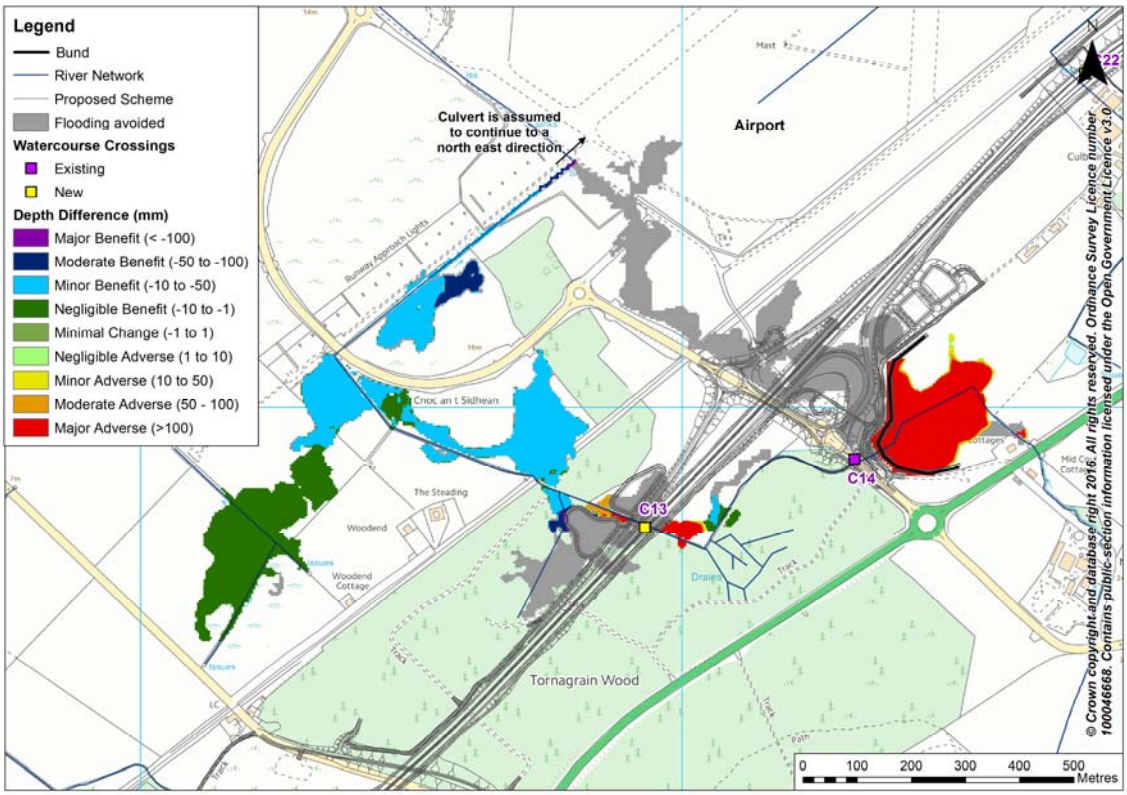
3.128 Out-of-bank overland flows would be controlled through the construction of flood embankments to create a formal flood storage area. The embankments at culvert C13 would need to be 2.2m including 0.6m freeboard and C14 would have a height of 1.9m including 0.6m freeboard.

Preferred Option: Option 1

3.129 Out of the three shortlisted options, Option 1 provides more control on the flows in the system and would be designed to store ~25,600m^3 of water upstream of culvert C14. 2.4m high embankments would be required to contain the water.

3.130 The results of the mitigation option development described above are based on a version of the proposed Scheme, which has subsequently been slightly modified for the final design. The design changes have been reviewed and it has been concluded that these would not affect the selection of the preferred mitigation option. The only material change in this area is to the shape of the detention pond downstream of C13. The preferred mitigation option has been modelled in conjunction with the finalised proposed Scheme. These results are shown in Diagram 28.

Diagram 28: Option 1 Depth Difference – final proposed Scheme



3.131 Due to the detention pond shape change, there is a greater extent of moderate adverse downstream of culvert C13. However, the ponds are both out of the flood extent and there are no sensitive receptors in this location.

3.132 This storage area would fall under the Reservoirs (Scotland) Act 2011. This requires the registration of all raised reservoirs capable of holding more than 25,000m^3 of water above the natural level of the surrounding ground. However, it is recognised that in the future, waterbodies containing more than 10,000m^3 may fall under the Act.

3.133 The arrangements for reservoir safety are based on a risk-based approach. The risk categorisation of the embankments cannot be established until detailed design is undertaken, but given the proximity to the proposed Scheme, the Aberdeen to Inverness Railway Line and Inverness Airport, it is likely to be categorised as 'Medium 'or 'High' risk. Under the Act, a formal maintenance regime would need to be established with regular inspections by a Reservoirs Engineer.

3.134 The area of major adverse flood impact shown on Diagram 28 upstream is a result of the proposed culvert C13. However, the proposed Scheme road level is 1m above the peak water level at this location.

3.135 With Option 1, the proposed Scheme would not be at risk of flooding in the 0.5% AEP (200-year)+CC design flood event and it would have the residual impact of reducing flood risk downstream, including the flood risk to sensitive rail and airport receptors.

3.136 For the purposes of the DMRB Stage 3 Assessment, SWF16 has been identified as being of very high sensitivity. The proposed Scheme mitigation includes a storage area with a maximum increase in depths of 1.8m, however no sensitive receptors are affected, and the increase in depth is a desired outcome of the design. At the crossing of the watercourse and the proposed scheme at C13, the localised increase in flood levels would result in a major magnitude but a freeboard of 1m at this location removes the proposed Scheme as consideration as a sensitive receptor. Downstream of the proposed Scheme, beneath the railway and to the airport culverts, the mitigation lowers water levels resulting in a minor beneficial magnitude. On balance between the upstream and downstream changes to flood levels along the watercourse, the impact is assessed as negligible magnitude. This results in an impact of Neutral significance.

Blockage Assessment

3.137 Blockage runs of 50% and 90% have been applied to the flow control culvert C14 and the dual carriageway culvert C13.

3.138 A blockage of 50% on culvert C14 results in flood water levels increasing by 0.1m immediately upstream of the culvert. This increase in water level is lower than the embankment level and will therefore be contained. The increase in water level does not increase flood risk to the proposed Scheme or properties.

3.139 Blocking culvert C14 by 90% increases water levels by 0.34m immediately upstream of the culvert, when compared to the 'with-mitigation' scenario. This leads to the embankment overtopping and flooding of the proposed Scheme. There are no flood sensitive receptors here other than the proposed Scheme.

3.140 The results of the 50% blockage scenario show an increase in water level of approximately 0.21m upstream of the culvert C13, compared with the 'with-mitigation' scenario. Due to the steep nature of the flood plain at this location, there is only a minimal increase in flood extent.

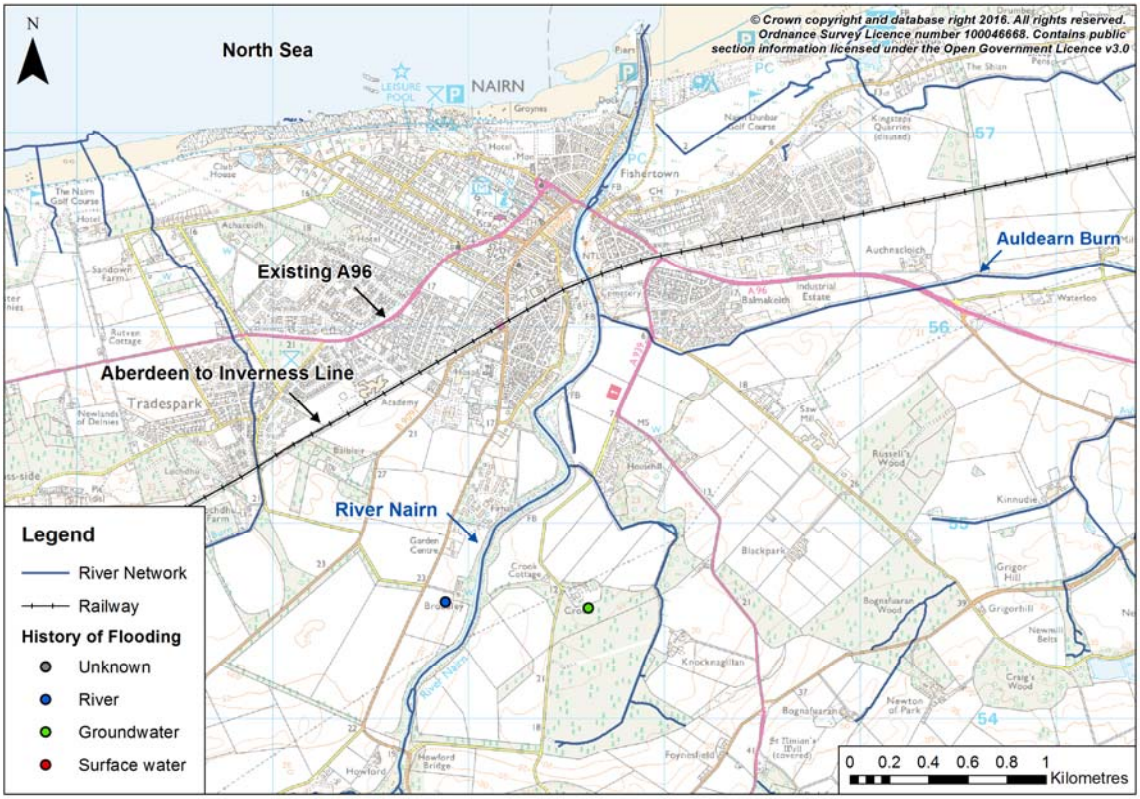
3.141 A 90% blockage of culvert C13 would result in water levels increasing by 1.59m compared to the 'with-mitigation' scenario. This change in water level leads to an increase in flood extent by 190m on the left bank and 109m on the right bank. However, there are no sensitive receptors within this location.

3.142 It is likely that a maintenance regime will be established for C14 under the Reservoirs Act. Therefore, it is unlikely that 50% or 90% blockage would occur at this location. As there are no sensitive receptors at risk, a reactive maintenance would be implemented for C13.

River Nairn (SWF23-1)

3.143 The River Nairn rises in the Monadhliath Mountains at an elevation of approximately 800m and flows north-east to the sea at Nairn, a distance of approximately 36 miles. At the point it is crossed by the proposed Scheme the river has been joined by all major tributaries. Locally upstream of the proposed crossing point the river is active and falls through a wooded valley. The proposed crossing point is at a narrowing of the river valley. Downstream of the proposed crossing the valley opens out, and the river becomes tidal as it passes through the urban area of Nairn (Diagram 29).

Diagram 29: River Nairn Location Plan



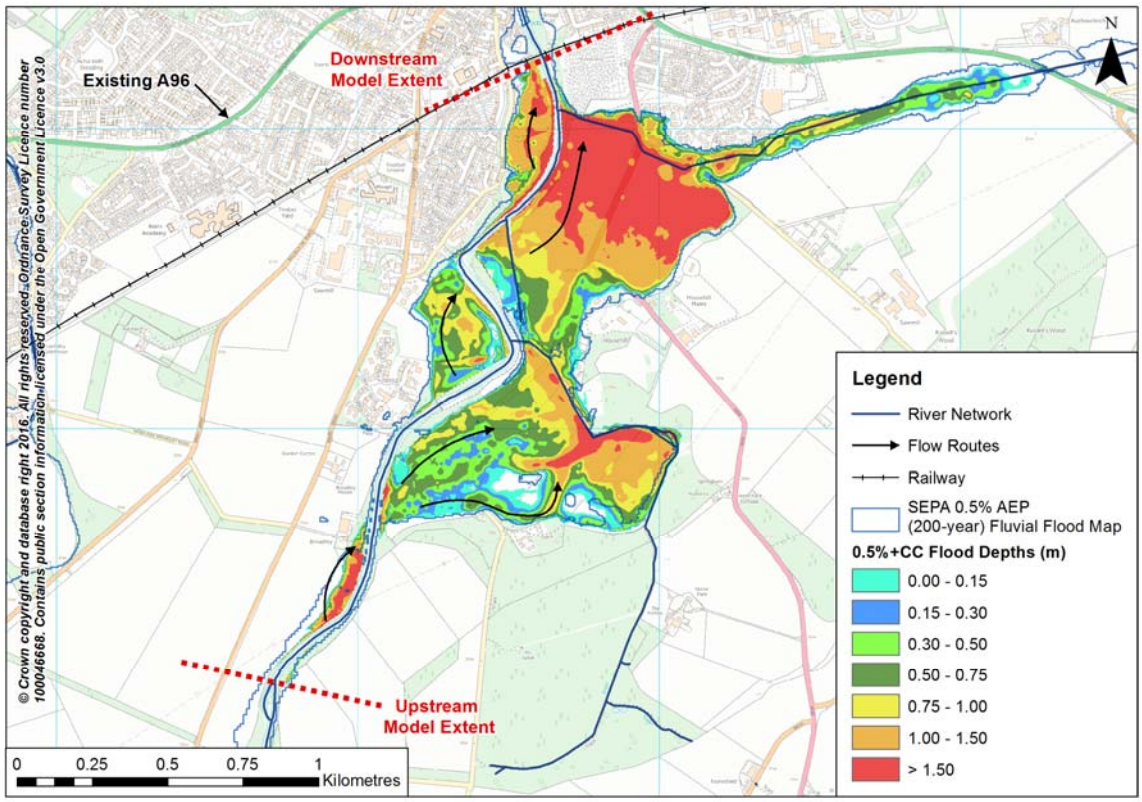
3.144 The history of flooding provided by The Highland Council for the area of interest is outlined below (Diagram 29):

- one groundwater incidence referring to boggy land; and
- one fluvial flood event refers to the inundation of fields and a property within the flood plain.

Baseline Flood Risk

3.145 Diagram 30 shows the baseline scenario for the River Nairn, based on hydraulic modelling.

Diagram 30: River Nairn Baseline



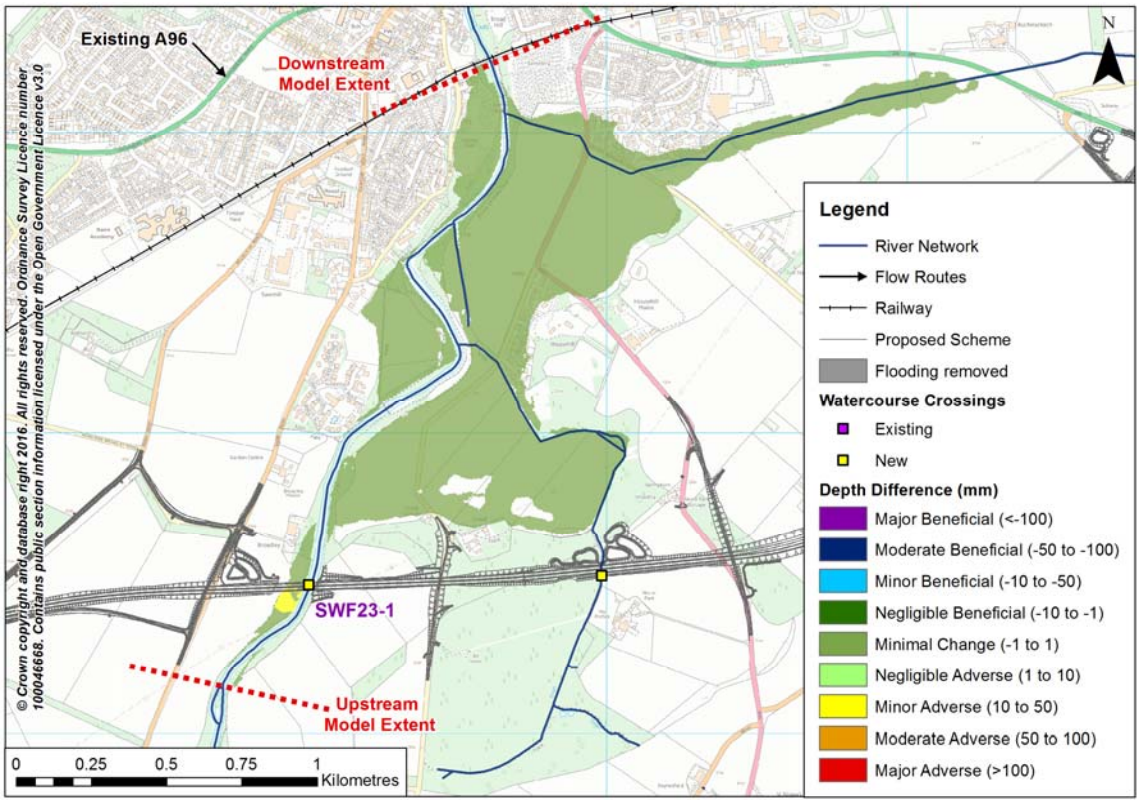
3.146 Within the focused area (circled in the Diagram above), the right bank is higher than the left bank and causes water to utilise the left hand flood plain and flows back in channel further downstream.

3.147 The nearest property is located approximately 5m above the 0.5% AEP (200-year)+CC flood level and therefore this property is not at risk of fluvial flooding.

'With-Scheme' Flood Risk

3.148 The proposed crossing over the River Nairn is a new bridge with two piers (PS14: River Nairn Underbridge). Diagram 31 illustrates the 'with-scheme' scenario (without any mitigation) for the River Nairn.

Diagram 31: River Nairn 'With-Scheme'



3.149 To mitigate against the potential impact of restricting the flows of the River Nairn, the proposed crossing is a new bridge, which has been designed to allow the 0.5% AEP (200-year)+CC flow to pass through.

3.150 The bridge includes two abutments set back from the river channel and two piers that are located within the flood plain. Due to this arrangement, one of the piers has a minor adverse impact, as indicated by the yellow area on the left bank on Diagram 31. The pier causes a small increase in water depth (14mm) immediately upstream of its location. The increase in water depth reduces to zero 60m upstream and there are no changes in flood level elsewhere. No sensitive receptors are affected by the localised change in level.

3.151 For the purposes of the DMRB Stage 3 Assessment, SWF23 has been identified as being of very high sensitivity due to the town of Nairn being located downstream of the bridge crossing. The proposed Scheme increases water levels by 14mm local to the bridge crossing and this impact is assessed as being minor, resulting in an impact significance of Moderate. However, given that there are no flood sensitive receptors within the affected area (90m local to the bridge), and the nearest property is located downstream 156m away, the impact magnitude at the receptor is negligible, and the impact significance is Neutral. Hence no mitigation measures are considered necessary at this location.

Blockage Assessment

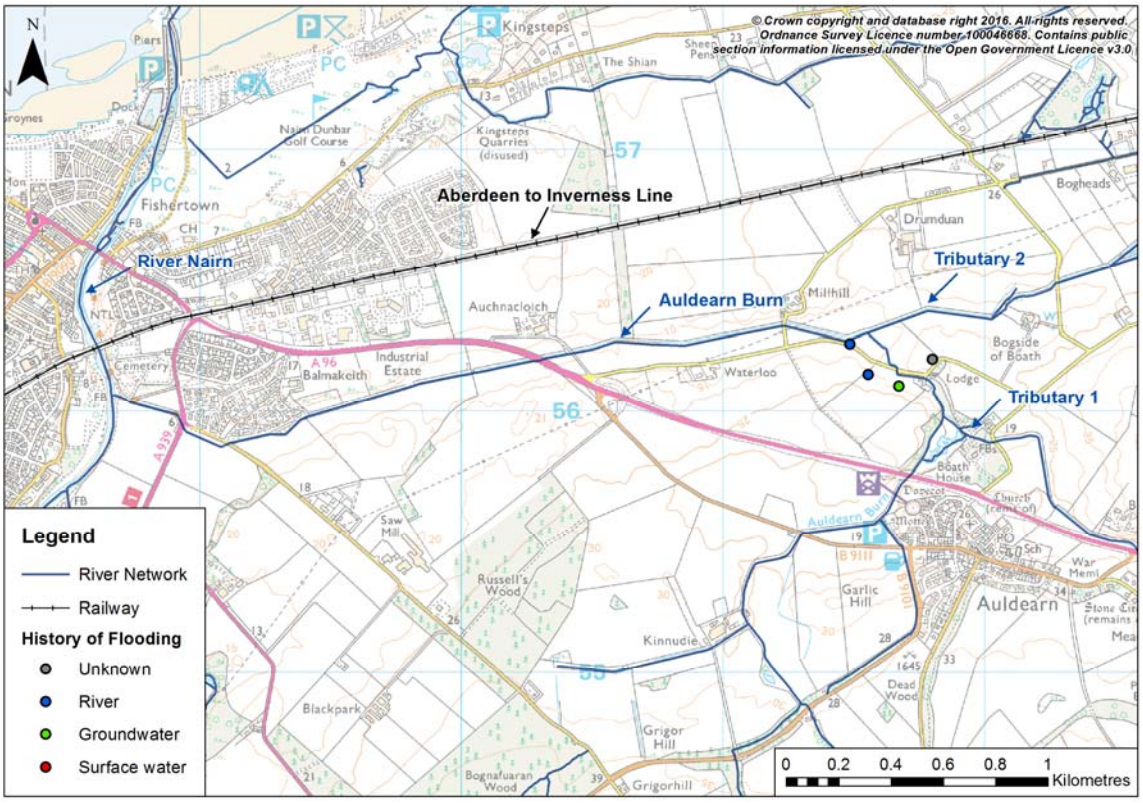
3.151.1 Due to the design and size of this crossing, it is unlikely that there would be a significant risk of blockage. Therefore, blockage has been discounted as a residual risk and no further assessment has been undertaken.

Auldearn Burn (SWF26)

3.152 Auldearn Burn comprises of the main river and two tributaries. The main Auldearn Burn rises at Stagachorrie and passes to the west of the village of Auldearn. It is a rural catchment and is joined by

a small tributary (Tributary 1), which rises to the south-east of Auldearn and passes to the east of the village. The two join approximately 370m upstream of where the proposed Scheme would cross the watercourse. Auldearn Burn is joined by a second tributary (Tributary 2) 80m downstream of the proposed Scheme crossing, which drains low lying agricultural land. Auldearn Burn continues in a straightened channel to its confluence with the River Nairn (Diagram 32).

Diagram 32: Auldearn Burn Location Plan



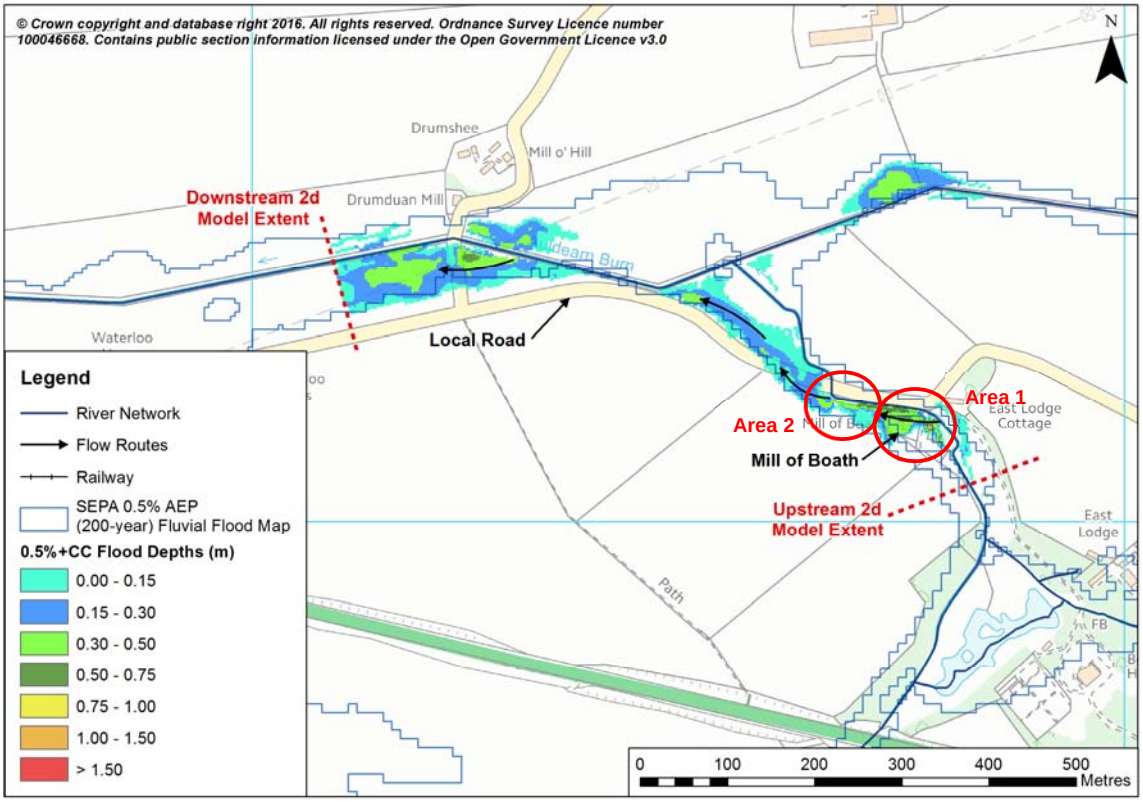
3.153 The history of flooding provided by The Highland Council for the area of interest is outlined below (Diagram 32):

- one groundwater incidence at the Mill of Boath property where the flooding from the burn occurred due to high water table;
- one incidence from an unknown source in 1997; and
- two fluvial flooding incidences state that there is a history of flooding in the area and it has been recorded that dredging has to helped to reduce the flood risk.

Baseline Flood Risk

3.154 Diagram 33 illustrates the baseline scenario for Auldearn Burn based on hydraulic modelling.

Diagram 33: Auldearn Burn Baseline



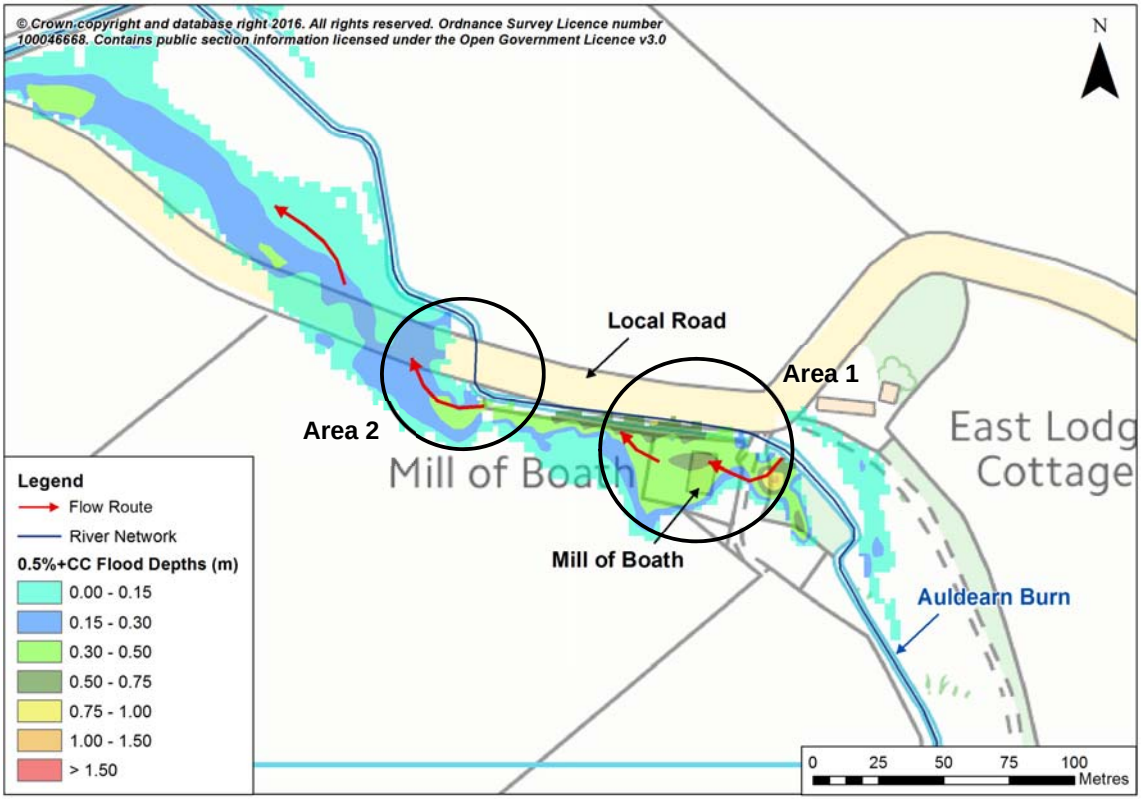
3.155 At Area 1, shown on Diagram 33, the hydraulic model indicates that there is a property at risk of fluvial flooding in the baseline situation. The flooding is related to a bridge across the watercourse that is used to provide access to the property (the Mill of Boath).

3.156 The bridge has insufficient capacity to freely pass the peak design flood flow and the model indicates that Auldearn Burn would overtop its left bank during the 3.33% AEP (30-year) flood event. Once out of bank, floodwater flows across the flood plain and floods the property before it re-enters the channel further downstream.

3.157 The culvert downstream of this location, under the local road (Area 2), restricts the 0.5% AEP (200-year)+CC flow of Auldearn Burn and causes water to overtop on the left bank. The water flows over the local road and re-enters Auldearn Burn further downstream.

3.158 Diagram 34 shows Areas 1 and 2 in more detail.

Diagram 34: Auldearn Burn Areas 1 and 2

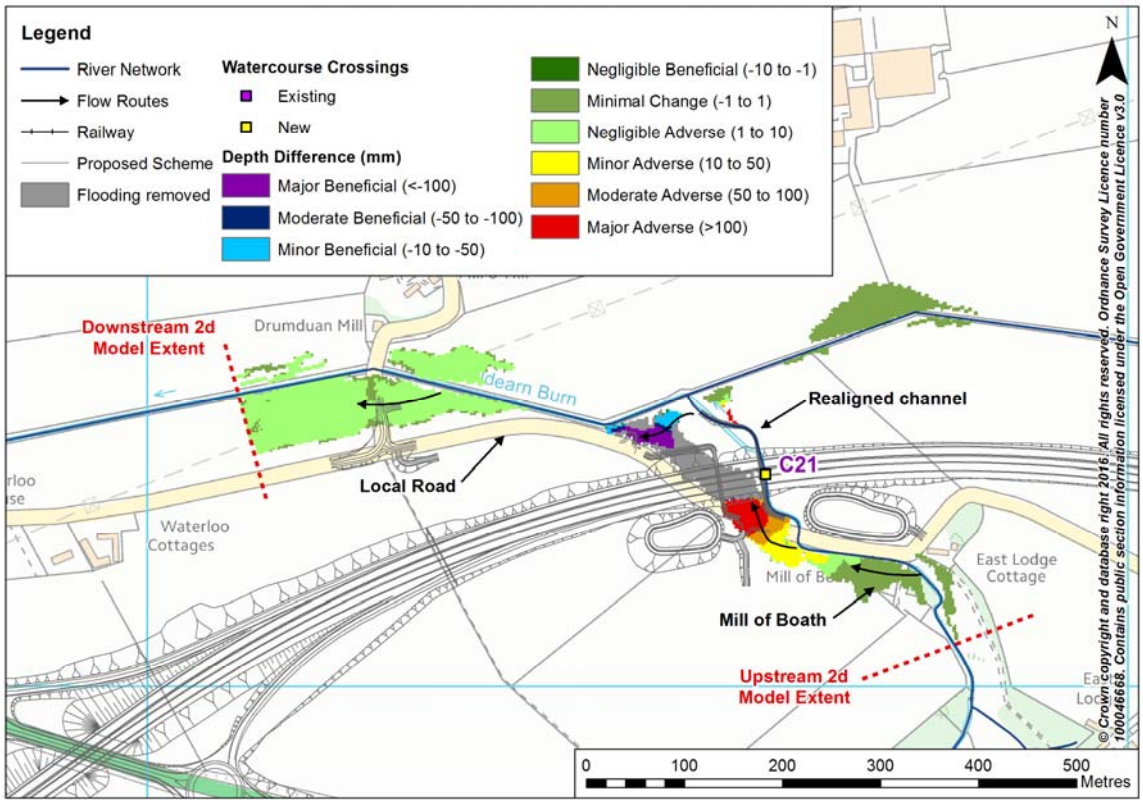


3.159 The property at Mill of Boath, a flood sensitive receptor, is currently located within an area at risk of flooding during the 0.5% AEP (200-year) +CC flood event.

'With-Scheme' Flood Risk

3.160 The proposed road crossing of the Auldearn Burn includes a new culvert and realignment of the watercourse downstream of the proposed Scheme. Diagram 35 shows the depth difference of the 'with-scheme' scenario (without any mitigation) compared to the baseline for Auldearn Burn.

Diagram 35: Auldearn Burn 'With-Scheme'



3.161 The proposed dual carriageway culvert (C21) would be designed to freely pass the 0.5% AEP (200year)+CC design event in accordance with DMRB guidelines. The dimensions of the culvert would be 3m wide by 2m high.

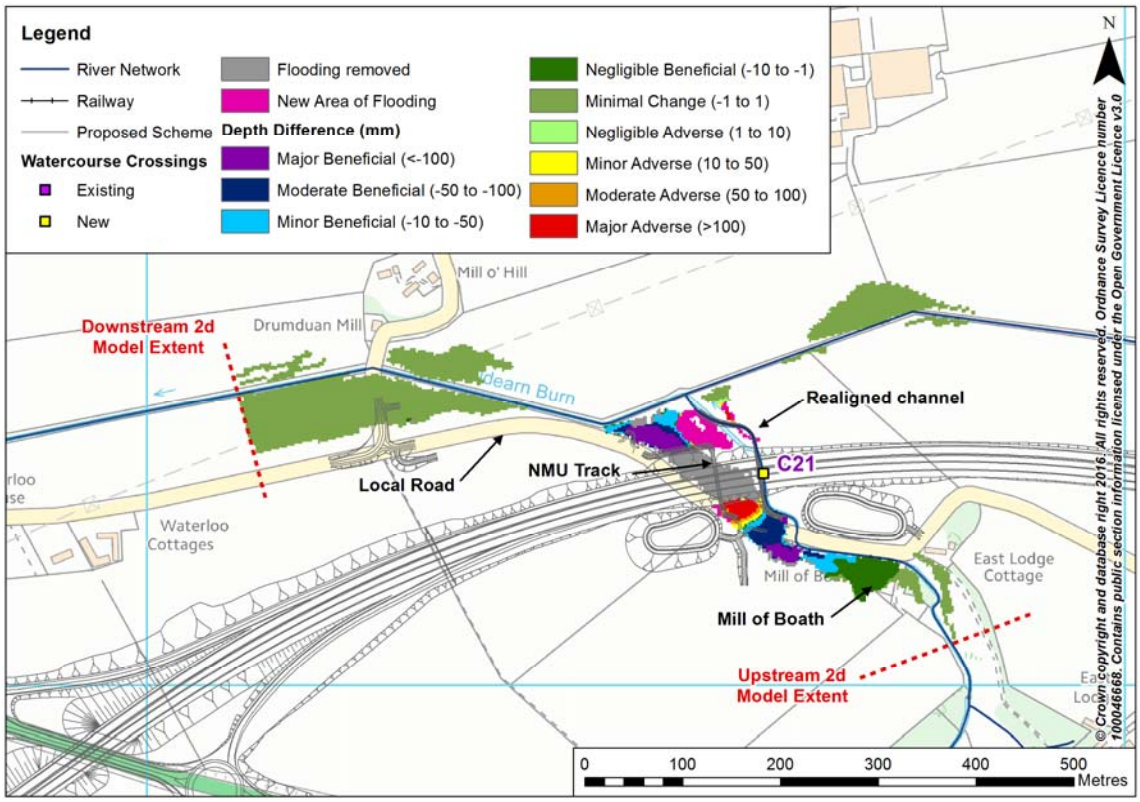
3.162 In addition, the proposed Scheme would cross the flood plain in this area and the dual carriageway would interrupt the flood plain conveyance. This interruption would result in water ponding against the proposed embankment with water level increasing by 0.7m above the baseline scenario, and the road embankment would need to be designed and constructed to account for this. The proposed Scheme road level would be 3.1m above the maximum peak level at this location. This change in mechanism has a backwater effect of 140m, and would not change the flood risk at the Mill of Boath property.

3.163 The modelling indicates that the dual carriageway embankment of the proposed Scheme would be at risk of flooding from impounding in the 0.5% AEP (200-year)+CC design flood event with an increase in water level immediately upstream of the dual carriageway embankment. Therefore, further flood mitigation is considered.

'With-Mitigation' Flood Risk

3.164 Diagram 36 shows the 'with-mitigation' scenario for Auldearn Burn.

Diagram 36: Auldearn Burn 'With-Mitigation'



3.165 To match the in-channel water levels, the channel immediately upstream of the culvert has been widened from 3m to 5m and would include a 2-stage channel. The culvert itself has also been increased in size to reduce the increase in water levels. A revised culvert of 5m wide by 2m high and 60m long would pass a peak flow of 10.3m^3/s in the 0.5% AEP (200-year)+CC design flood event.

3.166 The increase in water backing up at the culvert is approximately 0.7m in the 0.5% AEP (200-year)+CC event with no mitigation in place. With the culvert and channel widened, this would reduce to 0.55m. In this scenario the proposed Scheme road level would be 3.25m above the modelled peak water level.

3.167 A NMU track is proposed to cross under the dual carriageway in this area of flood plain in a separate culvert and this would act as a flow route during major flood events. This leads to a new area of flooding downstream of the proposed Scheme, compared to the baseline scenario, (Diagram 36). There are no sensitive receptors in this location. The flow entering the watercourse downstream of the proposed Scheme has reduced by 0.01m^3/s in the 0.5% AEP (200-year)+CC design flood event from the baseline scenario.

3.168 As shown on Diagram 36, the modelling predicts that there would be no change to the flood risk to the property at Mill of Boath.

3.169 For the purposes of the DMRB Stage 3 Assessment, Auldearn Burn (SWF26) has been identified as being of high sensitivity. The new culvert increases water levels by 0.55m immediately upstream of the proposed Scheme, but the road level would be 3.25m above the modelled road level and this removed it from consideration as sensitive receptor for this watercourse. At the location of the closest property to the Auldearn Burn, the change in flood level is negligible magnitude. This results in an impact of Neutral significance.

Blockage Assessment

3.170 A 50% blockage to culvert C21 would result in an increase in water level of 0.05m at the road embankment and extend approximately 140m upstream. At the Mill of Boath property, the water level is predicted to increase by 0.01m when compared to the 'with-mitigation' scenario.

3.171 A 90% blockage to culvert C21 would result in an increase in water level of 0.9m at the road embankment and extend approximately 250m upstream. The proposed Scheme would be approximately 1.5m above this water level. The 90% blockage results in an impact on water levels for a length of 250m upstream. At the Mill of Boath property, the water level is predicted to increase by 0.01m when compared to the 'with-mitigation' scenario.

Blockage of Existing Structures

3.172 A high-level qualitative screening assessment was undertaken to determine if the proposed Scheme would be at risk if an existing structure downstream became blocked.

3.173 This assessment focused on existing structures 1km downstream of the proposed Scheme. The invert outlet levels of the proposed culverts were used to compare to the crest level of the existing structures. Where the crest level of the existing structures were below the invert level of the proposed culverts, the assessment assumed that a blockage of this structure would not have a back water affect that could impact on the proposed Scheme.

3.174 However, where the existing structure crest levels were above the proposed invert levels, further analysis was undertaken. This further analysis included the following tasks.

- Elevation data was investigated to determine if there was another route for the water to go, indicating that it was unlikely that the proposed Scheme would be affected.
- In locations where the water could not go anywhere else, an analysis on whether the blockage would occur at the existing structure or if a structure upstream of this would be the blockage control, reducing the risk of blockage at that particular structure.
- If the existing structure was still imposing a risk to the proposed Scheme, an analysis on volume available was undertaken. Based on elevation data of where water would pond, it was determined if there was sufficient volume naturally available, so that the proposed Scheme would not be affected.

3.175 After this further analysis, it was determined that none of the existing structures would impose a risk to the proposed Scheme, if they were to become blocked. Refer to Annex 13.2.J (Existing Structure Screening Assessment) for the detailed results.

Minor Watercourses

3.176 Within the study area, 16 minor watercourses drain the adjacent land and flow underneath the proposed Scheme towards Moray Firth. The range of 0.5% AEP (200-year)+CC flows within the watercourses range between 0.1 m^3/s – 5.0m^3/s.

3.177 In addition to the 16 minor watercourse crossings, there are 18 culverts that relate to existing infrastructure (e.g. the existing A96), which could be affected by the proposed Scheme. Therefore, 34 culverts were assessed. Refer to Annex A13.2.H (Minor Water Assessment) for further information on this assessment.

Assessment Methodology

3.178 For each of the 34 culverts (new and existing), the channel capacity has been assessed and compared against the design peak flow. A conservative approach to calculating the capacity has been used as a precautionary measure (i.e. channel capacities have been underestimated). The flow was calculated using the Flood Estimation Handbook (FEH) (Centre for Ecology and Hydrology 1999)

statistical method. For further information on the hydrology, refer to Annex A13.2.G (Hydrology Report).

3.179 Where the assessment has determined that channel capacity is greater than the flow and there is no flood plain present, the proposed culvert has been sized to take the full 0.5% AEP (200-year)+CC flow following the DMRB design standards. Consequently, the proposed Scheme would not be at flood risk and it would not increase flood risk elsewhere, as it would not impede flows or result in a loss of flood plain.

3.180 Where the channel capacity assessment has determined that the volume of flow cannot be accommodated in channel, a simple routing model has been constructed. The extent of the flood plain has been determined based upon the water levels predicted in the model and topographic data (survey or LiDAR). Note that the channel capacity assessment included structures such as existing railway crossings.

3.181 If the proposed Scheme would not impact upon any area of identified flood plain, the proposed Scheme would not be at risk of flooding itself, or have an impact of flood risk elsewhere

3.182 However, if the proposed Scheme crosses any areas of the flood plain in the baseline situation, the model was updated to include the proposed Scheme and identify its impacts and more detailed investigations were undertaken to assess mitigation. Appropriate mitigation measures are included, where necessary in the proposed Scheme.

Results of Assessment

3.183 The preliminary assessment of channel capacity against predicted flow has indicated that 18 culverts would remain in-channel. Consequently, the proposed crossings were sized to pass the 0.5% AEP (200-year)+CC flow and no further assessments were required.

3.184 The remaining 16 culverts were assessed using a simple routing model, and this exercise indicated that four minor watercourse crossings could be adversely impacted by the proposed Scheme and would require mitigation. These watercourses are identified on Diagram 37 and the results of this assessment is summarised below in Table 4.

Diagram 37: Location of high-risk minor watercourses

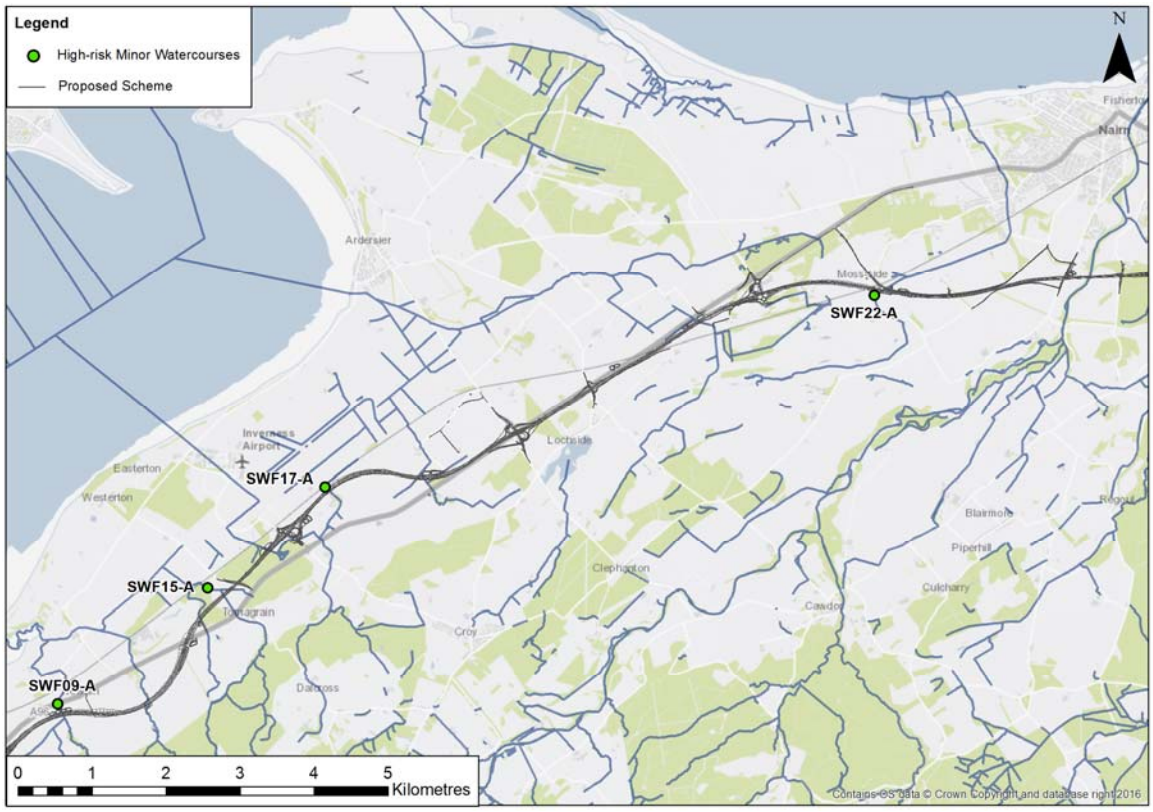


Table 4: Summary of Flood Risk - Minor Watercourses

Culvert	Further Assessment
SWF09-A Newton Burn	**Impact** An existing culvert (SWF09-A) under the existing A96 restricts the 0.5% AEP (200-year)+CC flow and causes water to back up and pond upstream of the existing A96. In this location the proposed Scheme consists of four detention ponds which displace approximately 1,100m^3 and increase the peak water level by 0.037m on the right bank and 0.363m on the left bank. The proposed Scheme increases the flood risk to the existing A96, which is approximately 0.3m higher than the maximum water level. The proposed Scheme is located approximately 1.5m above the maximum water level and is considered to be at a low risk of fluvial flood risk. **Mitigation** To achieve a neutral flood impact, compensatory storage has been included on both the left and right banks, to extend the current flood plain area. This will provide the same response as the current floodplain. **Summary** For the purposes of the DMRB Stage 3 Assessment, SWF09-A has been identified as being of very high sensitivity. The proposed scheme increases water levels by 0.363m, a major magnitude impact. This is an impact of very large significance. However, with mitigation the magnitude of impact will be negligible, hence the impact significance will be Neutral.

Culvert	Further Assessment
SWF15-A Tornagrain Wood	**Impact** With the proposed Scheme in place, there is a marginal increase in water level of 0.018m within the flood plain, which is caused by the proposed Scheme footprint being placed on the existing flood extent. This increase will not have any significant impact on the status of the woodland and use of the agricultural land. However, there is also a slight increase in the net pass forward flow. This may increase the flood risk immediately downstream, in particular the existing Aberdeen to Inverness Railway Line. **Mitigation** Two possible options have been considered: • provide compensatory storage to achieve a neutral impact; and • do-nothing and allow a marginal increase in flood risk and pass forward flow at this location. <u>Compensatory Storage</u> Additional compensatory storage could be provided by increasing the size (sectional area) of the channel beyond the left hand bank encroaching into the agricultural land (from 0.5m to 1.5m). This may require the formation of a two-stage channel. <u>Do-Nothing</u> With the do-nothing option the flood water is predicted to pond against the Aberdeen to Inverness Railway Line embankment. This is also shown on SEPA's flood map (SEPA 2015a). Peak water level is predicted to increase 0.092m against the baseline scenario. However, the simple hydraulic model employed in the assessment does not incorporate the Aberdeen to Inverness Railway Line culverts which would allow additional flows to pass through. Consequently, this assessment is considered to be a conservative estimate. The Aberdeen to Inverness Railway Line is likely to have over 1m of freeboard, and a minor increase in levels of a maximum 0.092m are not likely to compromise the operation of the railway. Given that the loss of woodland is undesirable, the use of the agricultural land and operation of the Aberdeen to Inverness Railway Line are unlikely to be affected by a marginal increase in water level and pass forward flow at this location, it is currently proposed that no further mitigation measures are proposed. **Summary** For the purposes of the DMRB Stage 3 Assessment SWF15-A has been identified as being of very high sensitivity due to the proximity of the railway and the proposed Scheme as flood receptors. The proposed Scheme increases in channel water levels by 0.80m at the proposed Scheme and 0.092m at the railway culverts. This would result in a moderate magnitude impact of Large significance, but the presence of 1m freeboard is sufficient to reduce the sensitivity of the receptor at this location. The DMRB Stage 3 Assessment is based on the 0.018m increase in water levels within the floodplain adjacent to the proposed Scheme, a minor magnitude impact. This is an impact of Moderate significance if judged against the proposed Scheme, but the baseline condition does not feature the proposed scheme, and the change is only experienced by the woodland area, which is of low sensitivity, resulting in an impact of Neutral significance.
SWF17-A Culblair	**Impact** The restriction of the Aberdeen to Inverness Railway Line culvert in this location, causes water to back up and pond on the right bank, adjacent to the railway line. The proposed Scheme displaces approximately $9m^3$ of water and causes the peak water level to increase by 0.029m in a grassland area with no sensitive receptors. The proposed Scheme is located approximately 8m above this water level and the Aberdeen to Inverness Railway Line is approximately 0.05m above the maximum water level. **Mitigation** Given the small volume of flood water displaced by the proposed Scheme and confined area of flood risk, it is proposed that care is taken when locating the toe of the road embankment in relation to the railway embankment, such that the hydraulic connectivity in this area is not compromised and where possible the ground between the two embankments is lowered slightly to accommodate the small volume of displaced flood water. **Summary** For the purposes of the DMRB Stage 3 Assessment, SWF17-A has been identified as being of high sensitivity. The proposed scheme increases water levels by 0.779m within channel and 0.029m within the right bank floodplain. The latter is considered to be a moderate magnitude impact. This results in an impact of Moderate significance. Appropriate mitigation at detailed design is likely to remove this impact.

Culvert	Further Assessment
SWF22-A Alton Burn	**Impact** With the proposed Scheme in place, water levels increase by 0.002m as the proposed Scheme is displacing water in the flood plain. The small increase of 0.002m is considered a negligible impact, however it does represent a slightly elevated risk to the Aberdeen to Inverness Railway. The proposed Scheme is located approximately 9m above the maximum water level, therefore the proposed Scheme is at a low risk of fluvial flooding. **Mitigation** Given that there is unlikely to be an impact on the use of the agricultural land and operation of the Aberdeen to Inverness Railway Line due to a 0.002m increase in water level, no further mitigation measures are proposed at this location. **Summary** For the purposes of the DMRB Stage 3 Assessment SWF22-A has been identified as being of high sensitivity. The proposed scheme increases water levels by 0.19m within channel and 0.002m within the left bank floodplain. The changes in floodplain water level are considered more significant in terms of flood risk, and result in a negligible magnitude impact. This is an impact of Neutral significance.

3.185 The minor increases in depths associated with the above culverts have been fully investigated and mitigation measures proposed where appropriate. It is concluded that there are negligible impacts of the proposed Scheme.

4 Surface Water Flood Risk

Introduction

4.1 Surface water (pluvial) flooding usually occurs when the capacity of the ground surface or urban drainage network is exceeded during extreme rainfall events. Excessive surface water runoff itself may pose a flood risk especially if running at high velocity. Localised depressions in the ground topography may result in the ponding of water, sometimes to a significant depth.

4.2 The permeability of the soil type or geology can affect the amount of runoff, whist the capacity and condition of the drainage network can affect how much water remains on the surface. The topography of the land and location of urban features such as buildings and road networks can also influence surface water risks by increasing the velocity of overland flow and depth of ponding.

Baseline Conditions

4.3 Steep hillsides can be found south of the existing A96 and these are likely to generate significant volumes of runoff during a high intensity rainfall event that would flow towards the proposed Scheme. There are also areas of flat land, which would be prone to ponding, especially where there are localised depressions surrounding existing infrastructure, for example the Aberdeen to Inverness Line or the existing A96.

<u>Baseline Assessment Methodology</u>

4.4 To predict the likely route of surface water runoff, ArcGIS was used to undertake a ‘rolling ball analysis’ to identify overland flowpaths by using topographic data from a Digital Terrain Model (DTM).The method was chosen as it provides a good level of detail regarding the location of routing pathways and is one of four methods described in Defra’s Surface Water Management Plan Technical Guidance (Defra 2010).

4.5 The rolling ball technique produces a series of theoretical flowpaths, otherwise known as a surface water routing network. Essentially, the flow path generated represents the path of ‘low spots’ over the ground along which water would flow if the ground was impermeable.

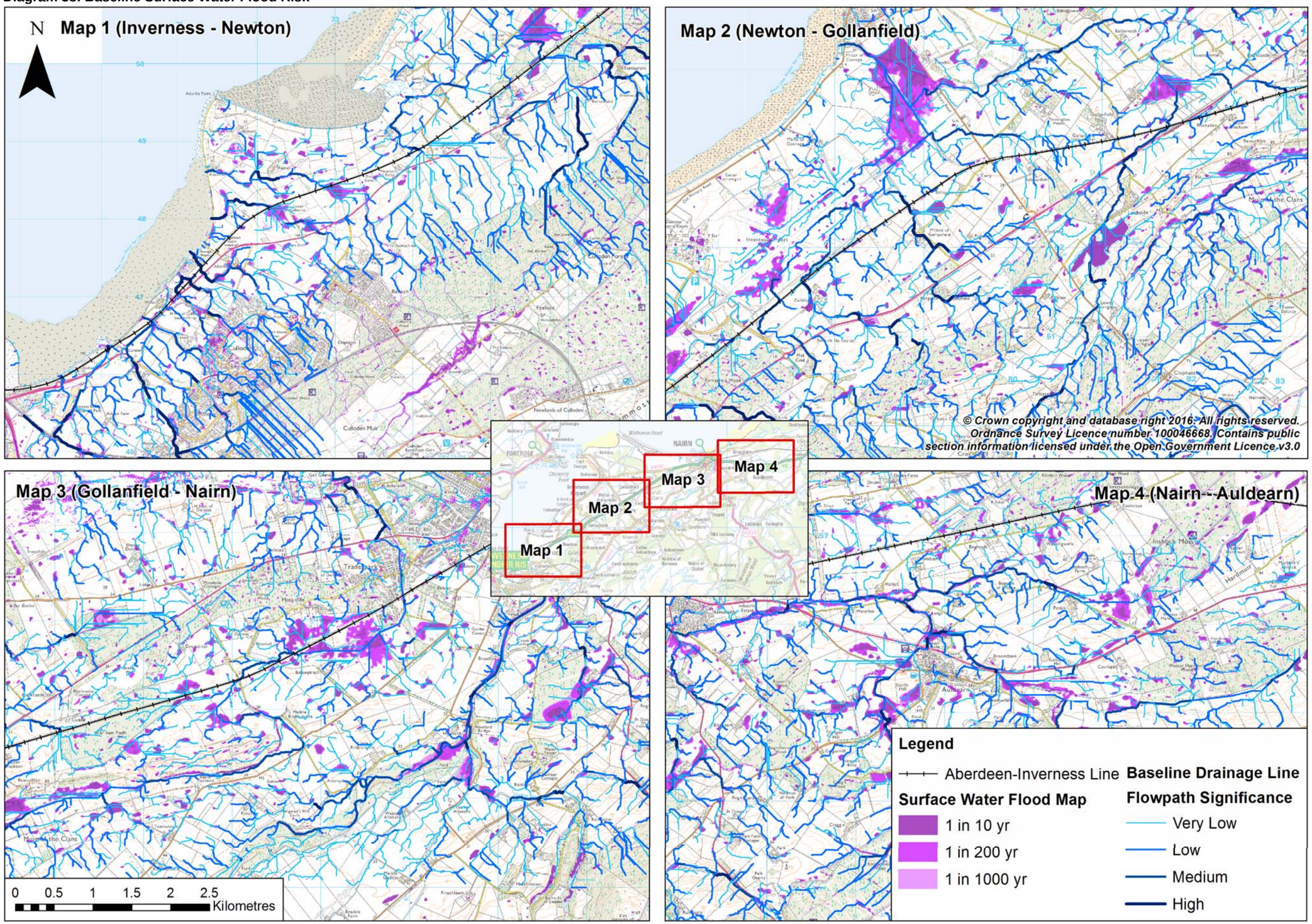
4.6 Areas at particularly high risk of surface water flooding have been identified based upon the catchment area and gradient of the flowpaths within that location. Flowpaths that are as a result of a steep gradient and/or a large catchment area results in a high flowpath significance. The flowpath significance helps to determine the level of hazard that the surface water flow route may impose to a receptor.

4.7 It should be noted that a full detailed Digital Terrain Model (DTM) was not available for the entire potential surface water catchment. However, the areas with poor coverage are at the extremities of the DTM and are unlikely to have a significant impact on the assessment. Furthermore, a conservative approach has been applied as every potential flowpath, regardless of hazard, has been investigated in more detail.

Baseline Results

4.8 The results of the surface water analysis is shown on Diagram 38.

Diagram 38: Baseline Surface Water Flood Risk



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Assessment of Impacts

4.9 To determine the impacts of the proposed Scheme on the baseline surface water flowpaths, another rolling ball analysis was undertaken with the road elevations of the proposed Scheme stamped onto the baseline DTM.

4.10 The 'with-scheme' flowpaths, along with the SEPA surface water flood map, were used to determine the impact on the surface water flood risk to and from the proposed Scheme. This impact assessment was undertaken in a separate technical note, which can be found in Annex A13.2.I (Surface Water Impact Assessment), however the high-risk flowpaths can be seen on Diagram 38.

4.11 Annex A13.2.I (Surface Water Impact Assessment) has outlined a number of mitigation measures required to make sure that the proposed Scheme does not increase surface water flooding to the proposed Scheme itself and elsewhere. These mitigation measures are outlined in the following section.

Design Changes and Mitigation measures

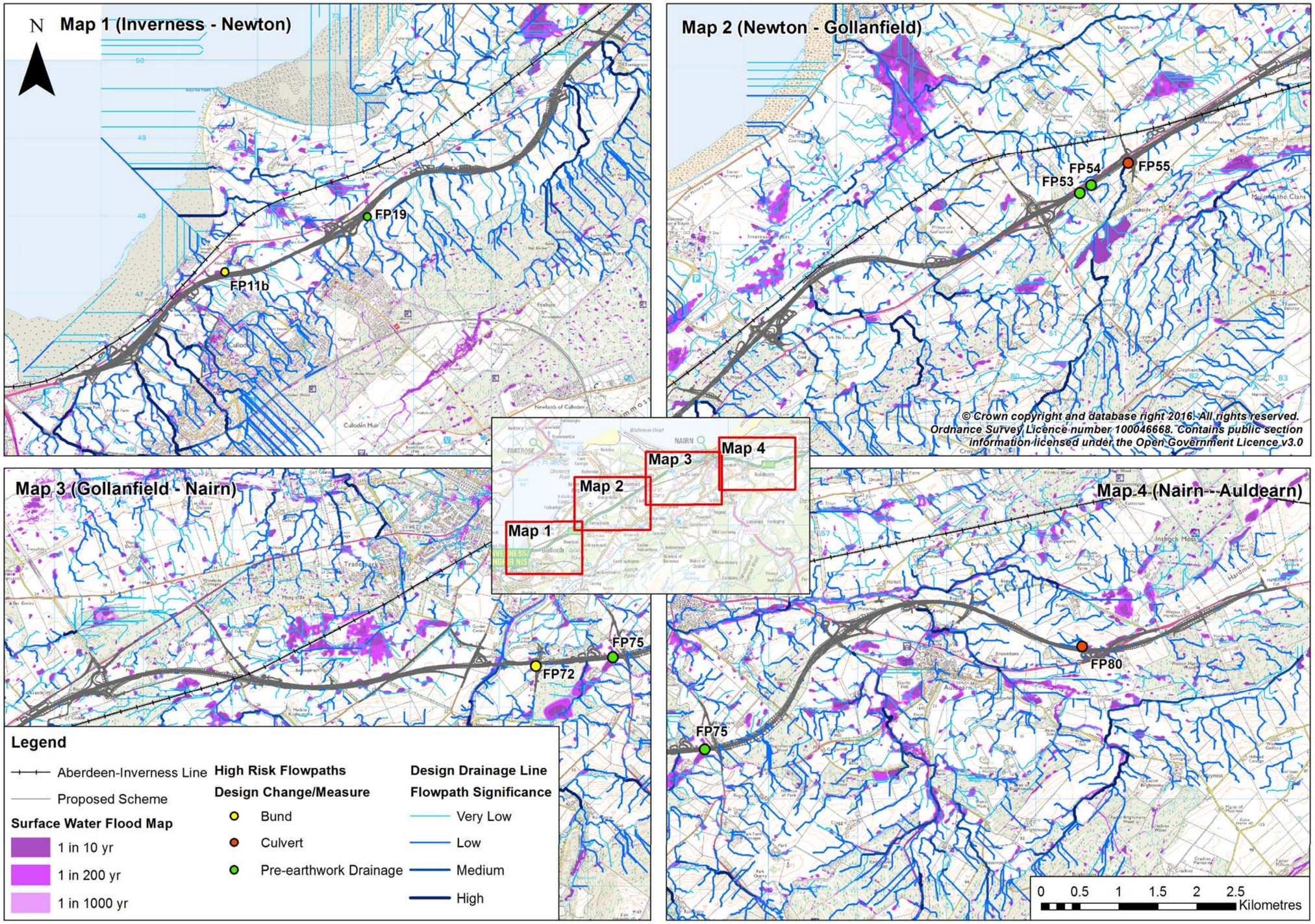
4.12 A number of design changes and mitigation measures were incorporated in the design based on the outputs of the rolling ball analysis. These were:

- additional pre-earthwork drainage to the toe of the embankment, which drain to nearby watercourses or detention ponds;
- earth bunds to hold water back and slowly release into the proposed drainage system; and
- new dry flood relief culverts to allow the water to flow under the proposed Scheme as it would have done in the baseline scenario.

4.13 Further information on these design changes and mitigation measures are contained in Annex A13.2.I (Surface Water Impact Assessment). The design changes and mitigation measures taken forward for the high-risk flowpaths, can be seen on Diagram 39.

4.14 It is considered that with the above design changes and mitigation measures in place, the risk of surface water flooding is low.

Diagram 39: High-risk Flowpaths



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5 Groundwater Flood Risk

Introduction

5.1 Groundwater flooding occurs where water levels, beneath the ground, rise above the ground surface. Flooding can occur where:

- there is a high unconfined water table (permanent or seasonal) and the land is low-lying and/or topographically flat relative to its surroundings;
- ground surface has been altered and groundwater pumping/dewatering has resumed and groundwater rebounds, reaching the surface; and
- a pathway is created with a deeper confined artesian aquifer, and the groundwater pressures are released to the surface.

5.2 Shallow perched groundwater bodies can also contribute to localised flooding, in particular when the presence of low permeability deposits such as clay prevent water from infiltrating into deeper horizons.

Assessment of Baseline Conditions

5.3 Bedrock geology in the study area is generally composed of the Middle Old Red Sandstone. This group is predominantly represented by the Hillhead Sandstone Formation, which is recorded as comprising red and grey quartzose sandstone with interbeds of micaceous siltstone and silty mudstone.

5.4 The 2016 preliminary Ground Investigation (GI) data received to date indicates the depth to bedrock is generally 10m or greater. The Old Red Sandstone is considered a moderately productive aquifer.

5.5 Superficial deposits include made ground, peat, alluvium, a variety of Flandrian and Late Devensian Raised Marine deposits, and Late Devensian glaciomarine and glacial deposits.

5.6 Quaternary sand and gravel superficial deposits across the study area are classified as a locally important aquifer, in which intergranular flow is significant. Areas of alluvium around the River Nairn and the Quaternary coastal deposits to the west constitute a concealed aquifer of limited or local potential.

5.7 Groundwater flow within the superficial deposits is likely to follow surface topography towards the local surface watercourses. The direction of flow of any bedrock groundwater is unconfirmed but is expected to be predominantly towards the coast, to the north-west.

5.8 In order to understand the groundwater flood risk implications of the proposed Scheme, GI have been commissioned. However, at the time of preparation of this draft of the FRA, there is limited data available from GI works, and no pre-existing data of groundwater flooding.

5.9 Full factual results from the 2016 GI have not been received at the time of writing. Only a proportion of the total expected borehole logs, peat probing information, groundwater monitoring data, gas monitoring data, permeability test results, soakaway test results and soil chemical analysis results are available to inform the assessment.

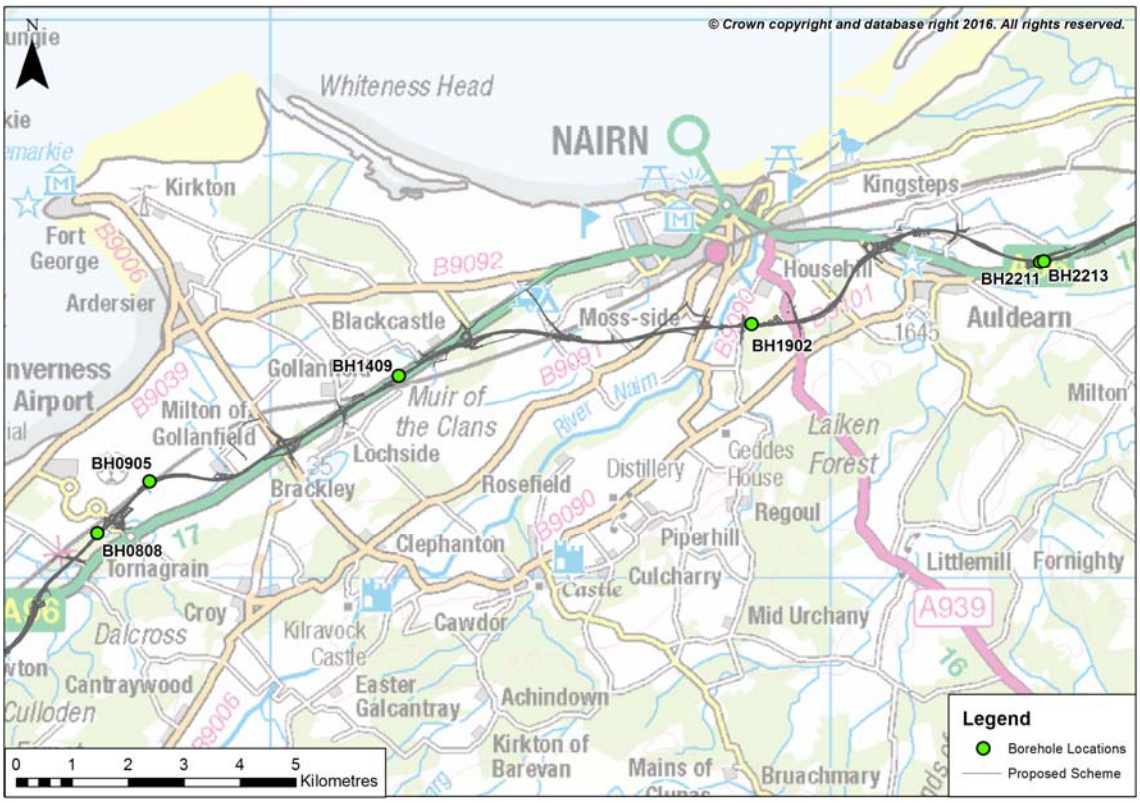
5.10 Survey information for the boreholes installed during the site-specific GI has not yet been received. However, a preliminary screening exercise has been undertaken based on the available information

Screening Results

5.11 A review of groundwater monitoring data recorded to date has been undertaken with a view to identify where maximum groundwater levels are less than 0.4m below ground level. This has included the review of continuous groundwater level monitoring data collected between 5 June 2016 and 25 August 2016 with 25 boreholes using automatic data loggers.

5.12 These locations were then assessed in more detail in relation to their proximity to existing surface water features and areas known to flood to gain a qualitative indication of the likelihood of their potential contribution to flood events. Refer to Diagram 40 for these locations.

Diagram 40: Borehole Locations



5.13 The results of the screening exercise are summarised in Table 5.

Table 5: Groundwater Screening Results

Borehole Ref	Screened Geology	Chainage (May 2016)	Location
BHP0808	Sands and Gravels	9760	The borehole is adjacent to Tributary of Ardersier Burn(SWF16), on the edge of Tornagrain Wood, south-west of Inverness Airport. BHP0808 is located within SEPA 1 in 10 and 1 in 200 year fluvial flood events.
BHP0905	Sands and Gravels	11500	The borehole is adjacent to Drain at Culblair (SWF17) on edge of Tornagrain Wood, south-west of Inverness Airport. BHP0905 is located 110m from the extents of SEPA 1 in 10 year and 1 in 200 year fluvial flood maps.
BHP1409	-	16500	The borehole is adjacent to drain that feeds into Balnagowan Burn(SWF19), south-west of Blackcastle Farm. BHP1409 is located 250m from the extents of SEPA 1 in 10 year and 1 in 200 year fluvial flood maps.
BHP1902	-	23040	The borehole is located in woodlands, east of the River Nairn. It is 360m from the nearest water feature (SWF24 Indirect Tributary of the River Nairn). BHP1902 is located 150m from the extents of SEPA 1 in 10 year and 1 in 200 year fluvial flood maps.
BHP2211	-	28930	The borehole is 370m away from an unnamed water body at Courage Steading, west of Wester Hardmuir Wood. BHP2211 is located 240m from the extents of SEPA 1 in 10 year and 1 in 200 year fluvial flood maps.

Borehole Ref	Screened Geology	Chainage (May 2016)	Location
BHP2213	Silts and Clays	28990	The borehole is 325m away from an unnamed water body at Courage Steading, west of Wester Hardmuir Wood. BHP2213 is located 250m from the extents of SEPA 1 in 10 year and 1 in 200 year fluvial flood maps.

5.14 BHP1902, BHP 2211 and BHP2213 are over 300m from the nearest surface water feature and have therefore been assumed to be too far away to contribute to flood events. The remaining three locations (BHP0808, BHP0905 and BHP1409) are described in more detail below.

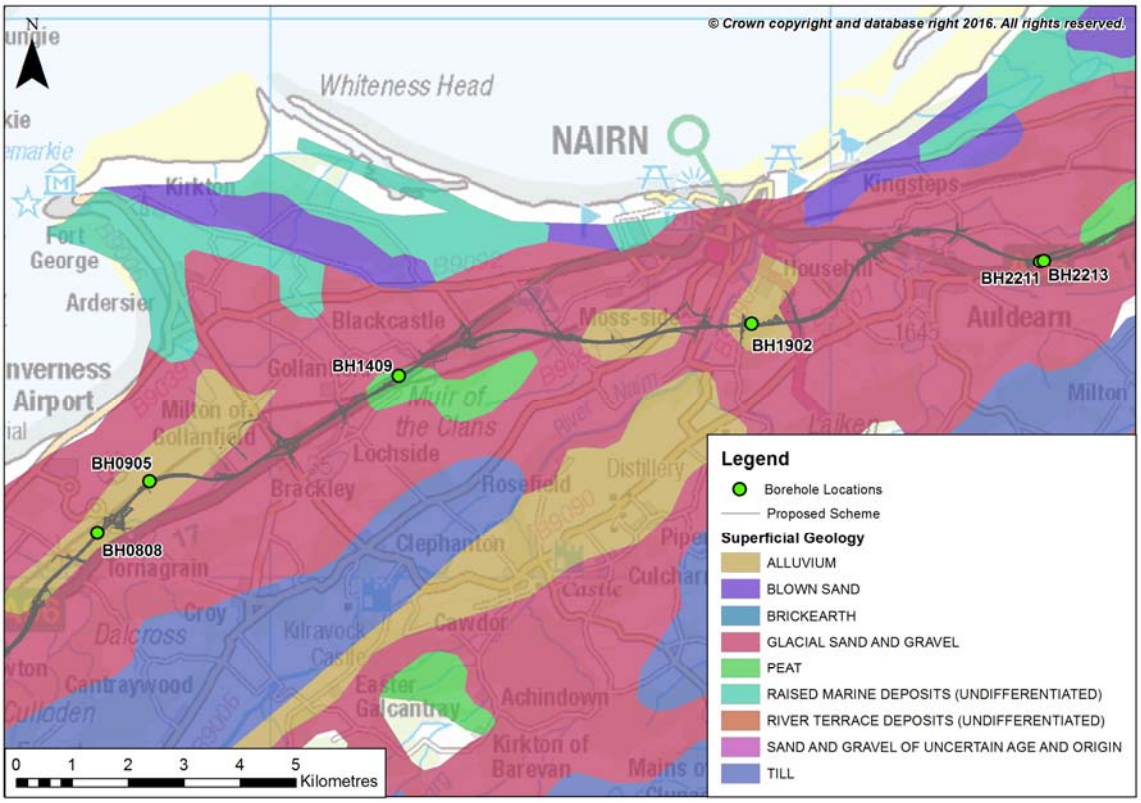
5.15 BHP0808 is located adjacent to Tributary of Ardersier Burn (SWF16), on the edge of Tornagrain Wood to the south-west of Inverness airport). Maximum groundwater levels are reported to be at ground level with the screened interval installed within sands and gravels 1.5m to 10mbgl. Borehole logs indicate the presence of peat in the upper 0.45m of the subsurface.

5.16 BHP0905 is located 40m from Drain at Culblair (SWF17), with maximum groundwater level recorded as 0.4mbgl. 0.6m of peat was encountered above this from 1 to 1.6mbgl.

5.17 BHP1409 is located to the south-west of Blackcastle Farm, adjacent to a field drain that feeds into Balnagowan Burn (SWF19). Maximum groundwater levels are recorded as 0.12mbgl. A 3.9m thick layer of peat was encountered 0.5mbgl during construction of the borehole.

5.18 Diagram 41 shows the superficial geology within the area of interest.

Diagram 41: Superficial Geology



Risk of Groundwater Flooding to Road

5.19 The screening study indicates that there are a few locations within the proposed Scheme where groundwater levels are likely to be high. However, the groundwater originates from the superficial

deposits and these conditions are very localised, and there is very low flood risk from regional aquifers. This is confirmed by the continuous groundwater level monitoring information recorded using data loggers along the proposed Scheme, which do not record any shallow groundwater levels. Although the monitoring period covered the summer season only, it is likely to be highly responsive to rainfall and could potentially reach ground level.

5.20 As the proposed Scheme is at, or below ground level (in cuttings) in several locations, there is a risk that groundwater flooding could affect the road, if not managed. A separate road cutting screening exercise has been undertaken as part of the geology, soils, contaminated land and groundwater assessment (Chapter 12: Geology, Soils, Contaminated Land and Groundwater) of the A96 Dualling Inverness to Nairn (including Nairn Bypass) Environmental Statement and has identified that there are 23 cuttings likely to intercept groundwater. These would require standard road water management through a combination of pumped and passive drainage during the construction phase and collection of any groundwater seepage into the road drainage network during the operational phase.

Impact of Scheme on Groundwater Flood Risk Elsewhere

5.21 Groundwater flooding is not generally highlighted as a risk across the proposed Scheme using SEPA's Flood Risk Maps (SEPA 2015a), although one area between Gollanfield and Blackcastle is identified as 'Low Likelihood'. The general orientation of the proposed Scheme, running cross gradient on widespread permeable alluvial deposits may cause some elevations in the groundwater table up gradient of the proposed Scheme. High groundwater levels are unlikely to cause groundwater flooding directly, but may make surface water flooding more likely. No receptors have been identified that would specifically be at risk of groundwater flooding.

Potential Mitigation Measures

5.22 Preliminary hydrogeological investigations have indicated that there are some groundwater flood risks that may need mitigation included within subsequent detailed design. However, there is no evidence to suggest that the risks would be significantly higher than other similar road schemes.

5.23 It is expected that the groundwater flood risk issues can be managed through the road design process using typical mitigation measures. These mitigation measures are detailed in Table 6.

Table 6: Potential Mitigation Measures

Measure	Description
Dewatering of cuttings	Standard excavation dewatering practices would be put in place during the construction phase, involving, as required, passive and/or active dewatering. The potential impacts associated with these dewatering activities are captured in Chapter 12 (Geology, Soils, Contaminated Land and Groundwater) of the A96 Dualling Inverness to Nairn (including Nairn Bypass) Environmental Statement.
Drainage of cuttings	Groundwater seepage would be collected by the road drainage system.
Pre Earthworks drainage	Appropriate sizing of pre earthworks drainage to intercept shallow groundwater flows.
Foundation design to permit groundwater flow	Where foundations are expected to intercept high groundwater levels these should be designed to permit existing groundwater flow paths to continue to function.

Conclusions

5.24 It is considered unlikely that groundwater flooding is an issue along the proposed Scheme and unlikely that it would affect the proposed Scheme itself. It is considered likely that localised groundwater flood risks would need to be managed as part of the proposed Scheme. However, uncertainties remain and further investigations are being undertaken to understand the groundwater regime in the area.

5.25 However, groundwater flood risk is not considered a major risk to the proposed Scheme and available information suggests that standard road scheme construction and operational measures such as standard drainage would mitigate groundwater seepages along cutting faces.

6 Construction Flood Risks

Impacts

6.1 Preliminary investigations have indicated that the construction phase has the potential to cause the following impacts:

- an increase in fluvial flood risk as a result of the construction works within the flood plain of watercourses;
- an increase in surface water flood risk due to the creation of temporary site compounds and the storage of construction materials within the natural surface water catchments;
- increased runoff from soil compaction due to works traffic, sedimentation and disturbance/unintentional changes to channel dimensions which may impact on the hydraulic flow characteristics of a watercourse;
- temporary watercourse diversions to facilitate culvert or bridge construction and any associated temporary works;
- diversions and re-direction of watercourses through constructed realignments or into pre-earthwork ditches;
- temporary attenuation features at drainage outfalls;
- temporary arrangements to control runoff;
- impacts on sewer network and mains;
- increase in contamination from haul routes; and
- increase in flood risk due to excavations.

Recommendations

6.2 The following general recommendations should be considered for the construction phase, so not to increase the risk of flooding:

- provision of construction phase detention ponds to manage site runoff
- monitor weather forecasts to provide advanced warning of future heavy rainfall events;
- provide an emergency evacuation procedure for removal of works items and contractor staff during a heavy rainfall event;
- have pumping equipment on standby to remove any surface water runoff that enters the working area;
- any dewatering/drainage water discharged overland would be done so at the greenfield runoff rate so as to avoid increasing the risk of surface water flooding elsewhere;
- any construction materials or equipment should be stored, where feasible, outside of those areas deemed susceptible to prominent fluvial flooding or surface water flowpaths or deep surface water ponding. Where this is not possible, construction material should only be placed in ‘at risk areas’ when required for use;
- any works items vulnerable to flotation should be elevated above ground level during storage;
- excavated materials should not be stored as bunds in areas susceptible to prominent surface water flows. Where this is not possible, topsoil bunds should be constructed with regular spaces between heaps to prevent surface water backing up behind the structure and being re-directed elsewhere;
- construct ditches along the edges of the haul route of the proposed Scheme to collect water and direct this to treatment facilities; and
- Cable Avoidance Tool (C.A.T) detection equipment should be used to verify the location of the underground services.

6.3 It is considered that these measures would offer adequate mitigation for any increases in flood risk as a result of the proposed works. These should be incorporated into site working method statements. However, the a detailed assessment of the risks and appropriate mitigation measures would be best identified and managed by the contractor on a case-by-case basis, depending upon the construction techniques to be used and the location.

7 Conclusion

7.1 A FRA is required to support Transport Scotland's promotion of draft Road Orders for development for the A96 Dualling Inverness to Nairn (Including Nairn Bypass) project (i.e. the proposed Scheme).

7.2 The proposed Scheme is being developed in broad accordance with the requirements of the DMRB, (HD 45/09) the requirements of Scottish Planning Policy (Scottish Government 2014) and SEPA's technical guidance for flood risk assessments (SEPA 2015b). The proposed Scheme is currently at DMRB Stage 3 'Detailed Assessment'.

7.3 In summary, the proposed Scheme should be constructed such that it remains safe and operational during time of flood, does not to impede water flow and does not result in an increase in flood risk elsewhere.

7.4 The FRA has focused on the 0.5% AEP (200-year)+CC flood event. The main findings of the FRA are discussed below.

- **Fluvial Flood Risk:** The proposed Scheme will be at risk of fluvial flooding in several locations. However, mitigation measures have been developed to manage fluvial flood risk appropriately. The potential impacts of the proposed Scheme have also been identified, and where appropriate, additional mitigation included so that the impact on sensitive receptors is fully mitigated or negligible. In some locations, and as a by-product of the proposed mitigation measures fluvial flood risk is reduced.
- **Surface Water Flood Risk:** There are a large number of surface water flow routes that the proposed Scheme intercepts. Consequently, the proposed Scheme could be at risk of flooding as a result of heavy rainfall. Furthermore, the proposed Scheme could alter overland flow paths and increase the risk of surface water flooding elsewhere. Mitigation measures have been included within the design that would reduce this flood risk and limit the impacts elsewhere to achieve a negligible surface water flood risk.
- **Groundwater Flood Risk:** The proposed scheme is likely to be at risk of groundwater flooding and further studies are in progress in order to understand the level of risk in more detail and determine appropriate mitigation measures. However, information available at the time of writing suggests that standard road scheme construction and operational measures would mitigate against those flooding risks.
- **Construction Phase Risks:** There are likely to be a number of activities during construction that could affect flood risks and potential mitigation measures have been identified. However, the a detailed assessment of the risks and appropriate mitigation measures would be best identified managed by the contractor on a case-by-case basis depending upon the construction techniques to be used and the location.

7.5 Other sources of flooding have been considered, however, they were scoped out early in the development of the FRA. These other sources of flooding include sewer and water mains, land drains and artificial drainage, failure of water retaining infrastructure and coastal.

7.6 The proposed Scheme would not result in additional flow being discharged into the existing sewer or mains network, therefore the risk of flooding is unlikely to change. A like for like replacement would be undertaken where land drains and artificial drainage is affected as part of the proposed Scheme. Therefore there is no change in flood risk.

7.7 There are no known man-made water retaining infrastructures located within the study area and therefore the risk of flooding is considered low and the proposed Scheme would not increase the risk of coastal flooding.

7.8 In summary, a comprehensive assessment of the risk to and from the proposed Scheme has been undertaken. Mitigation measures to manage any identified flood risks have been assessed and would be included in the proposed Scheme such that flood risk is managed appropriately up to the 0.5% AEP (200-year) plus an allowance for climate change design flood event. It is concluded that the proposed Scheme would meet relevant planning and design standards in terms of flood risk.

8 References

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Legislation

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