Appendix 11.2

Hydromorphology Assessment

Transport Scotland

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Glossary and abbreviations

Terminology	Abbreviation	Description
Alluvium		Sediment deposited by a river.
Baseline		The existing conditions which form the basis or start point of the environmental assessment.
Bedrock		Hard rock that lies beneath a superficial cover of soils and sediments.
Biodiversity		Biological diversity or species richness of living organisms present in representative communities and populations.
Catchment		The area contributing flow to a point on a drainage system.
Channel morphology		Physical characteristics of stream channels, such as width/depth ratio and sinuosity.
Controlled Activity Regulations (Scotland) 2011 as amended	CAR	Controls all engineering activity in or near watercourses.
Design Manual for Roads and Brides	DMRB	A series of 15 volumes that provide standards, advice notes and other documents relating to the design, assessment and operation of trunk roads, including motorways in the UK.
Desk study		Assessment of a site usually preceding ground investigations typically incorporating a review of available site information, consultation with relevant bodies and a site visit.
Dualling		The widening of an existing road in order to provide two carriageways in both directions.
Ecology		The branch of biology concerned with the relations of organisms to one another and to their physical surroundings.
Ecosystem		A biological community of organisms interacting with one another and the surrounding physical environment.
Environmental Impact Assessment	EIA	The process of evaluating the likely environmental impacts of a proposed project or development, taking into account inter-related socio-economic, cultural and human-health impacts, both beneficial and adverse.
Exchange		A reach which exhibits both erosion and deposition processes in similar measures.
Fluvial geomorphology		The study of landforms associated with river channels and the sediment processes which form them.
General Binding Rules	GBRs	GBRs represent a set of mandatory rules which cover specific low risk activities. Activities complying with the rules do not require an application to be made to SEPA, as compliance with a GBR is compliance with an authorisation.
Geomorphology		The branch of geology concerned with the structure, origin and development of topographical features of the earth's crust.
Habitat		Refers to the place in which a species lives, but also used to describe plant communities or agglomerations of plant communities, as used, for example in a Phase 1 Habitat Survey.
Hydromorphology		A term largely created for the Water Framework Directive comprising a blend of hydrology and geomorphology.

Terminology	Abbreviation	Description
Incision		Scouring of a river bed.
Infrastructure		The basic structure or features of a system or organisation.
Knickpoint		A step in a watercourse or a sharp change in channel slope. They reflect different conditions and processes on the river often caused by previous erosion and can often lead to instability
Landform		Combination of slope and elevation producing the shape and form of the land surface.
Landscape		Human perception of the land, conditioned by knowledge and identity with a place.
Lateral adjustment		Adjustment of the bank line (through erosion and deposition) leading to changes in planform i.e. sinuosity
Main water body		Designated under the WFD and visible on 1:50k OS maps.
Minor watercourse		Not shown on 1:50k OS maps.
Mitigation		Term used to indicate avoidance, remediation or alleviation of adverse impacts.
Ordnance Survey	OS	Mapping provider.
Palaeochannel		Remnant of an old river channel that has been filled or buried by younger sediment.
Planform		Channel shape and composition as viewed from above.
Pool and riffle sequence		In a flowing stream a riffle-pool sequence develops as an area of alternating areas of relatively shallow and deeper water. Riffles describe shallow water where the flow is rippling over gravel deposits whereas pools are deeper and calmer areas.
Proposed Scheme		The scheme design for the Dalraddy to Slochd section of the A9 used as the basis for environmental assessment and reporting.
Residual impacts		Residual impact means the environmental impact after the provision of mitigation measures, if any.
Riparian habitat		Natural home for plants and animals occurring in a thin strip of land bordering a stream or river.
River Basin District		The area of land and sea, made up of one or more river basins, together with the associated groundwater and coastal waters, identified by the Water Framework Directive as the main unit for the management of river basins.
River Basin Management Plan	RBMP	A plan setting out actions required within a river basin to achieve environmental quality objectives, reviewed on a six-yearly basis.
River Habitat Survey	RHS	A survey to assess the physical structure of freshwater streams and rivers, providing a broad assessment of habitat quality.
Runoff		Water that flows over the ground surface to the drainage system. This occurs if the ground is impermeable or if permeable ground is saturated.
Scottish Environment Protection Agency	SEPA	Regulating body responsible for the welfare of the water environment and enforcing the WFD.
Sediment Entrainment		The process by which surface sediment is incorporated into the flow as part of the operation of erosion.

Terminology	Abbreviation	Description
Sink		Sediment input to the reach is greater than sediment output to the next reach downstream
Source		Sediment output from the reach is greater than sediment supply from upstream
Step-pool sequence		Often occur in upland channel where the gradients are over 4%. Naturally forming features which regulate steep gradients and dissipate high flow energy.
Stream power		The rate of energy of flowing water expended on the bed and banks of a channel i.e. the potential for flowing water to perform geomorphic work.
Transfer		Sediment output is approx. equal to input from upstream, sediment is transmitted through the reach.
Water Body		A body of surface water, or a body of groundwater. The WFD defines discrete surface water bodies, but not necessarily a whole river, while groundwater bodies should be distinct.
Water Framework Directive	WFD	Wide-ranging European environmental legislation (2000/60/EC). Addresses inland surface waters, estuarine and coastal waters and groundwater. The fundamental objective of the WFD is to maintain "high status" of waters where it exists, preventing any deterioration in the existing status of waters and achieving at least "good status" in relation to all waters by 2015.
Water quality		The chemical and biological status of various parameters within the water column and their interactions, for example dissolved oxygen, indicator metals such as dissolved copper, or suspended solids (the movement of which is determined by hydrological process and forms geomorphological landforms).

1. Introduction

1.1.1. This report forms a technical appendix to the A9 Dualling Dalraddy to Slochd – Stage 3 Scheme Assessment Report, Chapter 11: Road Drainage and the Water Environment.

1.2. Aims and objectives

1.2.1. The assessment aims to inform the Road Drainage and the Water Environment Assessment about potential hydromorphological impacts of the Preferred Scheme on the receptors (affected fluvial watercourses) during the construction and operational phases.

1.2.2. The assessment will also examine the mitigation measures required to remove and reduce any potential adverse impacts to watercourses.

1.2.3. The specific objectives of this assessment are:

- Assess the baseline characteristics of each watercourse and categorise each with a sensitivity classification;
- Assess the potential impact on each watercourse for each of the Preferred Scheme Option;
- Outline measures required to mitigate potential impacts; and
- Identify further investigations required.

1.3. Study area

1.3.1. The study area for this assessment focuses on the Proposed Scheme within a 250m proximity. The Proposed Scheme begins around NGR 2851 8086 southeast of Loch Alvie, passing by Inverdruie and Aviemore on the west and ending west of Strathdearn at NGR 2281 8271. Figure A11.2.1 provides an overview of the Proposed Scheme extent and study area.

1.3.2. A full description of the Proposed Scheme can be found in Chapter 5 (The Proposed Scheme) in Volume 1 of the ES.

2. Approach and Methodology

2.1. Introduction

2.1.1. The hydromorphology impacts of the Proposed Scheme were determined by assessing the sensitivity of each watercourse and then the magnitude of the potential impact(s). The following section outlines the approach to the classification criteria and the methodology by which this has been applied to the watercourse assessment.

2.1.2. To some degree, the assessment of sensitivity and impacts relies on the professional judgement of the surveyor and therefore is partially subjective. Consequently, it is important that a wide range of information is considered when assigning values to each watercourse.

2.1.3. The baseline information collected for the Design Manual for Roads and Bridges (DMRB) Stage 2 assessment is deemed sufficient to inform the impact assessment for

Stage 3. Therefore, no further walkover has been undertaken and all baseline data is considered still valid.

2.1.4. The impact assessment is based on more detailed information on the size, alignment and connection of the proposed river crossings, plus the potential impacts on the watercourses more broadly.

2.1.5. Sediment entrainment and stream power calculations were also undertaken based on the outputs from the hydraulic models, providing additional context to the impact assessment.

2.1.6. An initial assessment of the magnitude of impact takes into account the Proposed Scheme design, including the standard and embedded mitigation. 'Standard mitigation' is considered best practice and assumed to be built into the design. 'Embedded mitigation' is over and above the standard mitigation, but already built into the design prior to the impact assessment. 'Specific mitigation' is any outstanding actions required to reduce the initial impact. The initial impact when combined with the specific mitigation results in the residual magnitude of impact.

2.1.7. The combination of the sensitivity and residual magnitude of impact will produce an overall significance of impact.

2.2. Desk study

2.2.1. The desk study was undertaken to identify current hydromorphological conditions and trends in river behaviour. Table 2.1 lists the data used during the desk study and the information it provided.

Table 2.1: Desk study data sources

Data source	Description and information provided
Contemporary aerial photographs	Aerial photographs provide contextual information about the site and surrounding landscape, including land use and vegetation types. It can also provide some insight into the distribution of fluvial features, such as gravel bars, palaeochannels and wetland features.
Contemporary Ordnance Survey (OS) Mapping	Providing basic contextual information, such as elevation, relative relief and an indication of channel gradients.
Geological mapping (solid and drift plus soils)	Indicates the underlying geology and feeds into the understanding of potential response/stability.
Historical mapping (where available): National Library of Scotland[i] and Old maps[ii]	Comparison of historical maps to determine channel change over a period of approximately 150 years. Provides important context and understanding to modifications and existing fluvial processes. Provides insight into long-term instability issues.
Topographic survey	Understanding the arrangement and topography of existing features and landscapes in the study area. The topographic survey is a combination of flown, aerially captured levels (LiDaR) and ground survey methods.
River Basin Management Plan (RBMP)	The RBMPs indicate which water bodies are classified under the WFD as main rivers and their relative status. It will also provide an insight into the proposed mitigation measures and targets which can be built into future designs.
The Proposed Scheme Options	To assess the potential impacts to the watercourses.

2.3. Field study

2.3.1. The field study complements and builds on the findings of the desk study to determine the specific character of the geomorphological forms and processes at each watercourse. The field study comprised a rapid hydromorphological walkover along each watercourse to broadly assess the following:

- Landscape and floodplain;
- Channel modifications;
- Planform and boundary conditions (bed and banks);
- Existing operating fluvial processes and features; and
- Riparian and in-channel vegetation.

2.4. Impact assessment

2.4.1. The DMRB does not outline a specific methodology or guidance enabling hydromorphological impacts to be evaluated. However, the general guidance contained in DMRB, Volume 11, Section 3, Part 10 Road Drainage and the Water Environment (HD 45/09) has been used as the framework for the assessment method outlined below.

Watercourse sensitivity

2.4.2. The sensitivity classification criteria for Stage 2 has been superseded following consultation with all design engineering consultants to ensure a consistent approach has been applied to all sections of the A9. The main changes are a more detailed consideration of the specific sediment regime, morphological condition and fluvial processes. Specific reference to the WFD was removed. The sensitivity of the identified watercourses are based on broad classification criteria (Table 2.2), which has been adapted from similar guidance[iii], taking into account research and development programmes of the Environment Agency and Scottish National Heritage (SNH) (as compiled[iv]), as well as professional experience.

Table 2.2: Watercourse sensitivity classification criteria

Sensitivity	Criteria
Very High	Sediment Regime: Water feature sediment regime provides a diverse mosaic of habitat types suitable for species sensitive to changes in sediment concentration and turbidity, such as migratory salmon, freshwater pearl mussels. Water feature appears in complete equilibrium with natural erosion and deposition occurring. The water feature has sediment processes reflecting the nature of the catchment and fluvial system. Channel Morphology: Water feature includes varied morphological features (e.g. pools, riffles, bars, natural bank profiles) with no sign of channel modification. Natural Fluvial Processes: Water feature displays natural fluvial processes and natural flow regime, which would be highly vulnerable to change as a result of modification.
High	Sediment Regime: Water feature sediment regime provides habitats suitable for species sensitive to changes in sediment concentration and turbidity, such as migratory salmon, freshwater pearl mussels. Water feature appears largely in natural equilibrium with some localised accelerated erosion and/or deposition caused by land use and/or modifications. Primarily the sediment regime reflects the nature of the natural catchment and fluvial system.

Sensitivity	Criteria
	Channel Morphology: Water feature exhibiting a natural range of morphological features (e.g. pools, riffles, bars, varied natural river bank profiles), with limited signs of artificial modifications or morphological pressures. Natural Fluvial Processes: Predominantly natural water feature with a diverse range of fluvial processes that is highly vulnerable to change as a result of modification.
Medium	Sediment Regime: Water feature sediment regime provides some habitat suitable for species sensitive to change in suspended sediment concentrations or turbidity. A water feature with natural processes occurring but modified, which causes notable alteration to the natural sediment transport pathways, sediment sources and areas of deposition. Channel Morphology: Water feature exhibiting some morphological features (e.g. pools, riffles and depositional bars). The channel cross-section is partially modified in places, with obvious signs of modification to the channel morphology. Natural recovery of channel form may be present (e.g. eroding cliffs, depositional bars). Natural Fluvial Processes: Water feature with some natural fluvial processes, including varied flow types. Modifications and anthropogenic influences having an obvious impact on natural flow regime, flow pathways and fluvial processes.
Low	Sediment Regime: Water feature sediment regime which provides very limited physical habitat for species sensitive to changes in suspended solids concentration or turbidity. Highly modified sediment regime with limited/no capacity for natural recovery. Channel Morphology: Water feature that has been extensively modified (e.g. by culverting, addition of bank protection or impoundments) and exhibits limited-to-no morphological diversity. The water feature is likely to have uniform flow, uniform banks and absence of bars. Insufficient energy for morphological change. Natural Fluvial Processes: Water feature which shows no or limited evidence of active fluvial processes with unnatural flow regime or/and uniform flow types and minimal secondary currents.

Table Source: Watercourse Sensitivity Classification Criteria (adapted from Table 14, WebTAG Unit A3, Department for Transport, 2014)

Magnitude of impact

2.4.3. Similarly to the sensitivity criteria, there is little guidance on the classification of the potential magnitude of hydromorphological impacts. The criteria used in this Stage 3 assessment has been adopted to ensure that a consistent approach to assessing the impacts has been undertaken. The guidance criteria are outlined in Table 2.3 below.

Table 2.3: Magnitude of impacts classification criteria

Magnitude	Criteria
Major Adverse	Sediment Regime: Significant impacts on the water feature bed, banks and vegetated riparian corridor resulting in changes to sediment characteristics, transport processes, sediment load and turbidity. This includes extensive input of sediment from the wider catchment due to modifications. Impacts would be at the waterbody scale. Channel Morphology: Significant/extensive alteration to channel planform and/or cross section, including modification to bank profiles or the replacement of a natural bed. This could include: significant channel realignment (negative); extensive loss of lateral connectivity due to new/extended embankments; and/or, significant modifications to channel morphology due to installation of culverts or outfalls. Impacts would be at the waterbody scale. Natural Fluvial Processes: Significant shift away from baseline conditions with potential to alter processes at the catchment scale.

Magnitude	Criteria
	Condition Status: Substantial adverse impacts at the water body scale, which causes loss or damage to habitats. Impacts have the potential to cause deterioration in hydromorphology quality elements*. Prevents the water body from achieving Good status.
Moderate Adverse	Sediment Regime: Some changes and impacts on the water feature bed, banks and vegetated riparian corridor resulting in some changes to sediment characteristics, transport processes, sediment load and turbidity. Impacts would be at the multiple reach scale. Channel Morphology: Some alteration to channel planform and/or cross section, including modification to bank profiles or the replacement of a natural bed. Activities could include: channel realignment, new/extended embankments, modified bed and/bank profiles, replacement of bed and/or banks with artificial material and/or installation of culverts. Impacts would be at the multiple reach scale. Natural Fluvial Processes: A shift away from baseline conditions with potential to alter processes at the reach or multiple reach scale. Condition Status: Moderate adverse impacts at the reach or multiple reach scale, which causes some loss or damage to habitats. Impacts have the potential to cause failure or deterioration in one or more of the hydromorphological quality elements. May prevent the water body from achieving Good status.
Minor Adverse	Sediment Regime: Limited impacts on the water feature bed, banks and vegetated riparian corridor resulting in limited (but notable) changes to sediment characteristics, transport processes, sediment load and turbidity at the reach scale. Channel Morphology: A small change or modification in the channel planform and/or cross section. Includes upgrade to and/or extension of existing watercourse crossing and/or structure with associated minor channel realignment with localised impacts. Natural Fluvial Processes: Minimal shift away from baseline conditions with typically localised impacts up to the reach scale. Condition Status: Minor adverse impacts at the reach scale, which may cause partial loss or damage to habitats. Impacts have the potential to cause failure or deterioration in one of the hydromorphological quality elements.
Negligible	Minimal or no measurable change from baseline conditions in terms of sediment transport, channel morphology and natural fluvial processes. Any impacts are likely to be highly localised and not have an effect at the reach scale.
Minor Beneficial	Sediment Regime: Partial improvement to sediment processes at the reach scale, including reduction in siltation and localised recovery of sediment transport processes. Channel Morphology: Partial improvements include enhancements to in-channel habitat, riparian zone and morphological diversity of the bed and/or banks. Natural Fluvial Processes: Slight improvement on baseline conditions with potential to improve flow processes at the reach scale. Condition Status: Slight beneficial impacts at the reach scale, which may cause partial habitat enhancement. Impacts have the potential to improve one of the hydromorphological quality elements.
Moderate Beneficial	Sediment Regime: Reduction in siltation and recovery of sediment transport processes at the reach or multiple reach scale. Channel Morphology: Partial creation of both in-channel and vegetated riparian habitat. Improvement in morphological diversity of the bed and/or banks at the reach or multiple reach scale. Includes partial or complete removal of structures and/or artificial materials. Natural Fluvial Processes: Notable improvements on baseline conditions and recovery of fluvial processes at the reach or multiple reach scale.

Magnitude	Criteria
	Condition Status: Notable beneficial impacts at the reach to multiple reach scale. Impacts have the potential to improve one or more of the hydromorphological quality elements and/or assist the water body in achieving Good status.
Major Beneficial	Sediment Regime: Improvement to sediment processes at the catchment scale, including recovery of sediment supply and transport processes. Channel Morphology: Extensive creation of both in-channel habitat and riparian zone. Morphological diversity of the bed and/or banks is restored, such as natural planform, varied natural cross-sectional profiles, recovery of fluvial features (e.g. cascades, pools, riffles, bars) expected for river type. Removal of modifications, structures, and artificial materials. Natural Fluvial Processes: Substantial improvement on baseline conditions at catchment scale. Recovery of flow and sediment regime. Condition Status: Substantial beneficial impacts at the catchment scale, which result in recovery/restoration of natural habitats suitable for supporting sensitive species. Potential improvement of overall status condition, which could lead to achieving Good status.

* Hydromorphological quality elements are: quality and quantity of flow; river depth and width variation; structure and substrate of the bed dynamics; river continuity; structure of the riparian zone.

Impact significance

2.4.4. The overall impact is determined using the impact matrix outlined in Table 2.4, which cross-references the sensitivity and the magnitude of impact ratings. The overall impact uses a significance rating score from neutral to very large as per the DMRB[v].

Table 2.4: Overall impact matrix

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

2.5. Limitations

2.5.1. Limitations to be aware of relating to the findings of this report are as follows:

- The results are based on a rapid fluvial geomorphological walkover rather than a full catchment fluvial audit approach. The findings of the walkover are focused around the immediate vicinity of the proposed crossings and are not broken into reaches, except for those sections upstream and downstream of the A9 crossing. Where possible a minimum of 250m upstream and downstream was surveyed;
- Access was limited in some areas by the relevant permissions and safe/easy access. Where access was not possible, spot checks were undertaken at existing watercourse crossings or via footpaths;
- The features and processes observed may vary over time/seasons and high flow events. The survey was undertaken under relatively dry conditions, and the overall function and stability was inferred through professional judgement and the interpretation of features on site;

- The Proposed Scheme is at preliminary design stage with detailed design to undertaken by the appointed contractor, therefore the precise nature of the impacts on the watercourses are potentially subject to change. In all cases the worst-case scenario has been considered and assessed;
- Sediment entrainment and stream power calculations are semi-empirical equations based on limited (sometimes geographically biased) variables, and arguably over-simplify fluvial processes (and pressures) within the river channel. The equations are considered appropriate for uniform gravel-bed rivers, but do not account for complex channel roughness properties, e.g. mixed particle sizes, sheltering or the presence of vegetation. The results of the calculations have therefore been interpreted in the context of the empirical site observations and measurements; and
- Some of the existing channel gradients for the smaller watercourses have been inferred from the topographic survey model in the absence of specific ground measurements. This is considered sufficient for assessing hydromorphological impacts and does not present a substantial limitation at the preliminary design stage.

3. Baseline

3.1. Initial screening

3.1.1. As part of the Stage 2 hydromorphology assessment a long list of watercourses crossed by the Proposed Scheme was initially developed and included 86 watercourse crossings.

3.1.2. An initial hydrological walkover survey assessed these crossings and identified several watercourse crossings of “hydromorphological interest” (those exhibiting some natural features and processes). The remaining crossings were screened further based on the available site photographs and desk study information (basemaps and aerial imagery) to confirm their elimination or inclusion. The screening aimed to identify those crossings which met a broad set of criteria based on a similar process undertaken for the aquatic ecology assessment (Appendix A11.3 Aquatic Ecology). These are:

- the watercourse is a permanent flowing system with a channel width >1m;

  AND

- the watercourse is to be lost/culverted/diverted or potentially experience a substantial change in water quality or quantity[1];

  AND

- is not obviously canalised or heavily managed;

  OR

- is hydraulically linked to a designated water-dependant site.

3.1.3. This assessment required some interpretation and professional judgement, therefore where it was unclear whether the watercourse crossing met the above criteria it was included for further investigation.

3.1.4. The two unnamed tributaries in Stage 2, DS-WC-031 and the other later referred to as Milton Burn, have been screened out for further assessment. DS-WC-031 was found to be too minor for inclusion and Milton Burn joins Aviemore Burn upstream of the A9 and is not directly affected by the proposed works. Therefore, a total of 16 watercourses

[1] Note. this was difficult to assess at the time as the options were still be confirmed

have been identified for further investigation for Stage 3. These watercourses are outlined in Table 3.1 and their locations are shown on Figure A11.2.2 (sheets 1 to 9) in Annex A. The assessment has been undertaken at watercourse level rather than for each individual crossing.

3.1.5. Please note that this document is intended to form an impact assessment with regards to the ES. All watercourses which require modification, i.e. realignment, including those minor watercourses screened out in this assessment, will require further consideration by a geomorphologist during detailed design.

Table 3.1: Watercourses requiring further assessment (from south to north)

Watercourse Name	Crossing ID
Allt an Fhearna	A9 1090 S
Allt Chriochaidh	A9 1100 and A9 1100 S
Caochan Ruadh	A9 1100 C70
Ballinluig Burn	A9 1110 C10
Allt na Criche (Lynwilg)	A9 1130
Aviemore Burn	A9 1150 C95
Easter Aviemore Burn	A9 1160 C14
Allt na Criche (Granish)	A9 1170 C12 S and A9 1170 C12
Avie Lochan Burn South	A9 1170 C20 and A9 1170 C20 S
Avie Lochan Burn North	A9 1170 C23
Allt Cnapach	A9 1170 C50 and A9 1170 C50 S
Feith Mhor	A9 1170 C75 and A9 1170 C75 S
River Dulnain	A9 1190
Allt nan Ceatharnach	A9 1200 and A9 1200 S
Bogbain Burn	N/A – not crossed by existing or proposed A9
Allt Slochd Mhuic	A9 1209 F, A9 1210 C46, A9 1210 C45, A9 1208 F, A9 1207 F, A9 1210 C39, A9 1210 C31 and A9 1206 F

3.2. Desk study results

Historical mapping analysis

3.2.1. A number of sources were investigated including the National Library of Scotland's online database[vi] and Old-Maps.co.uk[vii]. All of the watercourses surveyed and affected by The Proposed Scheme have existing road and/or railway crossings which appear to have had minimal impact on the alignment of the watercourses.

3.2.2. Maps from the 19th century indicate that Aviemore Burn and Allt Cnapach were modified to provide offtakes for mills at NH 8940 13740 and NH 9121 18370, respectively, which were removed in the late-19th and mid-20th centuries. Both watercourses show signs of recovery after removal of the offtakes, with some ponding of water and minimal channel change downstream.

3.2.3. The River Dulnain, Allt an Fhearna and Allt nan Ceathnarnach all exhibit some active meandering, with greater activity of natural processes (including mid-channel bars) seen in the larger River Dulnain, as shown on the 19th century maps. All three channels were stable through the 20th century and up to the present day with no other substantial channel change or modification visible on maps, apart from an offtake for a saw mill on the River Dulnain at NH 89948 22909 in the 19th century, although this appears to have no discernible impact on the planform of the river.

3.2.4. Some artificial straightening is evident along both Easter Aviemore Burn (NH 89683 14192) and Feith Mhor (NH 92319 22308) in the 19th century, but are otherwise naturally meandering and show no other substantial channel change or modification through the 20th century and up to the present day.

3.2.5. Maps from the 19th and 20th century show that the Unnamed Burn through Milton exhibits a natural planform which then flows into Aviemore Burn. However, the present-day map (2015) indicates that the channel bifurcates at NH 88149 14509, which was not seen on the earlier maps. Both channels then appear to flow into Aviemore Burn, as previously.

3.2.6. Evidence for the remaining watercourses suggest that Allt Chriochaidh, Caochan Ruadh, Ballinluig Burn, Allt na Criche, Unnamed Tributary of Loch Puladdern and the Avie Lochan Burn South have undergone no substantial channel change or modification over the past 170 years. All five watercourses are crossed by the existing A9 road and exhibit no evidence of channel change as a result of this construction.

3.2.7. The watercourses in this region of Inverness exhibit the planforms and processes of typical upland river systems. Overall, there has been minimal impact to the majority of the watercourse alignment. Other historic modifications observed on site include regrading and bed and bank reinforcement, in particular Allt Slochd Mhuic, Allt nan Ceatharnach and Allt na Criche (Lynwilg) all have artificial beds. Avie Lochan Burn South and Allt Chriochaidh also have significant concrete cascades leading into the existing structures.

Geology

3.2.8. The geological maps indicate that the site is underlain by metasedimentary and igneous rocks.

3.2.9. The site is underlain by a range of Quaternary Age superficial deposits. Quaternary Age glacial sand and gravel, till and diamicton are present in this region as a result of the Ice Age conditions which dominated up to 3 million years ago.

3.2.10. There is also evidence for pockets of peat of approximately the same age which were formed from organic accumulations in anaerobic conditions. The local environment was controlled by rivers up to 2 million years ago, resulting in alluvium deposits which dominate on the present-day floodplains. The alluvium is comprised of sands which would have been deposited by rivers to form river terraces, as well as fine silts and clays from subsequent overbank floods.

3.2.11. A more comprehensive study of the bedrock geology and superficial deposits can be found in the Geotechnical Preliminary Sources Study Report for the A9 Dualling Perth to Inverness, Slochd to Moy (B1557620/GEO/PSSR/11, Revision 04) prepared in October 2013.

Water Framework Directive (WFD)

3.2.12. The WFD underpins the nature of the assessment overall and will drive much of the design for the crossing structures and any channel realignments. The status of each water body is listed within the RBMP. The reportable WFD water body status applies to designated main water bodies, defined broadly as those watercourses visible on a 1:50,000 scale OS map. However, the water body catchment comprises a network of tributaries, small watercourse and drains. Hydrologically they are linked and therefore modifications to this network can have a direct impact on the main water body status. It is important to consider the impacts within this context.

3.2.13. The Proposed Scheme will directly affect four WFD water bodies, all of which will require a crossing. There are other WFD water bodies which would be indirectly affected cumulatively and/or within close proximity of the works. Those water bodies directly affected are listed in Table 3.2, below.

3.2.14. The current Morphological Impact Assessment System (MIMAS) total impacts are also included in Table 3.2 which is derived as a proportion of the combined physical impacts along the total length of water body. This percentage calculated by SEPA, provides an indication of how modified the water body is and the likely capacity remaining for further modifications before there is a potential derogation in Water Framework Directive classification.

3.2.15. It is assumed the compliance assessment will be captured as part of a scheme wide assessment under the Controlled Activity Regulations (CAR) applications prior to detailed design.

Table 3.2: WFD Water Body Status

Water Body Name	River Spey – River Feshie to River Nethy	River Dulnain – Lower Catchment	River Dulnain – Allt an Aonaich	River Dulnain – Allt Ruighe Magaig	River Dulnain – Feith Mhor	Allt na Fearna [sic] – u/s Loch Alvie
Water Body ID	23097	23106	23110	23112	23113	23126
National Grid Reference	NH 9126 1432	NH 9072 2293	NH 84215 22453	NH 8870 2513	NH 9186 2181	NH 8222 0796
Catchment	River Spey	River Spey	River Spey	River Spey	River Spey	River Spey
Heavily Modified	No	No	No	No	No	No
Water Body Length (MIMAS total Impact %)	27.7km (34.2%)	26.5km (21.6%)	8.3km (9.4%)	7.8km (8.3%)	7.3km (23.7%)	9.3km (7.9%)
Parameter	**Status**	**Status**	**Status**	**Status**	**Status**	**Status**
Overall status	**Moderate**	**Good**	**Good**	**Good**	**Good**	**Good**
Overall Ecology	**Moderate**	**Good**	**Good**	**Good**	**Good**	**Good**
Physico-Chem	High	High	High	High	High	Good
Temperature	High	High	High	High	High	High
Soluble Reactive Phosphorus	High	High	High	High	High	High
Dissolved Oxygen	High	High	High	High	High	High
Acidity	High	High	High	High	High	Good
Biological Elements	Good	High	High	High	High	High
Invertebrate Animals	High	High	High	High	High	High
Fish	Good	High	High	High	High	High
Aquatic Plants	-	High	High	High	High	High
Specific Pollutants	Pass	Pass	-	-	-	-
Zinc	-	Pass	-	-	-	-
Ammonium	-	Pass	-	-	-	-
Hydromorphology	Moderate	Good	Good	Good	Good	Good

Water Body Name	River Spey – River Feshie to River Nethy	River Dulnain – Lower Catchment	River Dulnain – Allt an Aonaich	River Dulnain – Allt Ruighe Magaig	River Dulnain – Feith Mhor	Allt na Fearna [sic] – u/s Loch Alvie
Morphology	Moderate	Good	Good	Good	Good	Good
Overall Hydrology	Moderate	High	High	High	High	High

3.3. Field survey results

3.3.1. A site walkover was undertaken between the 1st and 4th December 2015. The information obtained from the walkover (in combination with the desk study) forms the basis of the sensitivity classification.

Watercourse Name	Allt an Fhearna – upstream of existing A9
WFD Water Body	Main river: Allt na Fearna [sic] – u/s Loch Alvie (23126)
Crossing References	N/A – new crossing constructed as part of Kincraig to Dalraddy Scheme
Primary function	Exchange
Primary process	Laterally Adjusting (Minor Incision)

Description

The surveyed watercourse began just downstream of Easter Delfour. It was boarded by a low valley side on the left-hand bank (LHB) and an open floodplain on the right-hand bank (RHB), and broadly sits within the broader Spey Valley. The general land-use was primarily grazing pasture for cattle and sheep, however there was a good corridor of woodland (buffer) along much of the channel, becoming slightly sparser towards the existing crossing under the A9. The channel possessed a naturalised and sinuous planform. The channel became straightened leading up to the A9 and the tree line was much thinner, and there was also a ford crossing immediately before the bridge crossing of the A9. The cross-section throughout was quite varied, and the channel was well connected to its floodplain. There were also areas where the channel bifurcated around mid-channel islands and bar features.

The bed comprised coarse substrates, such as cobbles and gravels, with smaller sandier material at the margins where flow energies were lower. The bank material was obscured on the day of the survey due to recent snow cover, but observations indicated it comprised predominantly earth and sandy soils.

The channel presented a diverse range of sedimentary features and processes, including the mid-channel and marginal gravel bars discussed above, but riffles and large woody debris features were observed as well. The channel suggested some lateral adjustment occurring, with occasional steep eroded banks on the outside of meanders and shallow gravel bars on the inside, although on the whole the tree line has stabilised the channel planform. There were some signs that incision had occurred, with a knickpoint/ woody step (see P1040399 below) and some toe erosion along the banks.

P1040399 – View upstream of large woody debris dam and evidence of incision (NGR 2852 8091)

P1040405 – View downstream; eroding outer bank on the right and shallow gravel bar on the inside indicating a lateral adjustment (NGR 2852 8091)

Watercourse Name	Allt an Fhearna – downstream of existing A9
WFD Water Body	Main river: Allt na Fearna [sic] – u/s Loch Alvie (23126)
Crossing References	A9 1090 S
Primary function	Transfer
Primary process	Stable

Description

Access along the downstream section of Allt an Fhearna was restricted due to ongoing construction works associated with the A9. The channel continued to exhibit a predominantly gravel bed and sandy earth banks. The once dense woodland now constitutes a thin tree line having been removed as part of the construction works. Otherwise there was a wide floodplain on the RHB and the road embankment was set a little further back on the LHB.

The planform was also slightly less natural, appearing to have been historically straightened (probably relating to the construction of the existing A9) and eventually joins Loch Alvie some 600-700m downstream. The channel underneath the A9 was contained within a concrete lined channel (bed and banks), and temporary bank protection had been installed associated with the construction works.

There were no obvious signs of erosion and fewer gravel deposits than upstream within the channel from the limited section surveyed, suggesting sediment was being efficiently transferred through.

P1040416 – View upstream towards existing A9 crossing; the channel had been lined artificially with rip-rap and boulder protection as part of the ongoing construction works (NGR 2855 8092)

P1040417 – View downstream from temporary crossing showing wide and uniform channel leading towards Loch Alvie (NGR 2855 8092)

Watercourse Name	Allt Chriochaidh – upstream of existing A9
WFD Water Body	Ordinary watercourse upstream of Loch Alvie (100181) and Allt na Fearna [sic] – d/s Loch Alvie (23125)
Crossing References	A9 1100
Primary function	Transfer
Primary process	Stable

Description

Access to the channel upstream of the existing A9 was restricted due to an impassable high fence line.

OS maps show the channel winding its way off the steep valley side through a narrow gorge or valley to the north west. Where it is crossed by the A9 the gradient was slightly lower than upstream (approximated at 6-8% based on topo survey), but still relatively steep. The landscape was primarily coniferous woodland. The channel appeared to be naturally straight (likely due to the gradient), and there was a substantial concrete cascade structure immediately before the channel entered the culvert underneath the A9 (P1040419).

The bed and banks were primarily formed of coarse substrate, with sandy soils beyond. The steep gradient and coarse sediment had formed a step-pool sequence along the viewed section indicating a high potential stream power. There were no signs of erosion or substantial deposition features, and the channel presented itself as stable transfer system.

P1040418 – View upstream from A9 verge showing a steep gravel bed stream in a dense woodland (NGR 2857 8095)

P1040419 – View of existing A9 crossing with concrete stepped cascade leading into culvert (NGR 2857 8095)

Watercourse Name	Allt Chriochaidh – downstream of existing A9
WFD Water Body	Ordinary watercourse upstream of Loch Alvie (100181) and Allt na Fearna [sic] – d/s Loch Alvie (23125)
Crossing References	A9 1100 and A9 1100 S
Primary function	Exchange
Primary process	Lateral Adjustment (Stable)

Description

Continuing from the upstream catchment the channel flowed through coniferous woodland, although the gradient was much lower than upstream (3 to 4%) as the channel joined Loch Alvie some 300 to 400m downstream. On the whole the channel remained natural, except for a small area immediately downstream of the A9 where some boulders have been placed artificially (and subsequently failed), probably to form bank protection. The planform was irregularly sinuous, with a number of marginal and mid-channel gravel bars creating a divergence of the flow.

The bed substrate comprised cobbles and boulders, much like upstream. The banks were similarly sandy earth banks with coarse sediments embedded. Flows were mostly energetic and step-pools were also common throughout.

There was some evidence of lateral adjustment with some bank erosion on the outside of bends, however this was mostly kept in check by the surrounding woodland and on the whole the channel was stable. There was also some evidence of incision around the outlet of the culvert with the invert perched above the bed (P10401425), however this appeared to be localised and was likely a result of the construction of the existing A9.

P1040425 – View of culvert outlet with signs of incision downstream and the invert was perched above the channel bed (NGR 2857 8095)

P1040434 – View downstream showing sinuous planform with some evidence of minor lateral adjustment (NGR 2858 8095)

Watercourse Name	Caochan Ruadh – upstream of existing A9
WFD Water Body	Ordinary watercourse upstream of Loch Alvie (100181) and Allt na Fearna [sic] – d/s Loch Alvie (23125)
Crossing References	A9 1100 C70
Primary function	Exchange
Primary process	Stable (Lateral Adjustment)

Description

The Caochan Ruadh ("Red Stream") flows off the Creag Ghleannain to the northwest. During the survey the river was partially in spate due to snowmelt from the previous day. Broadly, the upper sections of the surveyed channel flowed through a peaty grassland and were well connected to the floodplain before flowing through a narrow and steep wooded gorge.

There was a ford crossing and some localised embankments at the downstream end of the reach. The surrounding area had broadly been cleared and transformed for agricultural purposes (primarily grazing). The planform although relatively unmodified meandered as it followed the topography and confined by bedrock rather than meandering as a result of fluvial processes.

The bed was formed from coarse substrate (cobbles, boulders and gravels) as well as bedrock in places. The banks were predominantly earth and bedrock, although at the upstream and downstream extents earthy soils were more dominant. Due to the steepness and roughness flows were highly energetic, with a number of chutes and cascades of step features, with some areas of rippled flow where the gradient was less steep. The channel is around 5 to 10% grade through the steep section, before shallowing to around 3% leading into the existing culvert.

Erosion and bank slips were common along the steeper channel and there were occasional gravel bars suggesting some lateral adjustment was occurring, but overall the channel was relatively stable.

P1040513 – View upstream towards start of surveyed reach; note a chicken farm on the left of the image (RHB) (NGR 2864 8102)

P1040514 – View downstream of wooded gorge, with landslips and bank erosion visible on the left; gravel bar on the RHB (inside bank) (NGR 2864 8102)

Watercourse Name	Unnamed tributary to Caochan Ruadh – upstream of existing A9
WFD Water Body	Ordinary watercourse upstream of Loch Alvie (100181) and Allt na Fearna [sic] – d/s Loch Alvie (23125)
Crossing References	A9 1100 C70
Primary function	Transfer
Primary process	Stable

Description

This minor tributary joined Caochan Ruadh just upstream of the existing A9 crossing. It was situated within an open, yet steep hillside, dominated by grassland (grazing land). It flowed along a field boundary near Ballinluig. Further upstream the planform was slightly more sinuous and more vegetated, but broadly followed a straight course, partially due to the gradient and partially as a result of historic resectioning.

Again, much like Caochan Ruadh, the channel was in spate at the time of surveying due to the snowmelt. The survey did show that the channel was likely to have been modified for agricultural purposes, i.e. drainage. The channel was crossed a few times (culvert and fords) for farm access along the track to Ballinluig.

There were some localised sections where boulders were apparent, forming step-pool sequences, but on the whole the bed was mostly obscured by vegetation, indicating potential for much finer sediment to be present (silt and fine gravels perhaps). This may also indicate that the channel had little flow for large parts of the year, thus allowing the vegetation to establish. There were few signs of instability and on the whole the channel was a stable transfer reach.

P1040489 – View upstream showing well vegetated channel (NGR 2866 8103)

P1040500 – View downstream of straightened course following the field boundary (NGR 2866 7102)

Watercourse Name	Caochan Ruadh – downstream of existing A9
WFD Water Body	Ordinary watercourse upstream of Loch Alvie (100181) and Allt na Fearna [sic] – d/s Loch Alvie (23125)
Crossing References	A9 1100 C70
Primary function	Transfer
Primary process	Stable

Description

The downstream reach of Caochan Ruadh only flowed for a small distance (c.130m) before it joined Loch Alvie. The channel flows through a long culvert underneath the A9 before emerging into a low gradient woodland, which was well connected to its floodplain (flooding out at the time of the survey).

The channel broadly followed a straight planform toward the Loch, although it did gently wander within this course. The bed was obscured at the time of survey, but indicated predominantly fine gravels and possibly silt. The banks comprised sandy soils, with some gravels. The gradient is much shallower here, approx. 1 to 3%.

There were no signs of erosion and it was difficult to see any in-channel deposits, although there were some large woody material which had fallen in from the adjacent woodland. As such the channel was a stable transfer.

P1040532 – The channel emerges from a large culvert underneath the A9 (NGR 2867 8100)

P1040537 – View downstream as the (flooded) channel flows through the woodland towards Loch Alvie (NGR 2867 8100)

Watercourse Name	Ballinluig Burn – upstream of existing A9
WFD Water Body	Ordinary watercourse upstream of Loch Alvie (100181) and Allt na Fearna [sic] – d/s Loch Alvie (23125)
Crossing References	A9 1100 C10
Primary function	Transfer
Primary process	Stable

Description

The Ballinluig Burn upstream of the A9 winds through a narrow self-contained valley. The channel was relatively small being approximately 0.5 to 1.0m wide. A dirt access track followed the valley downstream, crossing over the channel along the way on the RHB. Overall the vegetation was predominantly grasses, with the occasional overhanging tree. There appeared to be a lot of in-channel vegetation present suggesting that the flows were normally quite minimal.

The channel possessed a naturally meandering planform, although had been constrained by the adjacent road, being crossed several times and the road embankment forming part of the valley side. A two-stage channel profile was common and there was a well-connected floodplain throughout. The existing A9 crossing comprised a concrete culvert. The gradient was approx. 2 to 5%.

The substrate was primarily gravels and sands on the bed, the banks comprised sandy soils. The flows were rippled, with some cascades over infrequent steps, but there was little sign of any fluvial activity, with few areas of erosion and no deposition features. Overall the channel was considered to be a stable transfer reach.

P1040486 – View upstream from track crossing; track shown on the right (LHB) (NGR 2870 8103)

P1040471 – View upstream immediately before crossing underneath the A9 (NGR 2869 8102)

Watercourse Name	Ballinluig Burn – downstream of existing A9
WFD Water Body	Ordinary watercourse upstream of Loch Alvie (100181) and Allt na Fearna [sic] – d/s Loch Alvie (23125)
Crossing References	A9 1100 C10
Primary function	Transfer
Primary process	Stable

Description

The Ballinluig Burn downstream of the A9 was much more open than upstream, the narrow valley disappears and instead the channel flows through open agricultural fields. The channel was likely to have been modified historically, probably as a result of the A9 construction, with the channel possessing a slightly straighter planform than upstream. The channel was crossed once more a little further downstream of the A9 by an access track. The vegetation was dominated by grasses, with occasional trees. Downstream, just before the channel joined Loch Alvie there was small stand of woodland.

The banks were composed of sandy, earth soils. The channel immediately downstream (c.50 to 70m) of the A9 had a dense stand of in-channel emergent vegetation, which given the time of year indicated the channel was likely to have a low flow much of the year and the presence of fine substrate and some gravels were noted on the bed.

There were, once again, few signs of instability and flows were slightly less energetic (although still rippled given the high flows) than upstream due to the lesser gradient (1 to 3%). The amount of vegetation growth downstream potentially indicates some degree of aggradation, or deposition of fine sediments, however on the whole this was quite localised. Generally, Ballinluig Burn downstream of the existing A9 was a stable transfer reach.

P1040479 – View immediately downstream of the existing A9 crossing (NGR 2869 8101)

P1040482 – Crossing over the Ballinluig Burn (NGR 2869 8101)

Watercourse Name	Allt-na-Criche (Lynwilg) – upstream of existing A9
WFD Water Body	Ordinary watercourse upstream of River Spey – River Feshie to River Nethy (23097)
Crossing References	A9 1130
Primary function	Transfer (Sink)
Primary process	Stable

Description

Allt-na-Criche (Lynwilg) upstream of the A9 can be separated into two reaches, with the upper section operating as a sink for coarse sediment and the downstream section primarily a transfer.

The channel winds its way through a narrow, wooded valley gradually widening out downstream before it joins the River Spey (downstream of the A9). The woodland gradually thins out towards the A9. An access track for the various properties and Alltnacriche activity centre follows closely on the LHB and crossed the channel several times for access. It was constrained by the adjacent valley sides and access track, creating a broadly straightened course. At the downstream end around Lynwilg House and Farm the channel was also lined with gabion baskets along both banks (some of which had failed), and around the existing A9 crossing the channel had been channelised and protected with reinforced concrete and stone protection.

The bed substrates were predominantly gravels and cobbles, with the much larger material present at the top of the surveyed reach and smaller cobbles/gravel downstream. The channel had a range of high energy flows, including cascades and ripples over cobble bed features. The banks comprised sandy soils, with some vegetative growth over established gravel bars elsewhere.

There were a number of step-pools and large gravel bars in the upper section, coinciding with a likely decrease in gradient. As the gradient increased slightly towards the Lynwilg properties the deposits were more infrequent, the channel overall was primarily a transfer, and largely stable except for some isolated areas of bank failure.

P1040923 – View upstream toward large gravel bars and high energy flows (NGR 2877 8109)

P1040449 – View downstream towards existing A9 crossing; the channel here has been channelised and bank protected around residential properties (NGR 2881 8107)

Watercourse Name	Allt-na-Criche (Lynwilg) – downstream of the existing A9
WFD Water Body	Ordinary watercourse upstream of River Spey – River Feshie to River Nethy (23097)
Crossing References	A9 1130
Primary function	Sink
Primary process	Narrowing

Description

The access to Allt-na-Criche (Lynwilg) downstream of the A9 was constrained by poor access across the railway track. The channel was constrained underneath three major crossings (the A9, B9152 and the railway bridge). A short distance downstream of this the Allt-na-Criche (Lynwilg) joins the River Spey.

Because of these constraints the channel had been modified and straightened, including installation of concrete bed and bank protection (some of which had become damaged, see P1040468 below). There were few signs of fluvial erosion. However, there were a number of side bars underneath the crossings which were probably formed when coarser material from upstream has been transferred through and deposited where the gradient was less and the channel was wider. From the observations made, the channel appears to be narrowing through the preferential deposition of coarse material, however this may be localised underneath these crossings.

P1040468 – Collapse concrete/cobble bed leading towards the existing A9 crossing (NGR 2884 8106)

P1040470 – View upstream towards A9 crossing (NGR 2884 8106)

Watercourse Name	Aviemore Burn – upstream of existing A9
WFD Water Body	Ordinary watercourse upstream of River Spey – River Feshie to River Nethy (23097)
Crossing References	A9 1150 C95
Primary function	Transfer
Primary process	Stable

Description

The upper sections of Aviemore Burn were situated within a steep, self-contained wooded valley before flowing through the built up urban area of Milton, a suburb of Aviemore. The channel was a product of a number of upland tributaries joining together off Carn Dearg Mór.

Upstream the channel remains largely unmodified as it naturally wound (broadly in a straight course) through the steep woodland. However, through Milton the channel was more clearly modified, having been culverted under a road (Carn Elrig View) and another private road crossing a little further upstream of this. The channel was bank protected around these crossings with large boulders set in concrete (see P1040811). The landscape was also more manicured with mowed grassy banks associated with residential properties. The gradient noticeably lowered through Milton.

The banks (where not artificial) were predominantly earth, whilst the bed substrate comprised boulders, cobbles and gravels, with some sands at the margins.

The coarse bed material and steep gradient upstream formed a series of steps creating a range of energetic flows, including chute and cascade flows. Further downstream the flows were more rippled. There were no obvious signs of erosion, and only localised deposits. Overall the channel was behaving as a stable transfer.

P1040806 – The upstream section of Aviemore Burn was steep and wooded, a series of step-pools had formed created an energetic flows over the top (NGR 2892 8139)

P1040811 – As the channel flows through Milton the gradient reduces slightly, and the channel was affected much more by the surrounding development (NGR 2893 8138)

Watercourse Name	Aviemore Burn – downstream of existing A9
WFD Water Body	Ordinary watercourse upstream of River Spey – River Feshie to River Nethy (23097)
Crossing References	A9 1150 C95
Primary function	Transfer
Primary process	Stable

Description

Downstream of the A9 the channel gradient remained moderate. The adjacent land-use was clearly more constrained by residential properties, but there was still a good line of trees and riparian vegetation along the bank tops. The channel was crossed several times by access roads, and the channel was protected in places by boulder rip-rap.

From observations onsite and OS mapping the channel appears to have been resectioned, probably as a result of residential developments. Although there were a few areas where the channel had retained its sinuosity.

The bed still comprised cobbles and gravels, with some boulders immediately downstream of the A9 crossing and sands at the margins. The banks were sandy earth and well vegetated. Despite the likely modification and adjacent constraints, the channel possessed a diverse range of flows, with some chute flow over and around boulders, cascade and also ponded flow behind large boulders.

There were overall few signs of erosion and only localised minor deposition. The channel was primarily a stable transfer.

P1040829 – View upstream towards existing A9 crossing (NGR 2894 8139)

P1040828 – View downstream from Grampian View (NGR 2895 8137)

Watercourse Name	Easter Aviemore Burn – upstream of existing A9
WFD Water Body	Ordinary watercourse upstream of River Spey – River Feshie to River Nethy (23097)
Crossing References	A9 1160 C14
Primary function	Transfer
Primary process	Stable

Description

This tributary is adjacent to a new housing development at Milton within a sparsely wooded strip of land. The catchment was relatively steep and well vegetated (with grasses), including established and newly planted woodland along both banks. In the upper reaches the channel was naturally straight due to its gradient, however the channel became more modified further downstream as the track was culverted twice under the A9 and another smaller access track. The channel was fenced off and protected leading into the A9 culvert with boulder protection along the banks.

The bed comprised cobbles and coarse gravels, and the occasional boulder. The banks were predominantly earth with some boulders inset, and were well vegetated. Step-pools were common along the upper sections helping to create chute flow, cascades and rippled flows.

Overall there was little erosion and no deposition to indicate instability, the channel was functioning as a stable transfer.

P104837 – View upstream of tributary; new housing development shown on the left of the image (RHB) and new planting along bank tops likely associated with the development (NGR 2893 8142)

P1040843 – Gravel bed channel through grassy woodland (NGR 2894 8142)

Watercourse Name	Easter Aviemore Burn – downstream of existing A9
WFD Water Body	Ordinary watercourse upstream of River Spey – River Feshie to River Nethy (23097)
Crossing References	A9 1160 C14
Primary function	Transfer (Minor Sink)
Primary process	Stable

Description

Compared with upstream the gradient was much lower downstream of the A9. The landscape was more open grassland floodplain, used for grazing (horses). The planform although more sinuous compared with upstream, indicated that it had been resectioned probably as part of residential developments and for agricultural use.

The channel was crossed a number of times by a footpath and farming access, as well as road crossings (e.g. the A9 and the B9152). It was also embanked towards the lower end of the surveyed channel near to the B9152.

The bed was predominantly coarse substrate, such as cobbles and gravels, however the lower gradient had encouraged more fine sediment to be present. The banks were well vegetated (grass) and comprised sandy earth.

There were some step-pools where the gradient allowed it, creating chute flows, although predominantly the flows were rippled. There was little erosion or deposition, and although fine sediment was noticeably increased from upstream the channel was still mainly transferring sediment downstream.

P1040853 – View immediately downstream of A9 culvert outlet (NGR 2895 8141)

P1040865 – View immediately upstream of B9152 crossing (NGR 2897 8143)

Watercourse Name	Allt na Criche (Granish) – upstream of existing A9
WFD Water Body	Ordinary watercourse upstream of River Spey – River Feshie to River Nethy (23097)
Crossing References	A9 1170 C12 S and A9 1170 C12
Primary function	Transfer (Minor Sink)
Primary process	Stable

Description

Allt na Criche (Granish) flows steeply down from Cairn Mòr to the west, before the survey picked it up along a relatively low gradient valley bottom running parallel to the A9. The mainly grassy landscape was heavily saturated at the time of survey and the channel appeared very well connected to its floodplain. Although there were few signs of modification directly to the river channel, the channel was constrained by two embankments on either side, albeit the one on the LHB was part of a steep hillside already. The channel appeared naturally straight, although did occasionally wander slightly around its floodplain. The vegetation was primarily tussocky grassland, with some occasional tree cover. The valley side on the west comprised dense forestry. Concrete bed and bank protection had been installed leading up to the existing A9 culvert.

The bed primarily comprised fine sandy deposits, with coarser material in the minority. Some localised lengths of boulders were noted creating some step-pool sequences. The banks were sandy earth, although an orange hue to the channel suggested some peat.

Flows ranged from rippled to chute flow, and unbroken standing waves were noted in some locations where steep sections transitioned back to more moderate gradients. The more energetic flows were localised and primarily caused by boulders or woody material within the channel. Although there were some areas of erosion noted (mainly undercutting) and some fine sediment deposition along the bed (particularly due to the low gradient), overall the channel appeared quite stable and to be transferring material downstream.

P104751 – View downstream along channel course; flows appeared relatively high at the time of survey (NGR 2899 8155)

P104754 – View downstream along short wooded section of channel; the channel course was still largely straight but wood debris and steps occurred in some localised areas (NGR 2900 8155)

Watercourse Name	Allt na Criche (Granish) – downstream of existing A9
WFD Water Body	Ordinary watercourse upstream of River Spey – River Feshie to River Nethy (23097)
Crossing References	A9 1170 C12
Primary function	Transfer (Minor Sink)
Primary process	Stable

Description

The surrounding landscape was not too dissimilar to upstream, although there was clearly more woodland present. The valley side on the LHB disappears as the channel moves eastwards towards Loch nan Carriagean (where the channel seemingly doesn't continue to flow according to OS mapping). The gradient remained relatively flat, but the channel did still have a reasonable flow, probably due to the high flows it was experiencing.

Overall the planform was quite sinuous and (with the exception of the road crossings) appeared unmodified. The channel was culverted underneath the A9 and the A95, and was fenced off for some sections.

The bed substrate comprised a mixture of fine and coarse gravels (with occasional boulders), and fine sediment (mainly sand), which formed a cohesive and armoured bed. The banks comprised sandy earth and were well vegetated with grass. Flows were a diverse range from rippled flows and chute around localised steps, as well as some ponded flows behind the boulders.

Fine sediment deposition was common throughout and some minor undercutting was evident, but only in localised stretches. Overall the channel was functioning primarily as a stable transfer.

P1040769 – View downstream from just after the A9 crossing, wooded catchment with meandering watercourse (NGR 2902 8157)

P1040872 – View upstream from the A95 crossing (NGR 2905 8156)

Watercourse Name	Avie Lochan Burn South – upstream of existing A9
WFD Water Body	Ordinary watercourse upstream of River Spey – River Feshie to River Nethy (23097)
Crossing References	A9 1170 C20 and A9 1170 C20 S
Primary function	Transfer
Primary process	Stable

Description

The steeply graded unnamed tributary travels down from the forested hillside west of Avielochan. The landscape was dominated by woodland, with some occasional tracks across the stream for forestry access. The immediate banks were covered with grasses and ferns. Overall the channel was naturally quite sinuous flowing between the trees and formed of a series of steps. There are some areas of bank protection associated with the various crossings and a series of concrete steps leading into the A9 crossing (see P1040794 below). The channel was fenced off at the downstream end towards the A9, probably to keep deer from accessing the carriageway.

The channel bed was formed from large boulders which created the steps, with cobbles and gravels also noted. There was also some well sorted sand deposits in sheltered areas, i.e. behind boulders and along the margins. Large woody material (sourced from the surrounding woodland) occasionally helped create some ponded areas. The well vegetated banks were formed from sandy soils. Due to the steep gradient and coarse substrate the channel possessed a diverse range of flow types, primary comprising energetic flows such as chute, cascade, but sheltered areas helped form ponded areas.

Despite the high energies there was very little erosion noted (only some minor localised undercutting), as the tree roots and boulders help to naturally regulate the channel's energies, and overall the channel was a very stable transfer system.

P1040785 – Step-pool sequence upstream just downstream of forestry access crossing (in background) (NGR 2901 8165)

P1040794 – Artificial concrete steps leading into existing A9 crossing (NGR 2902 8164)

Watercourse Name	Avie Lochan Burn South – downstream of existing A9
WFD Water Body	Ordinary watercourse upstream of River Spey – River Feshie to River Nethy (23097)
Crossing References	A9 1170 C20
Primary function	Transfer (Minor Sink)
Primary process	Stable

<u>Description</u>

Downstream of the A9 the channel gradient was much lower than upstream. The forested landscape opened out, although there was a constant presence of trees on the banks, only less dense than upstream of the A9 crossing. The banks were still well vegetated with grasses and ferns. General Wade's Military Road crosses at this location, although the stone bridge was in a state of disrepair. Elsewhere the channel was fenced off on the RHB separating an area of much denser woodland, whilst the LHB was occupied by a herd of cattle.

The channel possessed a meandering course and had enough gradient to form steps, although less regularly than upstream. The meandering planform and low gradient did in place encourage some gravel point bars to form (P1040889). The bed substrate comprised coarse gravels and cobbles with some fines (sands) on the margins. The banks comprised sandy soils. Flows were varied, including cascade and chutes over steps, but predominantly rippled flow.

There was little fluvial erosion, although some poaching from the resident cattle was noted. There were however a few deposition features, but mostly corresponding with natural fluvial activity (point bars) and not widespread. Overall the channel was functioning as stable transfer, with some function as a minor sink for fine sediment.

P1040798 – View from existing A9 crossing downstream (NGR 2902 8164)

P1040889 – View downstream of meandering planform with gravel point bars and woody debris across the channel. (NGR 2903 8163)

Watercourse Name	Avie Lochan Burn North – upstream of existing A9
WFD Water Body	Ordinary watercourse upstream of River Spey – River Feshie to River Nethy (23097)
Crossing References	A9 1170 C23
Primary function	Unknown
Primary process	Unknown

Description

Avie Lochan Burn North was not surveyed during the hydromorphology walkover due to it being initially screened out, but has been subsequently inspected as part of the hydrology walkover. The watercourse possessed a variety of morphological features, including step-pool system and a steep, meandering planform upstream.

The channel is <1.0m wide, with its bed comprising coarse gravels and cobbles with the occasional boulder forming the step-pools, although towards the A9 the channel appears to be slightly incised, although no active signs of instability are visible in the photographs.

The channel around the existing A9 is heavily modified and culverted. No further survey information exists downstream of the A9.

P3230023 – View upstream of A9 crossing showing deep, gravel/cobble bed stream existing a steep hillside (NGR 2903 8168)

PB110128 – View downstream of structure underneath A9 with minimal flow and a lot of leaf litter (NGR 2904 8167)

Watercourse Name	Allt Cnapach – upstream of existing A9
WFD Water Body	Ordinary watercourse upstream of River Spey – River Feshie to River Nethy (23097)
Crossing References	A9 1170 C50 and A9 1170 C50 S
Primary function	Transfer
Primary process	Stable

Description

Situated within a self-contained valley with steep valley sides either side, the Allt Cnapach flows down from the west towards Kinveachy. The steep channel, although possessing a sinuous course, mostly followed the winding topography and where possible took a more direct path downhill. The channel became less steep towards the A9. The surrounding landscape was predominantly mixed woodland, with a variety of grasses and ferns along the bank tops. Although largely unmodified in the upper sections the channel was crossed (culverted) twice for access into the woodland and around Kinveachy Lodge. The channel leading into existing A9 culvert was protected with a short length of stone bed and bank protection.

The bed comprised primarily of gravels, with the occasional bedrock and boulders forming pronounced step sequences. Fines (sand) were less common and confined to the margins. The banks were well vegetated and comprised sandy earth soils, with embedded boulders and tree roots stabilising the bank line.

Fallen trees were also common, interacting with the channel, helping form energetic and diverse flow types along the course, dominated by a series of cascades over steps (note flows were considered high at the time of survey). There was however minimal erosion, except for minor undercutting downstream of large steps and some woody debris diverting flow towards vulnerable banks. Deposits were also uncommon and overall the channel was a stable transfer.

P1040704 – Channel had high flows at the time of the survey (NGR 2909 8185)

P1040712 – View downstream of broadly straight course towards existing A9 (NGR 2910 8185)

Watercourse Name	Allt Cnapach – downstream of existing A9
WFD Water Body	Ordinary watercourse upstream of River Spey – River Feshie to River Nethy (23097)
Crossing References	A9 1170 C50
Primary function	Transfer (Minor Sink)
Primary process	Stable

Description

Compared with upstream the gradient was much lower and the landscape was more open. The first 50m of channel was lined with stone bed and bank protection as the channel flowed underneath the railway line, having also been artificially straightened. The channel continued to be constrained by a track downstream of the railway crossing and along the A95. The bank tops were still lined with trees, with the landscape primarily used for grazing pasture. At the time of the survey the channel around the A95 was flooding, with a number of overland flow paths evident.

The bed substrates appeared to comprise mostly cobbles, gravels and sand, with the fines increasing further downstream as the channel became more ponded. The banks consisted of sandy earth soils with some boulders and cobbles.

Although no fluvial erosion was noted, there were clear signs of poaching from animal crossings just downstream of the railway bridge forming a fine sediment source. Flows were mainly rippled over and around woody features and cobble substrate, however the channel became increasingly ponded downstream as the watercourse was constrained by the culvert underneath the A95 and flowed into a series of ponds downstream of the road. The channel presents several functions over a relatively short distance, with the upper modified section transferring sediment, then an area of sediment input from poaching and finally a sink around and downstream of the A95 where the flows are ponded. Although the function more relevant to the A9 scheme was a sediment transfer and downstream sink, overall the channel was stable.

P1040720 – View downstream through the railway arch bridge and straight (and lined) channel (NGR 2911 8185)

P1040725 – View upstream just after the railway bridge with thin tree line and signs of poaching along the bank tops (NGR 2911 8185)

Watercourse Name	Feith Mhor – upstream of existing A9
WFD Water Body	Main river: River Dulnain – Feith Mhor (23113)
Crossing References	A9 1170 C75 and A9 1170 C75 S
Primary function	Transfer (Minor Source)
Primary process	Stable (Incising)

Description

The watercourse here was situated within a woodland, although the majority of the bank tops were dominated by tussocky grassland. The channel was crossed a couple of times by forestry access tracks (fords and culvert), but otherwise the channel was natural. The meandering planform was quite deep and appeared somewhat disconnected with its floodplain and had a number of adjoining tributaries.

The bed substrates were mainly sands and fine gravels and coarse sediments (gravels and cobbles) which although initially in the minority, increase further downstream towards the A9. The banks, as with most other areas, comprised sandy earth soils.

The deep channel was probably a result of a series of knickpoints creating incision moving upstream and leading to some destabilisation of the banks as they are undercut and steepened. The knickpoints and occasional fallen woody material help form a stepped longitudinal profile. Flows over these steps are energetic cascades, although lengths of rippled and smooth flows were more common. Lower down in the reach coarser substrate forms riffles, and the channel appeared better connected to the floodplain and flows were more uniform.

The function here included incision, but was primarily transfer and therefore stable.

P1040644 – Knickpoint and scour pool downstream displaying higher energy flows and evidence of incision (NGR 2905 8205)

P1040670 – Further downstream towards A9 the channel was wider and better connected to the adjacent floodplain (NGR 2907 8207)

Watercourse Name	Feith Mhor – downstream of existing A9
WFD Water Body	Main river: River Dulnain – Feith Mhor (23113)
Crossing References	A9 1170 C75
Primary function	Transfer
Primary process	Stable

Description

Downstream of the A9 Feith Mhor was still situated within a woodland, although denser than upstream, trees were right up on the bank tops. The gradient was noticeably lower downstream also. The channel was crossed several times by the A9, railway and A95. The planform was straightened but not clearly modified, and was perhaps regulated by the adjacent trees either side.

The bed substrates were mainly fine sediments (sands and gravels), with some cobbles also present. Downstream of the railway sand deposits dominated. The banks unsurprisingly comprised sandy soils.

There were occasional steps and knickpoints suggesting some incision, but not nearly as common as upstream. Large trees which had fallen into the channel are envisaged to play a key role in regulating flows, creating both pooled and rippled flows, however the flows were mostly uniform rippled/smooth. The channel on the whole was a stable transfer system.

P1040985 – Fine sandy deposits on the bed with some emergent in-channel vegetation (NGR 2909 8210)

P1040690 – Typical view downstream along Fèith Mhòr (NGR 2909 8211)

Watercourse Name	River Dulnain – upstream of existing A9
WFD Water Body	Main river: River Dulnain – Lower Catchment (23106)
Crossing References	A9 1190
Primary function	Transfer (Exchange)
Primary process	Stable (Lateral Adjustment)

Description

Flows were higher than what would be considered normal during the time of the survey. The river flowed through a largely rural landscape with wide open grazing pastures either side, although the immediate bank tops comprised trees and rough grasses. Closer to the A9 crossing, the RHB becomes more of a valley side constraining the river. Broadly speaking the river had a moderate gradient. The channel has been previously modified and constrained, with lengths of bank protection (gabions and stone) and riparian management, including fencing. However, the natural fluvial processes within the Dulnain still operate.

The size of the channel and high flows made it difficult to accurately assess the bed substrate, however observations suggested that it comprised cobbles and boulders, with some coarse gravels and sands at the margins. The banks were mainly sands and earth, some boulders were also noted, but may have been placed artificially as bank protection.

Aerial imagery suggests the gravel bars were more extensive than observed during the survey, although many were still visible. There were few signs of active erosion, although the Dulnain is known to have laterally migrated further upstream. Flows were perhaps more energetic than would normally be expected, with broken and unbroken standing waves over underwater obstructions. With little erosion, but a large number of coarse deposits noted it could be determined that the Dulnain was predominantly a sink, however it is more likely (according to historic channel changes) the channel was a stable system and these deposits are transient features which are constantly re-worked and re-organised within the wider river corridor.

P1040593 – View upstream on River Dulnain with gravel deposits clearly visible (NGR 2887 8225)

P1040609 – View downstream towards existing A9 bridge over the Dulnain (NGR 2856 8225)

Watercourse Name	River Dulnain – downstream of existing A9
WFD Water Body	Main river: River Dulnain – Lower Catchment (23106)
Crossing References	A9 1190
Primary function	Transfer (Minor Sink)
Primary process	Stable

Description

The River Dulnain downstream of the A9 crossing was much more constrained by adjacent residential developments than upstream of the A9. However, the immediate bank tops were still well vegetated and there was a persistent tree presence throughout. The A9 crossing itself, along with the railway, had resulted in the channel being protected with gabions and stone. The channel was clearly well connected to its floodplain having already partially flooded out at the time of the survey.

The bed comprises (where visible) coarse substrate but there was still an obvious amount of sands in the channel, but mostly confined to the margins. Bedrock was also more pronounced through this reach, and even more so around Carrbridge downstream. The banks were still well vegetated and comprised sandy earth, and increasingly more bedrock downstream.

There was some bank erosion on the RHB immediately downstream of the railway, but likely that gravel bars still dominate (according to the aerial imagery). In contrast to upstream of the A9, the constrained river system means the channel was less likely to be able to adjust, and has less room to re-work the gravel bars. The channel here was still predominantly a stable transfer system, with some minor deposition.

P1040617 – View immediately downstream of railway bridge, erosion (likely poaching) on the RHB (NGR 2897 8227)

P1040945 – Bedrock channel leading into Carrbridge (NGR 2906 8230)

Watercourse Name	Allt nan Ceatharnach – upstream of existing A9
WFD Water Body	Main river: River Dulnain – Allt Ruighe Magaig (23112)
Crossing References	A9 1200
Primary function	Transfer
Primary process	Stable

Description

The watercourse flowed through a narrow, wooded corridor and was considered to be moderately steep. The channel possessed a wandering planform, although generally the course was restricted either side by the railway and the B938 embankments, the embankment on the LHB being very steep. The channel underneath the railway and A9 was lined with concrete on the bed and banks.

The bed material comprised coarse substrate, such as boulders, cobbles and gravels, although mostly obscured by high flows. There did appear to be some sands in the pools and bedrock downstream towards the crossings. The banks were sandy earth soils with gravel.

The survey began with a 2.0m+ high waterfall (limiting the extent of the survey through the middle section), and elsewhere there was a good range of high energy flows, including cascades, broken and unbroken standing waves over the boulder formations and fallen trees. However, there were higher flows than considered normal at the time of the survey. Some bank erosion was noted on the LHB, but mostly appeared quite stable. Terraces on the RHB suggest the channel had previously shifted its course, but there was little evidence to suggest this process was ongoing.

P1040564 – View upstream of waterfall in the distance and railway embankment on the left (RHB) comprising a vertical wall of stone; flows are highly energetic (NGR 2891 8234)

P1040573 – View downstream underneath railway bridge and concrete bed and banks (NGR 2892 8233)

Watercourse Name	Allt nan Ceatharnach – downstream of existing A9
WFD Water Body	Main river: River Dulnain – Allt Ruighe Magaig (23112)
Crossing References	A9 1200 and A9 1200 S
Primary function	Transfer
Primary process	Stable

Description

Downstream of the A9 the Allt nan Ceatharnach, although still contained with a wooded corridor, was less constrained both sides and had more space in which to flow. As such the channel planform was markedly more sinuous, having a meandering course. The channel was well fenced off as the landscape evolved towards a more open rough grassland, which was used for grazing on the RHB. The channel was still modified around the crossings, there was also a ford and footbridge close to Dalrachney Beag. Downstream of here the woodland disappeared and the channel now flowed through an open grazing field.

The bed substrates (where visible) were still coarse, although fewer bedrock and boulders, and the banks much the same as upstream. Flows were still energetic but with fewer boulders interacting they were primarily rippled, with an occasional chute and standing broken waves.

There was some erosion and minor deposition. A relic channel was also obvious downstream near the confluence with the River Dulnain, however there was few suggestions that any active fluvial processes were operating beyond a stable transfer.

P1040584 – View upstream towards existing A9 crossing and surrounding woodland (NGR 2891 8230)

P1040603 – Further downstream the woodland was replaced with open grassland and much more uniform channel (NGR 2893 8225)

Watercourse Name	Bogbain Burn – downstream of existing A9
WFD Water Body	Main river: River Dulnain – Allt Ruighe Magaig (23112)
Crossing References	Side road
Primary function	Unknown
Primary process	Unknown

Description

The watercourse was not initially surveyed as part of the hydromorphology survey having been screened out as it was considered offline and not directly affected (i.e. not crossed by the A9). It has been subsequently screened in to account for potential impacts from the Black Mount Northbound junction embankment which may increase the confinement of the channel.

The channel is a tributary to Allt nan Ceatharnach, but is not itself directly affected by the existing A9. It has been however substantially affected by the railway and other roads, having been crossed a dozen times over a 2km distance. The planform has clearly been realigned and straightened, but does possess diverse and dynamic morphological features (see below) as it flows through a dense woodland.

There are few signs of stability, but the overall dominant processes are uncertain without further walkover information.

Watercourse Name	Allt Slochd Mhuic
WFD Water Body	Main river: River Dulnain – Allt an Aonaich (23110)
Crossing References	A9 1209 F, A9 1210 C46, A9 1210 C45, A9 1208 F, A9 1207 F, A9 1210 C39, A9 1210 C31 and A9 1206
Primary function	Transfer
Primary process	Stable

Description

Heavily modified and artificial channel which has been realigned and protected likely during the construction of the railway and/or existing A9 alignment. The channel has been realigned either sides of the A9, crossing over twice and running parallel along the railway. The channel flowed through a series of culverts and was bank protected along much of its surveyed course. Downstream of the A9 the channel was contained with a concrete lined uniform channel which was constrained parallel to the A9, before crossing again southwards. The channel at this point is less affected by the road and flow through a more open, wet woodland environment, with multiple channel threads.

The bed substrate, where not artificial (i.e. concrete) comprised of some bedrock and boulders, but primarily gravels and cobbles and fine silt at the margins (likely from road runoff). As the gradient decreases towards the railway the presence of fines increase. The banks, again where not artificial, were mainly earth and vegetated with rough grasses.

The flows were mainly rippled, some cascades over boulders and some very small steps. Overall there was no erosion and little deposition, except for some fine sediment on the bed. The channel did not possess the capacity to undertake any fluvial activity and was mostly a stable transfer.

P1040955 – The channel has been realigned and constrained into a narrow artificial valley through a series of culverts (NGR 2836 8256)

P1040970 – Channel between the railway and A9 was lined with gabion and stone wall protection through two culverts (NGR 2837 8254)

P1040973 – Downstream of the A9 the channel was contained within a concrete lined uniform channel with a steep gradient (NGR 2838 8253)

IMG_20170710_131549 – Downstream of existing impacted reach the channel bifurcates within a wet woodland area constrained by the hillside on the right and the A9 on the left (NGR 2842 8246)

3.4. Watercourse sensitivity classification

3.4.1. Based on the classification criteria outlined above (see Table 2.2) the sensitivity classifications and justification for each watercourse is summarised in Table 3.3, below.

Table 3.3: Watercourse sensitivity summary classifications

Watercourse name	Sensitivity	Justification
Allt an Fhearna	Medium	The watercourse around The Proposed Scheme possesses a diverse range of morphological processes and features (including large gravel deposits, steps, large wood and bank erosion). It has been historically modified (straightened) and is constrained underneath and alongside the existing A9.
Allt Chriochaidh	Medium	Channel possesses a diverse range of morphological forms and processes, with the downstream reaches shown to be able to partially laterally adjust the planform. Modifications are substantial, but limited to the existing A9 crossing.
Caochan Ruadh	Medium	The channel has been historically modified around the existing crossing and along the upper reaches, but does possess some geomorphic diversity, particularly upstream with a steep step-pool bedrock system evident.
Ballinluig Burn	Low	Modified and constrained watercourse, with uniform flows (heavily vegetated in-channel) and little morphological diversity evident.
Allt-na-Criche (Lynwilg)	Medium	Morphologically diverse in the upper reaches, with large gravel bars. Substantially modified adjacent to Lynwilg properties (gabion bank protection) and through the existing A9 and railway crossing (straightened and widened). However, there are signs of recovery underneath the A9 as the channel is shown to be narrowing through deposition of coarse substrate.
Aviemore Burn	Medium	Diverse watercourse throughout with a good range of flows and morphological features, however substantially constrained through recently constructed housing estate and existing crossings.
Easter Aviemore Burn	Medium	Some lengths possess diverse morphology especially in the upper reaches with step sequences common and clean coarse gravel substrate. However, overall the watercourse has historically been modified for residential and agricultural drainage purposes. Minor fine sediment deposition was noted on the downstream reaches were flow energy reduced.
Allt na Criche (Granish)	Medium	Although largely unmodified (except for the existing A9 crossing) morphological diversity was confined to localised lengths. The presence of boulders and large wood in the watercourse did create more dynamic flows, but overall some fine sediment deposition along the bed was noted.
Avie Lochan Burn South	Medium	Vast variety of morphological features, including high energy step-pool system in the upstream and meandering planform in the downstream. Heavily modified over short distance around the existing A9 crossing.
Avie Lochan Burn North	Medium	A variety of morphological features, including step-pool system and meandering planform likely to exist upstream. Heavily modified around the existing A9 crossing. Likely to

Watercourse name	Sensitivity	Justification
		possess the potential to be a dynamic system, but no signs of instability from photographs.
Allt Cnapach	Medium	Good range of flows and dynamic morphological features, but substantially modified in the downstream reaches. Few active morphological processes occurring and some fine sediment deposition was noted in the downstream reaches (including poaching downstream).
Feith Mhor	Medium	Some incision (knickpoints) evident in the upper reaches resulting in a series of steps, but on the whole flows were uniform around the A9 crossing. The channel lacked energy to recover from historic modifications downstream.
River Dulnain	High	Sub and highly active gravel bed river channel, with a dynamic and diverse range of morphological features, including large gravel bars. The river channel has been substantially modified underneath the A9 and through Carrbridge.
Allt nan Ceatharnach	Medium	Very active, moderately steep river channel although modified and constrained in sections due to existing river crossings (A9 and railway) and agricultural drainage. The bed of the channel is modified in places, but did possess bedrock features to form a dynamic range of flows.
Bogbain Burn	Medium	Heavily modified around the Highway Mainline Railway, but mapping and photographic evidence suggests natural meandering upstream, with diverse and dynamic flow patterns likely, including a coarse cobble/gravel substrate and some woody debris from adjacent woodland, but overall stable.
Allt Slochd Mhuic	Low	Heavily modified channel culverted several times and lined with concrete over long lengths. Downstream, the channel does evolve into a slightly more dynamic system.

4. The Proposed Scheme

4.1.1. For each proposed crossing Table 4.1 (below) outlines broadly the following impacts:

- **realignment** – SEPA requires a simple CAR licence application for "*All diversions, realignment, flood by-pass channels and culverting for land gain on rivers ≤3m wide*" and a complex licence for those >3m wide
- **new crossing** – a completely new crossing over a river
- **extended crossing** – an extension (or replacement) of an existing crossing on the A9 or existing minor roads
- **modification** – changes to an existing structure which may affect flow and sediment conditions, e.g. addition of bank protection at the inlet/outlet, installation of mammal passes or any other modification which does not fundamentally change the position or size of the crossing
- **no impact** – no obvious impact likely as a result of the Proposed Scheme

4.1.2. Please note other activities across the water environment will also require a CAR licence application[viii]. As stated in SEPA's guidance documents, the following activities require a CAR authorisation:

- Any activity liable to cause pollution of the water environment, including discharges of polluting matter and disposal of waste sheep dip and waste pesticides;
- Abstraction of water from the water environment;
- Construction, alteration or operation of impounding works (e.g. dams and weirs) in surface water or wetlands;
- Carrying out building or engineering works (a) in inland water (other than groundwater) or wetlands; or (b) in the vicinity of inland water or wetlands and having or likely to have a significant adverse effect on the water environment;
- Artificial recharge or augmentation of groundwater;
- The direct or indirect discharge, and any activity likely to cause a direct or indirect discharge, into groundwater of any hazardous substance or other pollutant;
- Any other activity which directly or indirectly has or is likely to have a significant adverse impact on the water environment.

4.1.3. These include the installation of ‘grey’ and ‘green’ bank reinforcement, bed reinforcement, sediment removal, culvert installation and channel diversions on main watercourses (i.e. those shown on 1:50k OS maps).

4.1.4. See Figure A11.2.2 (sheets 1 to 9) for the Proposed Scheme layout and watercourse crossings and diversions.

Table 4.1: Summary of Proposed Works

Watercourse Name	Crossing Ref	Realignment	New Crossing	Extended/ Replacement Crossing	Modified Crossing	No impact	Description of proposed works
Allt an Fhearna	A9 1090 S		✓				A new clear span access track crossing the watercourse. It will be 6.5m wide x 2.5m high. No watercourse realignment will be required. This will result in a total loss of 5m of open watercourse. 2 No. outfalls upstream of the main outfall.
Allt Chriochaidh	A9 1100			✓			The existing culvert will be demolished and replaced with a new 21.8m long portal frame culvert. The new structure will be 4.0m wide x 1.5m high. No watercourse realignment will be required.
	A9 1100 S		✓				A new clear span access track crossing the watercourse. It will be 6.5m wide x 1.5m high. When combined with A9 1100, this will result in a cumulative total loss of 17m of open watercourse. 1 No outfall downstream of A9 1100 S.
Caochan Ruadh	A9 1100 C70	✓		✓			The existing culvert will be demolished and replaced with a new 82m long portal frame culvert (compared with the existing 74m long culvert), constructed offline (adjacent) to the existing structure. The new structure will be 2.5m wide x 2.5m high, set at a gradient of 2.6%. The two watercourses upstream converge immediately upstream of the culvert inlet and both require realignment. A small tributary (ditch) running north to south will be realignment over 45m, with an initial gradient of 7-9% before shallowing out to 2.5% upstream of the headwall. The main channel joining from the west, will also be realigned over 45m with a gradient of approx. 5.6%. Downstream the watercourse will be realigned by 65m (including a plunge pool) set initially at 3.1% before shallowing to 1.9% at the tie-in with the existing watercourse. This will result in a total loss of 31m of open watercourse.
Ballingluig Burn	A9 1110 C10			✓			The existing 38.5m piped culvert is to be demolished and an “open” watercourse combined with the underpass. There will be a requirement for a short realignment upstream and downstream to tie-in with the existing channel. The upstream watercourse will be realigned over approximately 130m with a gradient fluctuating between 1 and 3.6%, before steepening to 5.9% upstream of the culvert

Watercourse Name	Crossing Ref	Realignment	New Crossing	Extended/ Replacement Crossing	Modified Crossing	No impact	Description of proposed works
							inlet. Downstream a shorter, 30m realignment will tie back in with existing channel at approximately 4.6% gradient. This will result in a loss of approx. 5m of open watercourse overall. 2 No outfalls, 1 upstream of A9 1110 C10 and 1 downstream.
Allt-na-Criche (Lynwilg)	A9 1130		✓		✓		The existing structure (13m span) will be repaired and a new structure constructed offline and adjacent to the existing culvert. The proposed new structure will be a 38m long portal frame, 6.0m wide x 3.4m high. In total the span of the combined structure will be 26m. No watercourse realignment will be required. This will result in a total loss of 13m of open watercourse. 3 No outfalls, 2 upstream and 1 downstream of A9 1130.
Aviemore Burn	A9 1150 C95	✓		✓			The existing culvert (34m in length) will be demolished and replaced with a new 40m long portal frame culvert, constructed offline (adjacent) to the existing structure. The new structure will be 2.5m wide x 2.5m high, set at a gradient of 6.1%. Upstream the watercourse will be realigned approximately 42m set at a gradient of 2-6% and downstream over a distance of 18m (including the plunge pool) at approximately 6%. This will result in a total loss of 16m of open watercourse. 1 No outfall upstream of A9 1150 C95.
Easter Aviemore Burn	A9 1160 C14	✓		✓			Upstream, the watercourse will be realigned over a distance of 11m at a gradient of 7.3%. The existing culvert will be demolished and replaced with a new 46m long box culvert, constructed offline (adjacent) to the existing structure. The new structure will be 1.2m wide x 1.2m high, set at a gradient of 7%. Downstream the watercourse will be realigned over a distance of 38m (including plunge pool), at a gradient of approximately 2.7%. This will result in a total loss of 2m of open watercourse. 3 No outfalls, 1 upstream and 2 downstream of A9 1160 C14.
Allt na Criche (Granish)	A9 1170 C12 S	✓	✓				1.2m box culvert, approximately 11m in length set at a gradient of 1.3%. Upstream the channel will be realigned over a distance of 16m, set at a gradient of 2.5%. Downstream the watercourse will be realigned to tie-in with the mainline culvert (see A9 1170 C12).

Watercourse Name	Crossing Ref	Realignment	New Crossing	Extended/ Replacement Crossing	Modified Crossing	No impact	Description of proposed works
							This will result in a total loss of 26m of open watercourse. 1 No outfall downstream of A9 1170 C12 S.
	A9 1170 C12	✓		✓			The existing culvert will be demolished and replaced with a new 64m long portal frame culvert, constructed offline (adjacent) to the existing structure. The new structure will be 2.5m wide x 2.5m high, set at a gradient of 2.7%. The watercourse upstream will be realigned between the side road over a distance of approximately 83m (including plunge pool) set at a gradient of between 0.9% and 1.2%. Downstream the watercourse will be realigned over a distance of 42m (including plunge pool), set at a gradient of 0.6%. When combined with A9 1170 C12 S, this will result in a total loss of 26m of open watercourse
Avie Lochan Burn South	A9 1170 C20 S	✓		✓			A 12m long 1.2m x 1.2m box culvert replacing the existing 6m long structure, set at 8.8% gradient. The channel will be realigned upstream over a distance of 14m at 11% and downstream over a distance of 39m at 14%, in what is already a very steep channel system.
	A9 1170 C20	✓		✓			The existing culvert will be demolished and replaced with a new 54m long twin box culvert, constructed offline (adjacent) to the existing structure. The new structure will comprise two 1.2m wide x 1.2m high culverts, set at a gradient of 8%. Upstream the watercourse will be realigned over a distance of 43m, including a cascade of approximately 10m. The proposed gradients are 13.6%, and 36% (1 in 3) across the cascade. Downstream the watercourse will be realigned by 39m (including plunge pool), at a gradient of 7.6%. When combined with A9 1170 C20 S, this will result in a total loss of 35m of open watercourse. 1 No outfall downstream of A9 1170 C20.
Avie Lochan Burn North	A9 1170 C23			✓			The existing culvert will be demolished and replaced with a new box culvert, constructed offline (adjacent) to the existing structure. The new 43m long structure will be 1.2m wide x 1.2m high, set at 8% gradient. A 20m realignment is required upstream, including a cascade of approximately 10m, with the channel varying between 11% and 47% at the cascade. Downstream the watercourse will be realigned

Watercourse Name	Crossing Ref	Realignment	New Crossing	Extended/ Replacement Crossing	Modified Crossing	No impact	Description of proposed works
							over 17m at a gradient of approximately 6%. This will result in a total loss of 9m of open watercourse.
Allt Cnapach	A9 1170 C50 S	✓		✓			2 x 750mm pipes will be installed over a distance of 14m at a gradient of 6.8%, replacing the existing 9m long crossing. The watercourse will be realigned upstream over 19m at a gradient of 8%, and then realigned downstream to tie-in with A9 1170 C50 (see below).
	A9 1170 C50	✓		✓			The existing culvert (approximately. 40m) will be demolished and replaced with a new 44m long portal frame culvert structure, constructed offline (adjacent) to the existing structure. The new structure will be 2.5m wide x 2.5m high, set at a gradient of 6.8%. Upstream the watercourse will be realigned to tie-in with the modified side road structure over a distance of 4m at a gradient of approx. 7.5%. Downstream the watercourse will be realigned over a distance of 15m (including plunge pool), at a gradient of 4.6%. When combined with A9 1170 C50 S, this will result in a total loss of 14m of open watercourse. 2 No of outfalls downstream of A9 1170 C50.
Feith Mhor	A9 1170 C75 S	✓		✓			A 1.2m x 1.2m box culvert. Upstream watercourse realigned over a distance of 31m, at a gradient of 1.8% leading into a new modified crossing across the access road. Downstream the channel will be realigned over a distance of 19m (including plunge pool) at a gradient of 1.8%.
	A9 1170 C75	✓		✓			The upstream watercourse will be realigned (combined with the downstream realignment of A9 1170 C75 S) over a distance of 12m, at a gradient of 1.3% and the existing culvert will be demolished and replaced with a new 60m long portal frame culvert structure, constructed offline (adjacent) to the existing structure. The new structure will be 2.5m wide x 2.5m high at a gradient of 0.9%. Downstream the watercourse will be realigned over a distance of 46m (including the plunge pool), at a gradient of 2.1%. When combined with A9 1170 C20 S, this will result in a total loss of 43m of open watercourse. 1 No outfall downstream of A9 1170 C75.
River Dulnain	A9 1190		✓				The existing bridge structure will be retained and repaired. A new structure will be constructed adjacent to the existing bridge to form the southbound carriage, with the

Watercourse Name	Crossing Ref	Realignment	New Crossing	Extended/ Replacement Crossing	Modified Crossing	No impact	Description of proposed works
							existing structure forming the northbound carriageway. The structure will span approximately 45m between the north and south piers. The piers will be set back away from the channel. The bridge will be 12-14m above the river channel, and each structure will be 13m wide (26m in total). The natural bed will be retained through the new structure. This will result in a total loss of 13m of open watercourse, although there may be little impact on loss of light given the height of the structure(s). 1 No outfall upstream of A9 1190.
Allt nan Ceatharnach	A9 1200		✓				The existing bridge structure will be retained and repaired. A new structure will be constructed adjacent to the existing bridge to form the southbound carriage, with the existing structure forming the northbound carriageway. The structure will span approximately 26m to a height of 9.7m, and the total combined width will be 26m. The natural bed will be retained through the new structure (although the bed through the existing structure is lined with concrete). 3 No outfalls, 1 upstream and 2 downstream of A9 1200.
Allt nan Ceatharnach	A9 1200 S		✓				A new clear span access track crossing the watercourse. The precise size of the access track is still to be determined. No watercourse realignment will be required. When combined with A9 1200, this will result in a total loss of 4m of open watercourse.
Bogbain Burn	n/a – not crossed						Indirectly impacted by a raised flood embankment on the right-hand bank upstream of the railway crossing. Existing channel cross-section dimensions will remain the same downstream of the raised embankment, with increased flow through railway culvert. The embankment will be raised by 410mm (313.2 compared to 312.79mAOD). No new or modified crossing, nor any realignment required. 3 No outfalls, 2 upstream and 1 downstream of the railway bridge.
Allt Slochd Mhuic	A9 1209 F					✓	The watercourse around Slochd will become very constrained against the A9, railway and cycle path. A9 1209 F will remain unaffected by the works. A replacement crossing underneath the A9 will be constructed (A9 1210 C46) using a 2.1m x 2.1m box culvert, around 44m in length at a gradient of approximately 2.7%. The
	A9 1210 C46			✓			

Watercourse Name	Crossing Ref	Realignment	New Crossing	Extended/ Replacement Crossing	Modified Crossing	No impact	Description of proposed works
	A9 1210 C45			✓			watercourse will then flow on the northbound side through a 2m wide concrete channel with natural substrate placed on the bed. The existing culverts underneath the railway (A9 1208 F and A9 1207 F) will be retained, before crossing the A9 again through A9 1210 C39, replacing the existing structure with a 58m long, 2.5m portal frame structure at a gradient of approx. 2.1%. The channel will then flow adjacent to the southbound carriageway for 130m through a concrete lined structure. The channel will utilise a rock trap before, once again, crossing the A9 through a 100m long combined underpass, shared with cycleway. Downstream of the combined structure the channel makes a rapid decent along a 1.6m x 1.5m concrete cascade structure, varying between 2.9% and 25% in gradient. The channel then discharges into the existing channel. The existing A9 culvert (A9 1210 C31) will be blocked off, however the existing structure underneath the side road (A9 1206 F) will be retained. See Section 4.2 for potential mitigation details to soften and naturalise the aesthetics around Slochd. The design for Slochd is ongoing and culvert sizes and arrangement are subject to change. 1 No outfall upstream of the A9 and 3 No outfalls downstream of A9.
	A9 1208 F					✓	
	A9 1207 F					✓	
	A9 1210 C39			✓			
	A9 1210 C31			✓			
	A9 1206 F					✓	

4.1.5. There are many minor watercourses previously screened out in Stage 2 from further assessment, but which will still require minor realignment(s) or modification(s) to enable the Proposed Scheme to be constructed. The risks from these structures are considered much lower and environmentally less sensitive.

4.1.6. Whilst these minor watercourses do not warrant further assessment as part of the ES, standard mitigation and good practice should still be followed. Geomorphological input into the detailed design will still be required to ensure the construction of any realignments are suitable and do not result in instability, such as bank erosion or bed scour (incision) which may undermine the crossing structures. Geomorphological guidance on the size and retention of substrate through the culverts where they are particularly steep may be required.

4.2. Embedded mitigation

4.2.1. The hydromorphology design team has made an active contribution towards the watercourse alignment design, providing advice on the vertical and horizontal alignments. Where possible, avoiding substantial changes in gradients and ensuring the proposed watercourse realignment ties-in efficiently with the existing watercourses, i.e. no sharp or abrupt change in direction.

Slochd Summit

4.2.2. The hydromorphology team has been consulted as part of the preliminary design process for the watercourse structures at Slochd Summit. This also included a site visit with SEPA's geomorphology specialist in July 2017 where the complexities and constraints of the site were presented and explained.

4.2.3. Every effort has been made to ensure the watercourse and structure design at Slochd Summit is sympathetic to the surrounding environment. However, the constraints surrounding the watercourse, including the encroaching A9 carriageway, national cycleway and the railway leave very little room for the watercourse. The existing channel is currently very modified and flows through several culverts and concrete cascade/chutes.

4.2.4. Where possible an open channel has been maintained, with a natural substrate layer in the bed especially upstream of the existing railway crossings also being important.

4.2.5. The upper cross-section of the cascade structure will be graded back and naturalised to improve the visual impact of the channel. This section of channel is expected to be utilised only as freeboard during a flood event. Freeboard has been set as a minimum of 300mm above the formal concrete channel. Some erosion geotextile or embedded cobbles might be required to protect the adjacent bank from erosion at high flows.

4.2.6. The cascade also has some gentle bends in the profile to improve the visual appearance of the cascade.

4.2.7. A sediment trap will be designed at the top of the cascade, likely to be upstream of the combined underpass structure to prevent excessive deposition where the design meets the existing channel.

4.2.8. Downstream of the A9 the channel flows through an open wet woodland environment. Several SuDS ponds are proposed on the left-hand bank of the channel. In consultation with the drainage engineering team these have been moved as far as possible away from the watercourse.

4.3. Standard mitigation

4.3.1. Standard design mitigation recommendations (and guidance) were outlined within the hydromorphology assessment at Stage 2 and are expected to be implemented in all cases. These recommendations, which also align to the Strategic Environmental Assessment Design Principles W4 and W7 (Appendix A4.1) are outlined below.

4.3.2. Exceptions (where known) will be explicitly identified within the magnitude of impacts table (Table 6.1, below).

Watercourse crossings

Bridges

4.3.3. Single span bridges are the preferred type of crossing, see SEPA's guidance on river crossings[ix]. This has the least impact on the natural fluvial regime, maintaining existing in-stream and bank side habitats. Sediment transport and migration of aquatic species can be maintained.

4.3.4. Structures with in-stream supports may be appropriate, but only for very wide rivers. Similarly, most of the in-stream and bank side habitats can be maintained, although careful consideration is required for the effect the supports may have on the bed (e.g. scour) and may block debris.

Culverts (extended and new)

4.3.5. If a clear span structure is not technically feasible nor economically viable, a closed culvert is likely to be required. Culverts are common along many of the UK's road and rail networks, as well as forming large parts of the river networks underneath urban environments. Depending on their age they often have artificial hard beds, may be oversized to allow flood flows and extend for long lengths. Vegetation growth through the culvert is limited to only the hardiest of species and culverts broadly prevent natural fluvial/sedimentary processes (including sediment transport) and create a barrier for the movement of fish and other wildlife. They can also block debris and create flood risk if not properly designed.

4.3.6. Good practice culvert design should consider the following:

- **Natural bed substrate**: for box culverts (i.e. with an artificial bed) a depressed invert set slightly below the existing bed level is required. This will allow space for natural bed substrates to be imported to form the bed level. For culverts less than 1.2 m diameter or height (internal height) the invert should be buried at least 15 cm below the natural bed level. For culverts 1.2 - 1.8 m diameter or height (internal height) the invert should be buried at least 20 cm below the natural bed level. For culverts greater than 1.8 m diameter or height (internal height) the invert should be buried at least 30 cm below the natural bed level[x]. Baffles (precast or otherwise) may be required if there is a risk of the natural sediment flushing through at high flows. The culvert design should reflect the natural bed profile including bank to bank channel width, channel gradients and substrates where possible. Portal frames which do not possess an artificial bed do not require specific bed mitigation, but do still need an appropriate bed substrate. Bed checks or step pools may also need to be considered if the bed gradient is locally steep;
- **Low flow channel**: a low flow channel (sized appropriately to each watercourse) should be constructed within the culvert to maintain sufficient water depths and sediment transport through the culvert during normal flow conditions;

- **Fish passage**: a ‘buffer’ zone will be created up and downstream of culverts to allow for the creation of habitats which will both enhance the watercourse, and incorporate features such as pools which will allow fish to rest before entering the culvert. The overall culvert design should not in any way impede fish passage up and downstream, and the gradient should reflect the surrounding landscape, overly steep or shallow gradient should be avoided where possible;
- **Bank protection**: although each culvert should be considered separately, it is likely that some bed and bank protection will be required upstream at transition between the watercourse and culvert. Hard (grey) bank and bed protection should be avoided where possible. Rip-rap and boulders (or ‘greener’ solutions where possible) and planted stone and coir rolls are preferable to gabions;
- **Transition**: appropriate inlet and outlet structures should be provided to ensure smooth hydraulic transition and avoid erosion. Headwall arrangements at the upstream and downstream ends of a culvert should be suitably keyed into the bed and banks of the watercourse, should be the shortest length possible, and should be appropriate to the local environment;
- **Scour pool**: scour pools at the outlet of the culvert should be constructed to dissipate energy and provide resting areas for fish. This is especially important for steeper culverts (>3%) and/or where stream powers are high; and
- **Outfalls**: it is also important that the alignment of outfalls are designed to reduce scour around the structure and erosion of the adjacent river bed and banks. Discharge from the outfalls should be in line with the flow and the structure should not protrude beyond the bank line (see SEPA guidelines for more information[xi]).

4.3.7. SEPA’s Good Practice Guidelines provide further information, as does the DMRB’s own guidance[xii], as does CIRIA[xiii].

4.3.8. Culverts are likely to lead to a loss of open river channel. It may be appropriate to compensate for this loss by extending the length of the watercourse elsewhere (if unnaturally straight) or alternatively, providing other wetland features, such as scrapes, meander cut-offs and backwaters. These features positively add to the biodiversity value of the watercourse. Likewise, artificial concrete beds (e.g. Allt-na-Criche), will be demolished and replaced with a more natural substrate where structurally possible.

River realignments/diversions

4.3.9. Many of the new or extended crossings may require some adjustment of the river planform to align the existing watercourse through the proposed culvert or bridge. These realignments may be relatively short, however it is still important to ensure they are properly designed by a qualified fluvial geomorphologist to safeguard their long-term stability. Badly designed realignments can increase or decrease sediment movements, resulting in instability through incision, bank erosion or excessive sediment deposition.

4.3.10. This is even more important for major realignments where the functioning of the watercourse needs to be maintained over a longer distance and potential instability can have much greater impacts to the structures and the river system as a whole.

4.3.11. As a minimum, realignments should be designed on a like-for-like basis. The following key considerations should be accounted for in any design:

- **Bed gradient**: maintaining the existing bed gradient will ensure the continuity of the existing sediment regime. Too low and excessive substrate may begin to deposit, blocking culvert entrances and/or reducing flood flow capacity, this also reduces sediment supply downstream. Too steep and excessive bank erosion and/or bed incision may begin to occur increasing sediment supply downstream (potentially depositing within culverts). If the design of the road requires a change of the bed gradient, mitigation such as step-pools, bed-checks or sediment traps may be necessary (see Figure 4-1);

- **Cross-section**: the design of an appropriate low flow channel will also ensure the continuity of the existing sediment transport regime. A two-stage or multiple-stage cross-section can provide a wide range of benefits and preserve the existing low flow processes, allowing for natural adjustment and improve system resilience to low flow events. The multiple stage cross-section also encourages a range of habitats to form and accommodates flood flow capacity whilst ensuring a low flow channel is maintained;
- **Planform**: the planform should reflect the existing channel where possible or restore historical planforms where the existing channel has been artificially modified; and
- **Boundary conditions**: existing substrates should be collected, stored (without contamination) and reinstated. Where re-use of is not possible, substrates should be matched to local material. The suitability of substrates should be considered using empirical observations made by a qualified geomorphologist, as well sediment transport calculations (where deemed appropriate) and local sources[vii].

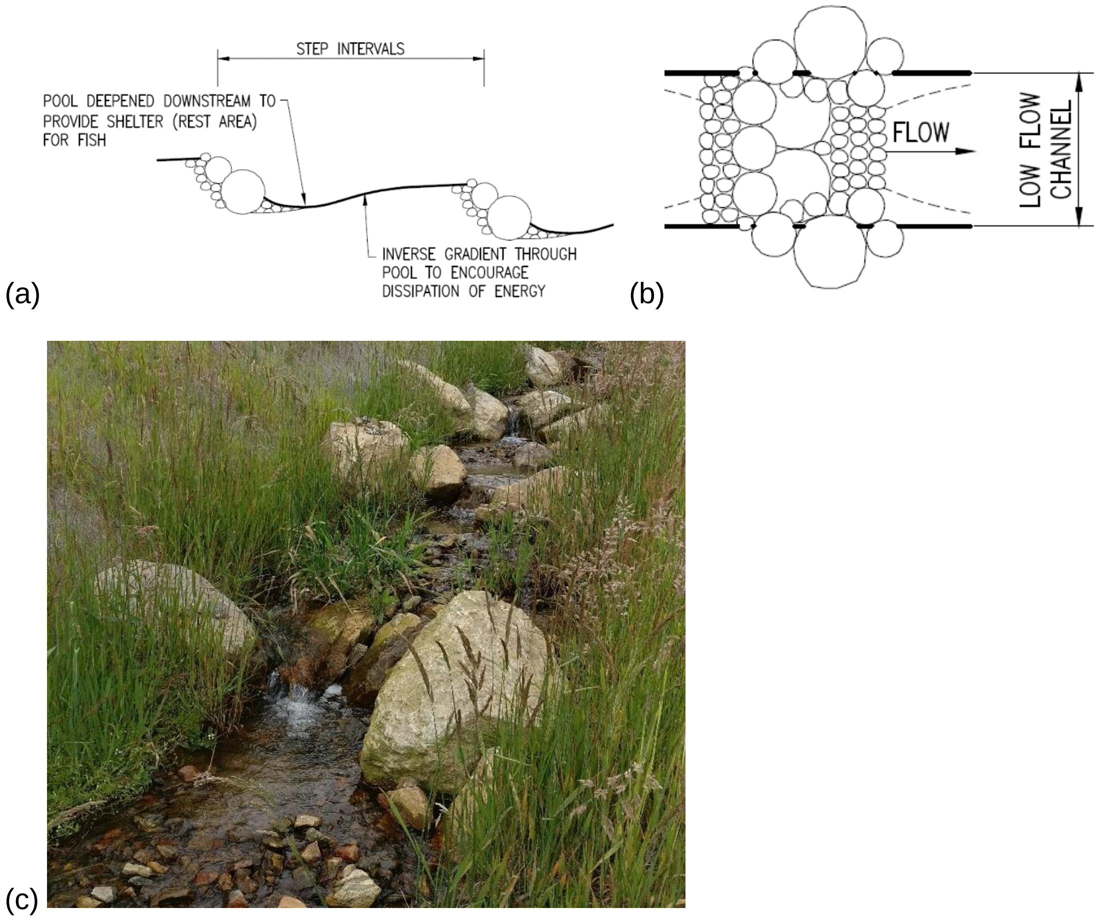

Figure 4-1: Indicative step-pool design (a) long-section; (b) plan view; (c) example constructed step-pool

4.3.12. Other mitigation features such as woody material, gravel features (bars), vegetation and riffle-pools (Figure 4-2) can also further enhance and restore habitats and natural processes to the watercourse in appropriate locations.

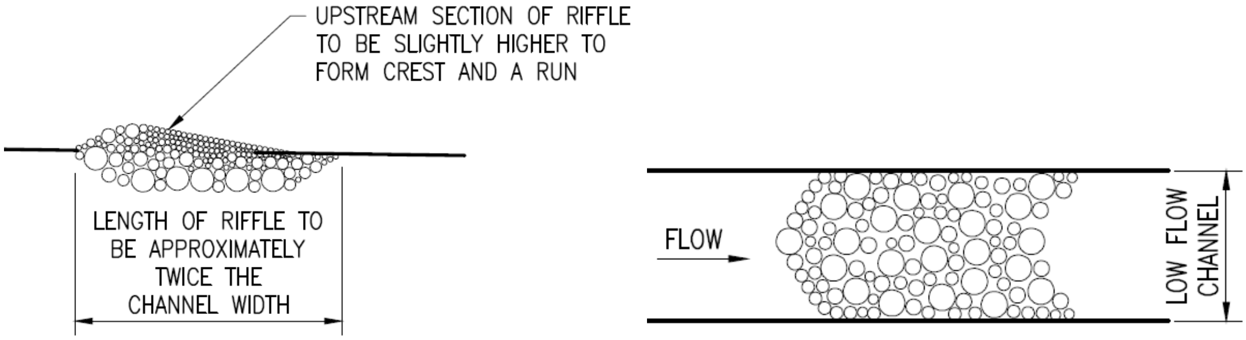

Figure 4-2: Indicative riffle design (a) long-section; (b) plan view

4.3.13. The design of any realignments, especially including features such as steps or bed checks will need to ensure they are suitable (i.e. passable) for any potential migratory fish species present. Consultation with freshwater aquatic ecologists is essential at the outset.

4.3.14. The need for a realignment in all cases should be avoided (or minimised) where possible. Unnecessary modification to a river channel may initiate instability as the channel attempts to recover to a natural course.

Bank protection

4.3.15. Bank protection may be required as part of the Proposed Scheme in addition to the culvert inlets and outlets, e.g. at tight meander bends or vulnerable areas. Where possible this should be formed of ‘rough’ bank protection measures, or ‘green’ bank protection using naturally occurring or biodegradable materials, geotextiles, stone (e.g. rip-rap along the bank toe) and/or locally sourced hardwood timber. If the channel requires more engineered solutions it should be sympathetic to the local landscape and habitats, and used in combination with a planting scheme to improve the aesthetics and long-term stability of the banks.

4.3.16. SEPA’s guidance on bank protection provides further information[xiv/xv]. The role of vegetation for channel stability should also not be underestimated and consultation with the landscape architect should be undertaken at the earliest opportunity[xvi].

Bed protection

4.3.17. In some cases it may be necessary to protect the bed from bed scour (incision). In all cases natural materials (boulders, ideally buried) should be used as opposed to smooth concrete to increase roughness, maintain flow diversity and reduce the risk of transferring the erosion downstream.

4.3.18. Temporary works should also be considered from the outset to minimise any direct or indirect impact on the watercourse.

4.3.19. Temporary bypass channels should be constructed to maintain flow continuity and allow unimpeded fish migration through the watercourse. Crucially, the design of any bypass diversion should also consider all the items listed above, especially if intended to be in-situ for a long period of time. Instability within a temporary channel can affect the channel upstream and downstream.

4.3.20. Temporary channels can have lasting impacts on the watercourse environment, such as the increase in fine sediment supply downstream and/or incision leading to instability migrating upstream. During construction the potential for fine sediment to enter the channel is a key risk. Silt fencing or filtration systems should be installed as standard.

4.3.21. Other temporary works such as pipes or over-pumping should be used where a temporary bypass channel cannot be constructed. In some cases, culverts will be constructed “offline” and reconnected to the existing channel upstream and downstream when the crossing works are complete. This minimises the construction impact and duration of impact. Those identified as being constructed “online” are listed in Table 4.2.

Table 4.2: Construction Method

Watercourse Name	Crossing Ref	Method
Allt an Fhearna	A9 1090 S	New culvert
Allt Chriochaidh	A9 1100	Online (demolish/ replace)
	A9 1100 S	New culvert
Caochan Ruadh	A9 1100 C70	Online (demolish/ replace)
Ballingluig Burn	A9 1110 C10	Demolish
Allt-na-Criche (Lynwilg)	A9 1130	Online (retain/repair)
Aviemore Burn	A9 1150 C95	Online (demolish/ replace)
Easter Aviemore Burn	A9 1160 C14	Demolish/replace
Allt na Criche (Granish)	A9 1170 C12 S	New culvert
	A9 1170 C12	Online (demolish/ replace)
Avie Lochan Burn South	A9 1170 C20 S	New culvert
	A9 1170 C20	Demolish/replace
Avie Lochan Burn North	A9 1170 C23	Demolish
Allt Cnapach	A9 1170 C50 S	Demolish/replace
	A9 1170 C50	Demolish/replace
Feith Mhor	A9 1170 C75 S	Demolish/replace
	A9 1170 C75	Demolish/replace
River Dulnain	A9 1190	Retain/repair
Allt nan Ceatharnach	A9 1200	Retain/repair
	A9 1200 S	New culvert
Allt Slochd Mhuic	A9 1209 F	Retain/repair
	A9 1210 C46	Demolish/replace
	A9 1210 C45	Demolish/replace
	A9 1208 F	Retain/repair
	A9 1207 F	Retain/repair
	A9 1210 C39	Demolish/replace
	A9 1210 C31	Demolish/replace
	A9 1206 F	Retain/repair

5. Stream Power and Sediment Entrainment Assessments

5.1.1. A series of sediment transport equations have been used to gain a better understanding of the character and behaviour of the watercourses in response to the Proposed Scheme.

5.1.2. Stream power is essentially based on the relationship between discharge and slope. The specific equations used are presented in Annex B. The discharges have been calculated as part of the hydraulic modelling assessment.

5.1.3. Note, these are semi-empirical equations based on a limited (sometimes geographically biased) datasets. The stability of sediment also relies on several other (often complex) forces, but for the purposes of crude assessments of the likelihood of sediment entrainment these equations are useful, but should be logic checked with direct site observations and measurements.

Stream power

5.1.4. Stream power (Ω) is a conceptual measure of the available rate of energy at a channel bed relating to sediment transport. Specific stream power (ω) is a derivative of the actual stream power divided by channel width. The units are expressed as watts per square metre, Wm^{-2}.

5.1.5. Peer-reviewed scientific work over the past 50 years has proven it to be a valuable measure of river stability. Research[xvii/xviii] has provided some thresholds which can be used to indicate potential behaviour[2]. These are as follows:

- **Low energy streams** (ω < 10 Wm^{-2}) likely to experience sedimentation
- **High energy streams** (ω > 35 Wm^{-2}) likely to experience localised erosion
- **Very high energy streams** (ω > 100 Wm^{-2}) likely to experience significant erosion leading to an increase in sinuosity after straightening. Where lateral erosion is inhibited vertical erosion is likely to occur.

5.1.6. Estimated stream powers have been calculated based on the available information for the upstream and downstream cross-sections, gradients and discharge values for both the baseline and the proposed conditions. The stream powers are considered indicative and should be reassessed in more detail during detailed design. The results for each watercourse are presented in Table 5.1 for Q2 flows and in Table 5.2 Q200+CC.

5.1.7. For simplicity, the cross-section dimensions for the proposed design are assumed to be the same (or similar) to the existing, unless otherwise specified, and so the changes in stream powers are primarily driven by gradient.

[2] Please note these thresholds were primarily established for channelised watercourses based on research in the UK and Denmark.

Table 5.1: Specific Unit Stream Power based on Q2 flows

Watercourse Name	Crossing Ref	Specific Stream Power (baseline) Wm^{-2}		Specific Stream Power (proposed) Wm^{-2}	
		Upstream	Downstream	Upstream	Downstream
Allt an Fhearna	A9 1090 S	125	49	127	49
Allt Chriochaidh	A9 1100	258	359	258	342
	A9 1100 S	359	436	342	406
Caochan Ruadh	A9 1100 C70	48	189	81	76
Ballingluig Burn	A9 1110 C10	52	15	357	125
Allt-na-Criche (Lynwilg)	A9 1130	342	71	237	106
Aviemore Burn	A9 1150 C95	323	1686	453	1301
Easter Aviemore Burn	A9 1160 C14	423	332	190	204
Allt na Criche (Granish)	A9 1170 C12 S	124	70	132	30
	A9 1170 C12	18	30	41	27
Avie Lochan Burn South	A9 1170 C20 S	998	5313	276	1547
	A9 1170 C20	1815	2197	898	715
Avie Lochan Burn North	A9 1170 C23	9706	86	9777	161
Allt Cnapach	A9 1170 C50 S	424	70	429	53
	A9 1170 C50	70	73	53	122
Feith Mhor	A9 1170 C75 S	370	458	415	292
	A9 1170 C75	458	289	292	251
River Dulnain	A9 1190	181	774	183	774
Allt nan Ceatharnach	A9 1200	79	204	92	204
	A9 1200 S	327	243	257	243
Allt Slochd Mhuic	A9 1209 F	402	691	402	100
	A9 1210 C46	691	76	100	96
	A9 1210 C45	75	12	97	117
	A9 1208 F	68	-76	117	-79
	A9 1207 F	68	356	69	403
	A9 1210 C39	356	719	403	304
	A9 1210 C31	837	78	419	2205
	A9 1206 F	78	138	2205	139

Table 5.2: Specific Unit Stream Power (Q200+CC flows)

Watercourse Name	Crossing Ref	Specific Stream Power (baseline) Wm^{-2}		Specific Stream Power (proposed) Wm^{-2}	
		Upstream	Downstream	Upstream	Downstream
Allt an Fhearna	A9 1090 S	330	116	307	121
Allt Chriochaidh	A9 1100	873	1050	873	1050
	A9 1100 S	1050	1318	1050	1246
Caochan Ruadh	A9 1100 C70	49	246	133	240
Ballingluig Burn	A9 1110 C10	185	49	663	295
Allt-na-Criche (Lynwilg)	A9 1130	1151	249	665	368
Aviemore Burn	A9 1150 C95	458	3608	1116	1287
Easter Aviemore Burn	A9 1160 C14	984	1176	404	542
Allt na Criche (Granish)	A9 1170 C12 S	211	115	151	50
	A9 1170 C12	20	31	80	70
Avie Lochan Burn South	A9 1170 C20 S	998	5313	680	4017
	A9 1170 C20	1815	2197	1684	1774
Avie Lochan Burn North	A9 1170 C23	1781	106	7094	65
Allt Cnapach	A9 1170 C50 S	548	91	529	53
	A9 1170 C50	91	91	53	185
Feith Mhor	A9 1170 C75 S	1522	1590	1447	1922
	A9 1170 C75	1590	943	1922	975
River Dulnain	A9 1190	285	1853	285	1853
Allt nan Ceatharnach	A9 1200	200	531	226	531
	A9 1200 S	656	381	559	395
Allt Slochd Mhuic	A9 1209 F	601	1079	601	265
	A9 1210 C46	1079	106	265	389
	A9 1210 C45	124	28	392	157
	A9 1208 F	148	-76	157	-77
	A9 1207 F	85	818	86	1008
	A9 1210 C39	818	2324	1008	968
	A9 1210 C31	1110	104	1590	2106
	A9 1206 F	104	279	2106	307

5.1.8. The River Dulnain (A9 1190) and Allt nan Ceatharnach (A9 1200) are new bridge structures, set high above the floodplain and therefore it is considered extremely unlikely that there will be any significant impact on the flows upstream, through or downstream of these two structures. The stream powers for the baseline and proposed in Table 5.1 and Table 5.2 confirm this.

Sediment entrainment

5.1.9. The potential maximum sediment size which could theoretically become entrained can be estimated using a critical discharge theory. The critical discharge (Q_{cr}) simply calculates the flow required to move a given sediment size. In addition, a critical water depth can also be established and together can form the basis for estimating sediment entrainment (see Annex B).

5.1.10. However, such equations have some limitations, primarily due to the over-simplification of the fluvial processes (and pressures) occurring within the river channel. The equations are considered appropriate for uniform gravel-bed rivers, and do not account for channel roughness, e.g. mixed particle sizes or vegetation.

5.1.11. Due to these limitations, the results should be treated as a guide and should be used in conjunction with empirical observations on site and professional judgement.

5.1.12. The results are shown in Table 5.3 and Table 5.4 for Q2 and Q200+CC flows respectively. The critical discharges and water depths for particular sediment sizes (based on standard sediment size thresholds) have been estimated for the proposed discharges and gradients. The results are discussed in Table 6.1.

Table 5.3: Potential (max size) sediment entrainment based on critical discharge theory (Q2 flows)

Watercourse Name	Crossing Ref	Max sediment size m (baseline)		Max sediment size m (proposed)	
		Upstream	Downstream	Upstream	Downstream
Allt an Fhearna	A9 1090 S	302	187	305	187
Allt Chriochaidh	A9 1100	254	505	254	600
	A9 1100 S	505	377	600	377
Caochan Ruadh	A9 1100 C70	159	159	140	164
Ballingluig Burn	A9 1110 C10	134	154	232	122
Allt-na-Criche (Lynwilg)	A9 1130	411	209	411	209
Aviemore Burn	A9 1150 C95	355	1183	521	874
Easter Aviemore Burn	A9 1160 C14	190	113	169	104
Allt na Criche (Granish)	A9 1170 C12 S	82	120	148	85
	A9 1170 C12	123	62	59	51
Avie Lochan Burn South	A9 1170 C20 S	1203	2179	1211	1474
	A9 1170 C20	1335	1313	1556	1006
Avie Lochan Burn North	A9 1170 C23	206	132	358	172
Allt Cnapach	A9 1170 C50 S	201	267	232	264
	A9 1170 C50	267	172	264	232
Feith Mhor	A9 1170 C75 S	158	143	155	111
	A9 1170 C75	143	104	86	128
River Dulnain	A9 1190	779	861	779	860
Allt nan Ceatharnach	A9 1200	294	389	294	389
	A9 1200 S	351	273	351	273
Allt Slochd Mhuic	A9 1209 F	235	140	301	151
	A9 1210 C46	255	49	151	49
	A9 1210 C45	100	81	101	85
	A9 1208 F	91	278	85	281
	A9 1207 F	99	376	112	346
	A9 1210 C39	376	219	346	166
	A9 1210 C31	446	181	254	1072
	A9 1206 F	202	381	1072	394

Table 5.4: Potential (max size) sediment entrainment based on critical discharge theory (Q200+CC flows)

Watercourse Name	Crossing Ref	Max sediment size m (baseline)		Max sediment size m (proposed)	
		Upstream	Downstream	Upstream	Downstream
Allt an Fhearna	A9 1090 S	576	335	552	344
Allt Chriochaidh	A9 1100	632	1256	847	1314
	A9 1100 S	1256	938	1314	899
Caochan Ruadh	A9 1100 C70	399	399	350	411
Ballingluig Burn	A9 1110 C10	339	387	586	309
Allt-na-Criche (Lynwilg)	A9 1130	1027	522	1025	522
Aviemore Burn	A9 1150 C95	870	2364	1303	1422
Easter Aviemore Burn	A9 1160 C14	473	291	418	257
Allt na Criche (Granish)	A9 1170 C12 S	124	226	193	152
	A9 1170 C12	216	101	93	103
Avie Lochan Burn South	A9 1170 C20 S	1120	1444	1211	1474
	A9 1170 C20	1335	1315	1556	1007
Avie Lochan Burn North	A9 1170 C23	545	125	948	164
Allt Cnapach	A9 1170 C50 S	248	355	285	374
	A9 1170 C50	355	228	374	232
Feith Mhor	A9 1170 C75 S	406	329	357	390
	A9 1170 C75	329	230	300	316
River Dulnain	A9 1190	1805	1994	1806	1995
Allt nan Ceatharnach	A9 1200	683	904	683	903
	A9 1200 S	753	422	753	433
Allt Slochd Mhuic	A9 1209 F	604	359	772	387
	A9 1210 C46	656	123	387	124
	A9 1210 C45	255	197	257	214
	A9 1208 F	221	681	214	703
	A9 1207 F	237	897	273	841
	A9 1210 C39	897	522	841	403
	A9 1210 C31	1068	430	184	2606
	A9 1206 F	479	911	2606	959

6. Impact Assessment

6.1.1. The initial and residual magnitude of impacts for the Proposed Scheme are summarised in Table 6.1, below. The table lists each watercourse and its sensitivity from Table 3.3.

6.1.2. The Proposed Scheme is then assessed in terms of type of impact, i.e. whether they result in an adverse or beneficial impact. Any impact which may result from a new or extended culvert is considered to be adverse, all other impacts are considered on a case-by-case basis.

6.1.3. The initial impact magnitude is assessed taking into consideration the embedded mitigation, but without any standard or additional specific mitigations. The residual magnitude takes all proposed mitigations into account.

Table 6.1: Summary of impact table

Watercourse Name	Crossing Ref	Summary of initial impact	Initial impact	Additional Specific Mitigation	Residual Impact
Allt an Fhearna	A9 1090 S	The SuDS access track currently crosses the watercourse approx. 300m downstream of the A9 crossing. The clear span structure across the channel will have minimal impact on the channel, with only 5m of open watercourse lost and no requirement for a realignment upstream or downstream. This is also supported by the stream power assessment in Table 5.1 and Table 5.2, with little notable change from the baseline to the proposed. However, given A9 1090 S is a new structure the initial impact is considered Moderate.	Moderate (Adverse)	Assumes application of standard mitigation measures specified in Section 4.3.	Minor (Adverse)
Allt Chriochaidh	A9 1100	There is currently no realignment proposed associated with either structure. The extension to the existing A9 crossing (A9 1100) and new SuDS access track crossing will result in a cumulative loss of 17m. There will be limited or no impact on the sediment transport and channel morphology. This is also supported by the stream power assessment in Table 5.1 and Table 5.2, with little notable change from the baseline to the proposed. However, given A9 1100 S is a new structure the initial impact is considered Moderate.	Negligible	Assumes application of standard mitigation measures specified in Section 4.3.	Negligible
	A9 1100 S		Moderate (Adverse)	Assumes application of standard mitigation measures specified in Section 4.3. Assumes the existing cascade structure upstream will be demolished and replaced with a structure that allows easier fish passage, such as a rock ramp etc.	Minor (Adverse)
Caochan Ruadh	A9 1100 C70	A total of 230m of watercourse will be affected, equating to approximately 85m	Minor (Adverse)	Assumes application of standard mitigation measures specified in Section 4.3.	Minor (Adverse)

Watercourse Name	Crossing Ref	Summary of initial impact	Initial impact	Additional Specific Mitigation	Residual Impact
		realignment upstream and 65m downstream and the 80m culvert. The realignment will result in an initial gradient of between 7 and 9%, before reducing to 2.5% and similar gradient downstream. There is a slight increase in stream powers upstream, particularly during higher flows, but a reduction in stream power downstream.		Step-pool features to be installed upstream to dissipate the slight increase in stream powers (estimates indicate 300-400mm for Q200+cc, see Section 5).	
Ballingluig Burn	A9 1110 C10	The existing culvert will be demolished and the watercourse diverted into a combined underpass. The realigned channel will be an “open channel” and less confined, but still covered as part of the underpass. Overall there will 160m of realigned channel, with a slightly steep entry into the underpass. The stream powers show a significant increase especially upstream of the underpass.	Minor (Beneficial)	Assumes application of standard mitigation measures specified in Section 4.3. Bank reinforcement upstream of the underpass should be considered given the increase in stream powers, together with step-pool features to slow the flow into the culvert (estimates indicate 300-600mm for Q200+cc, see Section 5)	Minor (Beneficial)
Allt-na-Criche (Lynwilg)	A9 1130	The existing structure will be retained, repaired and extended. There is no realignment proposed and therefore limited or no impact on the sediment transport and channel morphology, however the new structure will result in a 13m loss of open channel with the extended road crossing, in what is an already quite modified section.	Negligible	Assumes application of standard mitigation measures specified in Section 4.3. Options to remove or mitigate the concrete bed of the existing structure will be explored during detailed design.	Negligible
Aviemore Burn	A9 1150 C95	The existing 34m culvert demolished and replaced with a slightly longer, 40m long culvert. The watercourse will be realigned 42m upstream and 18m downstream. To fit the culvert in under the road safely the upstream and downstream gradients will	Minor (Adverse)	Assumes application of standard mitigation measures specified in Section 4.3. Step pool features to be installed on channels >3-4%, to dissipate velocities, sediment entrainment calculations estimate >1-2m boulders required at Q200+CC to mitigate	Minor (Adverse)

Watercourse Name	Crossing Ref	Summary of initial impact	Initial impact	Additional Specific Mitigation	Residual Impact
		be steepened by 2 percentage points (pp) (4 to 6%). The stream powers are currently very high (>3000 Wm^{-1}) downstream of the structure, with the new structure resulting in significantly lower stream powers. Whilst upstream, there will be an increase in stream powers as shown in in Table 5.1 and Table 5.2.		steep gradients leading into and out of the culvert (see Section 5). These could be reduced if they are structurally supported (concrete or steel pinning etc.).	
Easter Aviemore Burn	A9 1160 C14	In total 83m of watercourse will be affected. The existing culvert will be demolished and replaced with a 45.5m length box culvert. The watercourse will be realigned 10m upstream and 25m downstream. Generally, the gradients are proposed to decrease by 2pp both upstream and downstream, from 9% to 7% upstream and 5 to 4% downstream, although the gradient generally shallows to 1 from 2% a little further downstream. This reduction in gradient results in a decrease in stream power by over half (see Table 5.1 and Table 5.2.	Minor (Adverse)	Assumes application of standard mitigation measures specified in Section 4.3. Straightened alignment downstream (embedded mitigation) to reflect more natural gradient and reduce risk of deposition. Step pool features to be installed upstream (estimates indicate 200-500mm, see Section 5).	Minor (Adverse)
Allt na Criche (Granish)	A9 1170 C12 S	The proposed works will affect over 200m of watercourse, comprising two culverts (11m and 64m) and 140m of watercourse realignment. The gradients will vary by approx. 1-2% upstream and downstream of both structures. Increasing upstream of the side road structure from 1.2 to 2.5%, and decreasing from 2 to 1.2%. Similarly, upstream of the main culvert the gradients	Moderate (Adverse)	Assumes application of standard mitigation measures specified in Section 4.3	Minor (Adverse)
	A9 1170 C12		Minor (Adverse)	Assumes application of standard mitigation measures specified in Section 4.3	Minor (Adverse)

Watercourse Name	Crossing Ref	Summary of initial impact	Initial impact	Additional Specific Mitigation	Residual Impact
		will decrease from 2 to 1.2% and 1.5 to 0.6% downstream. Stream power through the watercourse increase from low to moderate as a result of the Proposed Scheme (see Table 5.1 and Table 5.2), and decrease for the side road. However, given A9 1170 C12 S is a new structure the initial impact is considered Moderate.			
Avie Lochan Burn South	A9 1170 C20 S	Approximately 200m of watercourse will be affected by the proposed works here. Including a 54m culvert, and watercourse realignments comprising 40m upstream and 40m downstream. The gradients across the existing access track (to be replaced by A9 1170 C20 S) are already very steep, varying between 8 and 14%. The proposed channel leading into the main A9 crossing (A9 1170 C20) will comprise a steep, 4m high, cascade set at 1 in 3 (approx. 40%), which would replace an existing cascade structure. Downstream the channel gradients vary between 5 and 13% and the proposed realignment will be set at 7.6%. Stream power, although still relatively high, generally decrease as a result of the Propose Scheme (see Table 5.1 and Table 5.2).	Minor (Adverse)	Assumes application of standard mitigation measures specified in Section 4.3	Minor (Adverse)
	A9 1170 C20		Minor (Adverse)	Assumes application of standard mitigation measures specified in Section 4.3. Step pool features to be installed on channels >3-4%, to dissipate velocities, however this is more likely to form an engineered cascade structure at such steep gradient (sediment entrainment calculations estimate 1-1.5m boulders, although these could be reduced if they are structurally supported, i.e. using concrete or steel pinning etc.). Design of engineered cascade to promote sediment transfer.	Minor (Adverse)
Avie Lochan Burn North	A9 1170 C23	Similar to above there will be a steep cascade structure (>40%) constructed	Minor (Adverse)	Assumes application of standard mitigation measures specified in Section 4.3.	Minor (Adverse)

Watercourse Name	Crossing Ref	Summary of initial impact	Initial impact	Additional Specific Mitigation	Residual Impact
		upstream of the A9 crossing (A9 1170 C23). However, the existing channels leading into the culvert are already very steep >10% and there is unlikely to be any significant impact on the stream powers. Downstream there will be an increase of 2pp, from 4% to 6%. Stream power significantly increase (to >7000 Wm^{-1}) as a result of the upstream cascade structure (see Table 5.1 and Table 5.2).		Step pool features to be installed on channels >3-4%, to dissipate velocities, however this is more likely to form an engineered cascade structure at such steep gradient (sediment entrainment calculations estimate almost 1m boulders, although these could be reduced if they are structurally supported, i.e. using concrete or steel pinning etc.). Design of engineered cascade to promote sediment transfer.	
Allt Cnapach	A9 1170 C50 S	Almost 100m of watercourse will be affected in total, of which much of it will be culverted including the proposed 70m A9 culvert (A9 1170 C50) and the existing forestry access track crossing will be replaced by two 750mm pipes (approx. 10m in length) (A9 1170 C50 S). The remaining length will be realigned to tie-in with the new offset culverts. The realignment in between the road and railway is very constrained. The existing channel is currently very steep, varying between 5 and 16%. Upstream through the side road and leading into the A9 culvert the channel will be set at 7-8%, and will be broadly in line with the existing. Stream power, although still relatively high, significantly decrease as a result of the Propose Scheme (see Table 5.1 and Table 5.2).	Minor (Adverse)	Assumes application of standard mitigation measures specified in Section 4.3.	Minor (Adverse)
	A9 1170 C50		Minor (Adverse)	Assumes application of standard mitigation measures specified in Section 4.3. Step pool features to be installed on channels >4%, to dissipate velocities (size of boulders and spacing 200-300mm, see Section 5).	Minor (Adverse)
Feith Mhor	A9 1170 C75 S	184m of watercourse will be affected in total, including the proposed 60m A9	Minor (Adverse)	Assumes application of standard mitigation measures specified in Section 4.3.	Minor (Adverse)

Watercourse Name	Crossing Ref	Summary of initial impact	Initial impact	Additional Specific Mitigation	Residual Impact
		culvert and 11m side road culvert. The remaining length will be realigned to tie-in with the new offset culverts.		Averaged gradient between the two structures (embedded mitigation).	
	A9 1170 C75	Upstream of each structure the gradients will decrease by around 1pp, broadly from around 2.5 to 1.5%. This will result in an increased gradient downstream, from 2.3% to 3.4% downstream of the side road and from 1.5 to 2.1% downstream of the A9. Stream powers remain very high (>1000Wm^{-1}), but generally lower as a result of the Proposed Scheme with an increase downstream of the side road and increase upstream at C75 at Q200+cc	Minor (Adverse)	Assumes application of standard mitigation measures specified in Section 4.3. Specifically, high stream powers suggest potential for erosion and erosion protection should be considered upstream and downstream of culvert structure.	Minor (Adverse)
River Dulnain	A9 1190	There is currently no realignment proposed, but the new structure will result in some loss of open channel. The bridge will be clear span with no structures (piers) within the channel. There are no impacts to the stream powers through the structure. Therefore, there is expected to be very little or no impact on the watercourse permanently.	Negligible	Assumes application of standard mitigation measures specified in Section 4.3.	Negligible
Allt nan Ceatharnach	A9 1200	There is currently no realignment proposed, but the new structure will result in some loss of open channel. The bridge will be clear span with no structures (piers) within the channel. Therefore, there is expected to be very little or no impact on the watercourse permanently.	Negligible	Assumes application of standard mitigation measures specified in Section 4.3. Options to remove or mitigate for the concrete bed of the existing structure will also be explored during detailed design.	Negligible
	A9 1200 S	A new SuDS access track (A9 1200 S) will be constructed adjacent an existing residential access structure. This is a clear span structure, resulting in a loss of 4m of open watercourse. There will be limited or	Moderate (Adverse)	Assumes application of standard mitigation measures specified in Section 4.3.	Minor (Adverse)

Watercourse Name	Crossing Ref	Summary of initial impact	Initial impact	Additional Specific Mitigation	Residual Impact
		no impact on the sediment transport and channel morphology. Stream power, although still relatively high, significantly decrease as a result of the Propose Scheme (see Table 5.1 and Table 5.2). However, given A9 1100 S is a new structure the initial impact is considered Moderate.			
Allt Slochd Mhuic	A9 1206 F, A9 1210 C31, A9 1210 C39, A9 1207 F, A9 1208 F, A9 1210 C45, A9 1210 C46, A9 1209 F	A challenging environment with an already very modified watercourse. Open watercourse proposed where viable, including a concrete channel with natural substrate on the bed. A cascade structure varying between 2.9% and 25% in gradient, will discharge into the existing channel. The cascade is where the greatest stream powers are (>2000 Wm^{-1}), similar to the existing concrete chute downstream of A9 1220 C39, which is also currently >2000 Wm^{-1}.	Negligible	Assumes application of standard mitigation measures specified in Section 4.3 and embedded mitigation in Section 4.2.	Negligible

6.2. Residual significance of impact

6.2.1. Table 6.2 summarises the overall significance of impact for each crossing.

Table 6.2: Overall significance of impact

Watercourse Name	Crossing Ref	Sensitivity	Residual impact	Overall significance of impact(s)
Allt an Fhearna	A9 1090 S	Medium	Minor (Adverse)	Slight
Allt Chriochaidh	A9 1100	Medium	Negligible	Neutral
	A9 1100 S	Medium	Minor (Adverse)	Slight
Caochan Ruadh	A9 1100 C70	Medium	Minor (Adverse)	Slight
Ballingluig Burn	A9 1110 C10	Low	Minor (Beneficial)	Neutral
Allt-na-Criche (Lynwilg)	A9 1130	Medium	Negligible	Neutral
Aviemore Burn	A9 1150 C95	Medium	Minor (Adverse)	Slight
Easter Aviemore Burn	A9 1160 C14	Medium	Minor (Adverse)	Slight
Allt na Criche (Granish)	A9 1170 C12 S	Medium	Minor (Adverse)	Slight
	A9 1170 C12	Medium	Minor (Adverse)	Slight
Avie Lochan Burn South	A9 1170 C20 S	Medium	Minor (Adverse)	Slight
	A9 1170 C20	Medium	Minor (Adverse)	Slight
Avie Lochan Burn North	A9 1170 C23	Medium	Minor (Adverse)	Slight
Allt Cnapach	A9 1170 C50 S	Medium	Minor (Adverse)	Slight
	A9 1170 C50	Medium	Minor (Adverse)	Slight
Feith Mhor	A9 1170 C75S	Medium	Minor (Adverse)	Slight
	A9 1170 C75	Medium	Minor (Adverse)	Slight
River Dulnain	A9 1190	High	Negligible	Neutral
Allt nan Ceatharnach	A9 1200	Medium	Negligible	Neutral
	A9 1200 S	Medium	Minor (Adverse)	Slight
Allt Slochd Mhuic	A9 1209 F	Low	Negligible	Neutral
	A9 1210 C46	Low	Negligible	Neutral
	A9 1210 C45	Low	Negligible	Neutral
	A9 1208 F	Low	Negligible	Neutral
	A9 1207 F	Low	Negligible	Neutral
	A9 1210 C39	Low	Negligible	Neutral
	A9 1210 C31	Low	Negligible	Neutral
	A9 1206 F	Low	Negligible	Neutral

6.2.2. With the additional specific mitigation included, the residual impact magnitudes are all at worst Minor (Adverse), primarily because the watercourses have already been impacted by the existing A9 and the impacts are localised. These impacts also assume the standard and embedded mitigations are applied as stated in Sections 4.2 and 4.3.

6.2.3. The watercourses will be subject to a **Neutral or Slight** overall significance of impact.

6.2.4. The impact magnitude on Ballinluig Burn was considered to be a Minor (Beneficial) due to the opening up of the culvert and combination with the underpass, resulting in a **Neutral** significance of impact.

6.2.5. Whilst the majority of those watercourses assessed within this report individually result in a relatively small loss of open watercourse as a result of the widening of the A9 mainline carriageway and new side roads, cumulatively this is over 200m. However, replacing the concrete box culverts (with artificial beds) with portal frames which allow for natural substrates through the structures is an important benefit. Overall, the scheme impact is considered to have a neutral impact overall.

6.3. Controlled Activities Regulations Impact

6.3.1. The Proposed Scheme does not directly affect any main stem (reportable) baseline water bodies and therefore will not increase the MIMAS scores. It is unlikely that there will be a substantial impact resulting from the scheme due to the existing modifications associated with the A9 and the proposed mitigation to alleviate any further impacts.

7. Recommendations and Conclusions

7.1. Further investigations

7.1.1. Further consideration of watercourse realignments will be necessary at the detailed design stage to ensure the appropriate location and construction of bed check and step-pool features to reduce and mitigate any potential increase in stream powers. This will reduce the likelihood of erosion occurring either on the bed or the banks and outflanking the crossing.

7.1.2. Additional consideration of proposed flood storage areas, SuDS and outfalls should also be considered in greater detail.

7.1.3. Updated sediment entrainment calculations and/or scour assessments are required as the design progresses and more detailed information is obtained (hydraulic modelling, channel dimensions, bed gradients etc.) to ensure the geomorphological mitigation features are appropriate and sustainable.

7.1.4. The effect of geomorphological features on aquatic species, e.g. migration upstream, should be intrinsically linked during detailed design.

7.1.5. Guidance on appropriate substrate should be considered during detailed design to ensure the stability and continuity of the bed. This is particularly important through the culverts themselves.

7.1.6. The geomorphological input in the detailed design should not be limited by this environmental assessment. All modifications to the form and function of the watercourses should consider the same geomorphological principles to ensure the stability of the watercourse in relation to the surrounding assets. This applies to all (and not limited to) watercourse realignments, box culvert or portal frame crossings, piped culverts, cascades and outfalls.

7.1.7. Consultation with SEPA and other stakeholders (local authority and community, fisheries groups etc.) will be essential.

7.1.8. A cumulative WFD assessment and CAR licence applications should be carried out to ensure there will be no deterioration or prevention on attaining GES to those impacted or downstream water bodies.

7.2. Conclusions

7.2.1. This Stage 3 DMRB hydromorphology assessment has built on previous work during the Stage 2 assessment. The remaining watercourses (screened in from Stage 2) have been examined in more detail in relation to the Proposed Scheme, including their overall impact on the geomorphological stability, loss of open watercourse length, constructability and sediment transport competence (e.g. stream power assessment and sediment entrainment calculations).

7.2.2. The assessment has also outlined a series of standard mitigation and geomorphological principles to be considered during detailed design, including the installation of bed checks and step-pools to mitigate for particularly steep gradients (typically over >3-4%), substrate composition through culvert structures, bank protection and temporary works.

7.2.3. An initial assessment of impact was undertaken and specific mitigation was identified to further reduce the potential impacts on the watercourses. These included recommendations for boulder sizes for bed check and step-pool features based on sediment entrainment calculations.

7.2.4. The residual impacts for all the watercourse crossings were deemed to be Minor (Adverse) magnitude, primarily because of the existing modifications on the watercourses (having been already affected by the existing A9) and/or the impacts considered to be very localised.

7.2.5. In addition, the standard mitigation, plus additional specific mitigation recommendation was considered adequate to minimise impacts on the environment.

7.2.6. Cumulatively the loss of open watercourse throughout the scheme is offset by the proposed improvements to the crossing structures which enable the installation of natural bed substrate, maintaining sediment transport continuity through the A9.

7.2.7. As a result, the significance of impact(s) were considered no more than **Slight**.

7.2.8. Overall, the Proposed Scheme is unlikely to have direct substantial impact on the watercourses considered as part of this assessment.

Annex A. Figures

Annex B. Sediment transport equations

B.1. Stream power

Stream power (Ω) can be calculated using the following equation:

$$\Omega = \rho\ g\ Q\ s \quad Watts\ per\ metre\ (Wm-1)$$

Where ρ is the specific weight of water, g is acceleration due to gravity, Q is the discharge and s is the slope.

For comparison stream power can be calculated relative to a unit width (specific stream power) by dividing the unit stream power Ω by channel width w:

$$\omega = \Omega/w \quad (in\ units\ of\ Watts\ per\ square\ metre, Wm-2)$$

B.2. Critical discharge and water depth

The critical discharge (Q_{cr}) equation was developed by Schoklitsch[xix], later adapted by Bathurst *et al*[xx]. The equation is simply:

$$Q_{cr} = 0.15\ g^{0.5}\ D^{1.5}\ s^{-1.12}$$

Where Q_{cr} is the critical water discharge per unit width, D is the sediment size and s is the slope. This equation was developed for steeper slopes (0.25 to 20% grade) and coarse gravels (3 to 44mm).

An estimation of the critical water depth can be calculated by using the boundary shear stress calculation, which reads:

$\tau_0 = \rho g d s$ or $\tau_0 = \gamma d s$

Where τ_0 is the actual boundary shear stress and d is depth (m) τ_0 and γ is the specific weight of water. The equation can be rearranged to work out the depth:

$$d = \frac{\tau_0}{\rho g s}$$

By substituting actual shear stress (τ_0) with critical shear stress (τ_{cr}) it is possible to calculate d. For example for a normal gravel bed river channel, with D_{50} of 1cm and a slope of 0.005 the critical shear stress would be:

$$\tau_{cr} = 730D = (730)(0.01) = 7.3Nm^{-2}$$

And for the shear stress:

$$\tau_0 = \rho g d s = (1000)(9.81)(d)(0.005) = 49.05d$$

Therefore:

$$49.05d = 7.3$$

$$d = 0.15\ m$$

Annex C. References

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