Appendix 39.1 – Surface Water Hydrology

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Contents

1 Introduction

1.1 General Background

1.1.1 This hydrological assessment report is a technical appendix of Chapter 39 (Water Environment) of the Environmental Statement for the proposed Aberdeen Western Peripheral Route (AWPR). It focuses specifically on the hydrological impacts of the proposed scheme on watercourses crossed by the road, within the Fastlink study area.

1.1.2 Hydrology is concerned with the natural water cycle and is the earth science of water on or near the land surface. For the purposes of this report, the hydrological assessment addresses impacts on the flow and quantity of water on or near the land surface and associated flood risk.

1.1.3 Road schemes can impact on surface water hydrology through the introduction of structures and by disturbing the natural characteristics of a watercourse and its catchment. Watercourses may be affected by direct runoff from the road itself. As a result, the natural magnitude, direction and timing of flood events can become significantly altered. Alterations to surface water hydrology could have associated implications for the local ecology, society and economy, as has been recognised by the EU Water Framework Directive and the Risk Framework of Scottish Planning Policy Guidance 7 (SPP7).

1.1.4 Within the study area, 19 watercourses and Fishermyre wetland may potentially be affected by the construction and operation of the Fastlink section of the proposed scheme. These watercourses range in size, from small ephemeral field drains to larger fast flowing streams, such as the Burn of Muchalls.

1.2 Assessment Aims

1.2.1 This report presents the assessment of potential impacts of the proposed scheme during operation and construction. Mitigation measures to avoid or reduce impacts of the proposed scheme on the hydrology of local watercourses are provided.

1.2.2 Impacts on hydrology are intrinsically linked to hydrogeology (refer to Chapter 38: Geology, Contaminated Land and Groundwater), water quality (refer to Appendix A39.3), geomorphology (refer to Appendix A39.2) and freshwater ecology (refer to Appendix A40.9). The inter-relationship of the environmental assessment chapters and appendices is illustrated in Figure 1.

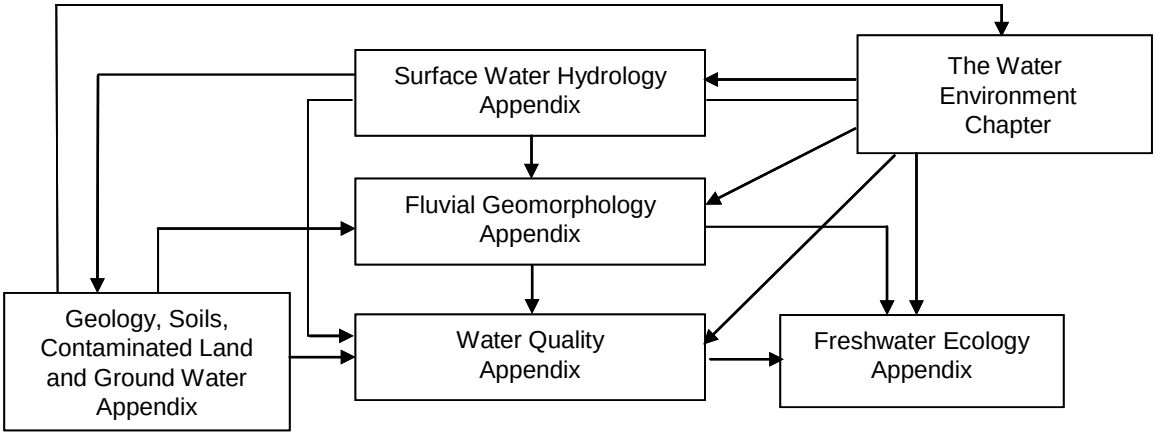

Figure 1: Flow chart illustrating the relationships between the technical appendices and chapters.

2 Approach and Methods

2.1 General Approach

2.1.1 The system of assessment followed the basic methodology detailed below:

- describe the present baseline condition;
- assess the potential impacts of the proposed scheme;
- provide mitigation measures for the potential impacts; and,
- assess the residual impacts following adoption of the suggested measures.

2.1.2 The hydrological criteria used to assess the sensitivity of surface water features and the magnitude of potential impacts are defined in Table 1 and Table 2. The resultant significance of impact is defined by reference to both the sensitivity of the feature and the magnitude of impact, according to the matrix presented in Table 3.

2.1.3 The assessment of sensitivity of water features (Table 1) takes into account both the natural and built environments.

Table 1 – Criteria to Assess the Sensitivity of Water Features

Sensitivity	Criteria
High	A watercourse/hydrological feature with hydrological importance to: sensitive and protected ecosystems; critical economic and social uses (e.g. water supply, navigation, recreation, amenity etc); the flooding of property (or land use of great value) that has been susceptible to flooding in the past. Or a watercourse/floodplain/hydrological feature that provides critical flood alleviation benefits. Or any property that is at risk of flooding due to the proposed road scheme.
Medium	A watercourse/hydrological feature with some but limited hydrological importance to: sensitive or protected ecosystems; economic and social uses (e.g. water supply, navigation, recreation, amenity etc); the flooding of property (or land use of value) that may potentially be susceptible to flooding. Or a watercourse/floodplain/hydrological feature that provides some flood alleviation benefits.
Low	A watercourse with minimal hydrological importance to: sensitive or protected ecosystems; economic and social uses (e.g. water supply, navigation, recreation, amenity etc); the flooding of property (or land use of value). Or a watercourse/floodplain/hydrological feature that provides minimal flood alleviation benefits.

Table 2 – Criteria to Assess the Magnitude of the Potential Impact on Water Features

Magnitude	Criteria
High	Major shift away from baseline conditions and major changes to the flow regime (low, mean and or high flows – at the site, upstream and/or downstream). An alteration to a catchment area in excess of a 25% reduction or increase in area. The extent of "medium to high risk" areas [classified by the Risk Framework of Scottish Planning Policy Guidance 7 (SPP7)] will be significantly increased. This means there will be significantly more areas/properties at risk from flooding by the 0.5% (1 in 200-year) or greater annual exceedence probability (AEP).
Medium	Moderate shift away from baseline conditions and moderate changes to the flow regime. An alteration to a catchment area in excess of a 10% but less than 25% reduction or increase in area. The extent of "medium to high risk" areas [classified by the Risk Framework of Scottish Planning Policy Guidance 7 (SPP7)] will be moderately increased.
Low	Minor shift away from baseline conditions and minimum changes to the flow regime. An alteration to a catchment area in excess of a 1% but less than 10% reduction or increase in area. The extent of "medium to high risk" areas [classified by the Risk Framework of Scottish Planning Policy Guidance 7 (SPP7)] will be similar to the magnitude of the errors attached to the estimate of the extent.
Negligible	Very slight shift away from baseline conditions and negligible changes to the flow regime (i.e. changes that are within the monitoring errors). An alteration to a catchment area in excess of a 1% reduction or increase in area. The extent of "medium to high risk" areas [classified by the Risk Framework of Scottish Planning Policy Guidance 7 (SPP7)] will be much smaller than the errors attached to the estimate of the extent.

Table 3 – Impact Significance Matrix

Sensitivity	Magnitude			
	High	**Medium**	**Low**	**Negligible**
High	Substantial	Moderate/Substantial	Moderate	Slight/Negligible
Medium	Moderate/Substantial	Moderate	Slight	Negligible
Low	Moderate	Slight	Negligible	Negligible

2.1.4 The assessment takes into account the Scottish Executive 'Scottish Planning Policy (SPP) 7: Planning and Flooding' (2004) and the Design Manual for Roads and Bridges (DMRB) Volume 4, Section 2 "Drainage". DMRB (Volume 11 Section 3 Part 10 HA 216/06 2.37 – 2.41) advises that if a scheme has the potential to significantly affect floodplain capacity, an assessment should be undertaken on:

- the reduction of capacity;
- the effectiveness of the proposed mitigation works; and
- the residual impact of the scheme on increased flood risk.

2.1.5 Other appropriate studies should be undertaken where other potentially significant hydrological effects are identified that could impinge on any of the current or proposed uses of the receiving waters.

2.1.6 In addition, the requirements of the EU Water Framework Directive were also taken into account when developing the methodology using SEPA policy guidance 'The Future for Scotland's Waters, Guiding Principles on the Technical Requirements of the Water Framework Directive' (SEPA, 2002).

2.1.7 Controlled Activities (Scotland) Regulations 2005 (CAR) state that it is an offence to discharge to all wetlands, surface waters and groundwaters without CAR authorisation. There are three different types of authorisation under CAR: General Binding Rules (GBR), Registration and License (both simple and complex). The level of regulation increases as the activity poses a progressively deleterious impact on the water environment. The level of authorisation required for the AWPR is dependent on the activity proposed but is likely to range from GBR, covering some construction activities and outfalls, to licences required for outfalls (draining over 1km of road in length), culverting and watercourse realignment. The applications will require baseline environmental information of the watercourse, details of the proposed design and a detailed construction method statement. These will be developed prior to construction and will require approval from SEPA before construction can begin.

2.2 Surface Water Assessment Methodology

Consultation

2.2.1 In Scotland, local authorities are responsible for watercourses and flooding matters. Aberdeen City and Aberdeenshire Councils were contacted to obtain baseline information including information on economic and recreational uses of the watercourses, existing and historic flood risk and relevant flood studies. Similarly, SEPA were also contacted with regards to their understanding of the flood risk posed by the various watercourses as well as flow and watercourse information. The 'Hydrological Data United Kingdom: Hydrometric Register and Statistics 1996-2000' (Centre for Hydrology and Ecology, 2003), SEPA, and the HiFlows-UK website were consulted to gain information on gauged catchments.

Existing Conditions

2.2.2 For each watercourse, the following estimates have been calculated for existing baseline conditions:

- 95-percentile flow (Q_{95});
- mean flow (Q_{mean});
- bankfull (Q_{BF}) and embankment-full (Q_{EBF}) flow;
- median annual maximum flood (Q_{MED});
- mean annual maximum flood (Q_{BAR});
- flood design peak flows including the 1% and 0.5% annual exceedance probability (AEP) flows (also known as the 100-year and 200-year flood design peak flows); and
- present potential flood risk using the SEPA 'Indicative River and Coastal Flood Map (Scotland)' site visits and desktop analysis of 1:25,000 Ordnance Survey maps.

2.2.3 Necessary hydrological catchment characteristics were obtained from Ordnance Survey, soils, geological and land use maps as well as the Flood Estimation Handbook (FEH) CD-ROM

2.2.4 Table 4 identifies the flow parameters and methodologies that were used to calculate these estimates. It is noted that all watercourses in the Fastlink study area that would be crossed by the proposed scheme are relatively small, ungauged catchments. Flow estimation on ungauged watercourses is generally subject to significant uncertainties.

2.2.5 In order to increase the confidence in the standard desk based flow estimates, site measurements aimed at refining several of the hydrological parameters were undertaken for representative catchments in May 2005. In addition, each watercourse was carefully inspected during site visits in 2006. The hydrological analyses used desk-based procedures, gauged data from donor/analogue catchments and where appropriate, spot gauging data.

Assessment of Impacts

2.2.6 The significance of a particular impact depends on the baseline conditions of each individual watercourse and the type and position of any road structure.

2.2.7 Potential post-development changes to catchment parameters (Table 4) are highlighted, in addition to potential changes to flood risk and floodplain inundation. These are assessed by recalculating parameters (Table 4) for a catchment with the scheme in place. The most significant parameter that is likely to change is generally the size of catchment area for a watercourse as the presence of the road would sever existing catchments.

2.2.8 Flood risk assessment for watercourses that would be crossed by the scheme has been carried out using the SEPA 'Indicative River and Coastal Flood Map (Scotland)'. These maps have been designed to show the flood extent from watercourses and the sea of the 0.5% AEP (1:200-year flood) event. The SEPA flood risk maps, however, do not show the flood risk for watercourses with a catchment smaller than 3km^2. Table 5 shows the flood risk at the proposed road crossing point where flood risk information is available. More information regarding the 'Indicative River and Coastal Flood Map (Scotland)' can be found on the SEPA website.

2.2.9 For watercourses outwith the SEPA Indicative Flood Maps, flood risk was determined through a desk based assessment of each affected watercourse. The desk based flood risk assessment was based on the distance, position and height difference (assessed using 1:25000m Ordnance Survey plans and 1:1250m detailed design plans) between the proposed culvert and any properties upstream of the proposed culvert entrance. Identification of land use upstream of the culvert was

also required as wooded areas can potentially produce more debris that can block culverts. This approach was used to identify properties that could potentially be at risk during extreme events.

2.2.10 The potential impacts of watercourse realignments is assessed assuming that realigned sections of watercourses would be constructed to a specification that would maintain existing channel dimensions, gradient and surface runoff pathways.

2.2.11 In the assessment, all culverts are considered to be flood flow culverts. Flood flow culverts are designed to convey the 0.5% AEP (200-year flow). All network culverts are designed to the standard 1.33% AEP (75-year flow) in line with the road drainage network, which is designed to the standards set out in the DMRB HA 106/04. While the potential flood risk posed by the presence of network culverts is assessed, they have not been assigned a baseline sensitivity as they are not an existing feature.

2.2.12 When assessing the impact of the proposed scheme on a watercourse, the percentage change in total catchment area of an affected watercourse is viewed as one indicator of potential impacts. Catchment changes of 1% or less are considered to be of negligible magnitude, changes of less than 10% are considered low, changes of less than 25% are considered medium and changes greater than 25% are considered a high impact. These values have been selected as indicators of the likely significance of changes in catchment area to a watercourse. These values are an estimate based on professional hydrological judgement however, they provide a guide to the potential significance of a loss/increase of catchment area on a watercourse.

Allowance for Climate Change in Hydrological Parameters

2.2.13 Guidance on allowance for climate change has been taken from a scoping study regarding climate change and hydrological parameters (SEPA, 2005). SEPA do not define a specific value, but suggests that the sensitivity of flows within flood risk analysis could be carried out up to a 20% increase for the east of Scotland. This is considered a maximum change and evidence suggests that by 2050 there is more likely to be an increase of approximately 15% in the east of Scotland (Price and McKenna, 2003).

2.2.14 The Scottish Executive (2004) states in the SPP7 Planning and Flooding Report that the threshold annual exceedance probability floods 0.5% (200-year) and 0.1% (1000-year) include an allowance for climate change. The Scottish Executive also indicates that developments should now be designed to the 0.5% annual exceedance probability design flood event instead of the 1% annual exceedance probability event (AEP) to allow for possible future climate change increases.

Table 4 – Hydrological Parameters and Methodologies

Description	Parameter	Proposed Methodology
Median annual maximum flood	Q_{MED}	Estimation of median annual maximum flood flow (QMED) was required in order to determine flood design peak flows and was estimated for all watercourses following the guidance of the Flood Estimation Handbook (FEH) (IH, 1999). The QMED from catchment descriptors at ungauged subject sites was refined by using a regional factor based upon interpretation of general performance of the FEH empirical equations against values obtained from gauged sites on the Rivers Don, Dee and Ythan, that were deemed to have sufficient hydro-climatic similarity to help refine the estimates. FEH guidance on the degree of uncertainty associated with QMED estimates from catchment descriptors is ± 55%. This methodology provides a baseline characteristic for each watercourse. Potential impacts may also be assessed using this method if there is an increase or decrease in catchment size caused by the scheme.
Mean annual maximum flood	Q_{BAR}	Estimation of average annual maximum flood (Q_{BAR}) was required in order to determine flood design peak flows and as a comparison to the calculated Q_{MED} values. For all catchments Q_{BAR} was estimated using the methodology of the Institute of Hydrology Report No.124 (IH124) (IH, 1994). IH124 guidance on the degree of uncertainty associated with Q_{BAR} estimates from catchment descriptors is ± 65% This methodology provides a baseline characteristic of each watercourse. Potential impacts may also be assessed using this method if there is an increase or decrease in catchment size caused by the scheme.
Flood design peak flows	Q-Tyr	Standard application of the FEH statistical pooling group method was used on a sub set of catchments to determine flood frequency curves for each burn. The curve was defined using the following % AEP: 50%, 20%, 10%, 2%, 1%,0.5% AEP (design return periods: 2, 5, 10, 50, 100, 200-years). Based upon the similarity of the growth curves and the apparent similarity in catchment characteristics across the area of interest, a single average growth curve was derived and applied to the other catchments. No formal quantification of Q-Tyr uncertainty is provided in the FEH but it is likely to be at least in the order of the Q_{MED} uncertainty ± 55% and in some circumstance will be appreciably larger. For comparison purposes and to fulfil the requirements of the DMRB the IH124 method was also followed, using the regional growth curve of the Flood Studies Supplementary Report No.14 (FSSR14). For completeness, a comparison of the results of the FEH and IH124 is included in the Appendix A39.4 Annex 1. The 0.5% AEP (200-year) design flow was further used for culvert design. Comparison was made with bankfull flows to give an indication of stream capacities and potential flooding. High flows were provided to support fluvial geomorphological assessments. This methodology provides baseline conditions as well as providing the potential impacts for the removal or culverting of any watercourses along the scheme. These values will also provide the mitigation values to correctly size any structures across watercourses.
Mean flow and 95-percentile flow	Q_{mean} Q_{95}	Mean flow (Qmean) and 95-percentile flow (Q_{95}) for ungauged watercourses for which LF2000 was not applied, were estimated by applying the donor catchment principle using the flow duration curves obtained for the ten selected watercourses. A donor for each ungauged watercourse was selected based on hydrological similarity, which was determined on the basis of the parameters SPRHOST and BFIHOST. CEH Wallingford state that the predictive uncertainty associated with the estimate of annual Q_{95} is 1.32 l/s/km² and the uncertainty in the estimate of annual mean flow is ±11%. These quoted uncertainties are 68% confidence limits on the estimated natural values.

Description	Parameter	Proposed Methodology
Bankfull flow * Embankment-full flow **	Q_{BF} Q_{EBF}	Bankfull (Q_{BF}) and embankment-full (Q_{EBF}) flow were estimated using Manning's Equation. Q_{BF} and Q_{EBF} are baseline conditions and were provided to support geomorphological assessments During a site visit in May 2005, measurements of the dimension of channel cross-sections and estimates of channel roughness were taken. These were verified with information from OS contour maps and photographs. The parameters presented are indicative only. There is inherent uncertainty associated with empirical measurements. The roughness coefficient is a subjective value based on best estimate, which can vary from 0 to 1. Flow is directly proportional to changes in the roughness coefficient irrespective of gradient. A change in the roughness coefficient of 10% gives a 10% change in flow. Sensitivity to roughness coefficients on a channel with gradient > 0 < 0.05 is in the region of < ±15% for a 0.005 variation in roughness. For a gradient > 0.05 < 0.1 uncertainty for a similar variation in the roughness coefficient is approximately < ±15%.
Monthly mean flow velocity	v_{month}	Monthly mean flow velocities (v_{month}) are baseline conditions and were provided to support ecological assessments Long-term mean monthly flow velocities were estimated using Manning's Equation and were based on approximate channel dimensions and mean monthly flows from flow duration curves. Mean monthly flows for ungauged watercourses for which LF2000 was not applied, were estimated by applying the donor principle using the flow duration curves obtained for the ten selected watercourses (see method statement for Q_{mean} and Q_{95}). Uncertainty with this method will incorporate errors associated with the calculation of Q_{BF}, Q_{EBF}, Q_{95} and Qmean. An approximate estimation of the uncertainty of these calculations combined would be in the region of ±20 – 25%.
Greenfield runoff rate	q green	In order to provide an estimate of Greenfield runoff rates (q green) for each of the drainage outfall locations, the average of two methodologies was used. These methodologies are the FEH catchment area method and the Rational Method. SEPA guidance is given in the booklet 'Guidance for Developers and Regulators Drainage Impact Assessment' (DP 300 3/02) and states, that in general the two-year one hour rainfall event should be used to determine the pre-development runoff for the existing site (refer DP 300 3/02) (i.e. predevelopment or as a 'Greenfield site'). According to CIRIA 609 (CIRIA, 2004) common values used for Greenfield runoff rates vary between 5 to 7 l/s/ha. However, care should be taken if applying these values as they may not be applicable to individual sites and the runoff rate is dependent on factors that include soil type and site gradient. Thus, to provide more site specific estimates of Greenfield runoff, the average of the FEH catchment area method and the Rational Method was applied to the outfall locations on the scheme. The FEH catchment area method uses the 2-year return period (Q_{MED}, see above method for calculation of median flood flow) FEH flow estimate at the drainage outfall location divided by the area of the catchment to this point to derive a Greenfield runoff rate in l/s/ha. The Rational Method assumes a 1 hectare (ha) catchment and a 60 minute storm duration. The basic form of this method is the following equation: Peak Flow (l/s) = 2.78 * *C* *I*(mm/hr) * *A* (ha) Where: *C* is the coefficient of runoff *I* is the intensity of rainfall *A* is the area under consideration

Description	Parameter	Proposed Methodology
		Values of *C* are described as varying from 0.05 to represent flat lawns with sandy soils to a maximum of 0.95 representing almost completely impermeable heavily urbanised areas (Maidment, 1993, Table 9.4.1). In this case the value of *C* was set at 0.2 to represent rural land with heavy soils. The rainfall intensity value, *I*, is determined by dividing the rain depth (mm) for various return periods by the 'Time of Concentration' or storm duration. The rain depth for each return period is determined using the Flood Studies Report (FSR) method. This approach involves obtaining the depth of rainfall with a return period of 5-years from the standard FSR maps (Wilson, 2004, Appendix A) and multiplying this value by the appropriate growth factor for the desired return period (Wilson, 2004, Tables, 2.6 and 2.7). Uncertainty within these methods is likely to be at least in the order of the QMED uncertainty ± 55% and in some circumstance will be appreciably larger.
SEPA Indicative River and Coastal Flood Map (Scotland)	N/A	Where available, flood risk assessment of the watercourses that would be crossed by the scheme has been carried out using the SEPA 'Indicative River and Coastal Flood Map (Scotland)'. The maps have been designed to show the flood extent from watercourses and the sea of the 0.5% AEP (1 in 200-year flood event). These maps do not show the flood risk for watercourses smaller than 3km². Table 5 describes the flood risk at the proposed road crossing point where flood risk information is available. The relevant annex (A39.4) shows the map. More information regarding the 'Indicative River and Coastal Flood Map (Scotland)' can be found on the SEPA website. Areas not covered by the SEPA 'Indicative River and Coastal Flood Map (Scotland)' have been assessed using 1:25,000 Ordnance Survey Maps.

Low Flows 2000 estimates were supplied by CEH Wallingford. Basic input information such as catchment area and boundaries were checked and where necessary refined in line with understanding gained during site visits and mapped information.

* Bankful flow = the flow capacity of the watercourse with out any water inundating adjacent ground.

** Embankment-full flow = the flow capacity of the watercourse feature including any artificial embankments or berms. It can be thought of as the confined flow that does not spread away from the path of the watercourse corridor.

2.3 Limitations to Assessment

2.3.1 The watercourses in the study area are ungauged and therefore inherent uncertainties exist in the estimation of flows. A higher degree of accuracy would require the installation of hydrometric monitoring equipment and the collation of a relatively long period of data (preferably several years of record). This is considered to be outwith the scope of the current study. Where possible, site visits and one-off measurements have been taken to improve the robustness of the estimates.

3 Baseline

3.1 Baseline Assessment

3.1.1 An assessment of baseline hydrological conditions has been carried out for each of the water features in the study area. It should be noted that Blaikiewell Burn and Burnhead Burn would be affected by both the Fastlink and the Southern Leg proposals, however the assessment for these two watercourses are reported in the Southern Leg report for consistency.

3.1.2 Table 5 details the baseline hydrological conditions of water features in the study area. Figures 39.2a-b presents the location plan of catchments, proposed culverts, flow gauges and rain gauges referred to in the assessment. Figure 39.2c provides a more detailed plan of Fishermyre Wetland and its hydrological catchment.

3.1.3 Estimated flood flows are provided in Annex 1 of Appendix A39.4. Annex 22 of Appendix A9.5 summarises the flow duration curves derived by using Low Flows 2000 (LF2000) software and compares them to spot gaugings that were taken during a site visit in 2005 for selected watercourses. The LF2000 information was then applied to other parameters following donor principles and in that sense are pertinent to this report.

3.1.4 Annexes 3-21 of Appendix A39.4 provide information on the parameters indicated in Table 4 for each of the potentially affected watercourses.

Table 5 – Baseline Conditions

Water Feature	Annex	Description	Sensitivity
Megray Burn	3	Catchment area at proposed road crossing point (ch600) = 0.6km^2. A small watercourse draining agricultural land flowing through a well defined valley in a southerly direction before discharging into the Cowie Water. At present there is an abstraction on the Megray Burn which has caused the downstream area to run dry. There is also extensive culverting in the downstream reaches of the burn. There is also a private water supply within the vicinity of the watercourse. Desktop assessment of the 1:25,000 OS maps indicates there is a potential flood risk to properties located in the northern area of Stonehaven, particularly when heavy rain coincides with high tides or a storm surge when water could back up from the coast along the Cowie Water. Flood risk assessment using the SEPA 'Indicative River and Coastal Flood Map (Scotland)' has not been completed for this site as SEPA Flood Risk maps are not available for catchments less than 3km²	Low
Limpet Burn	4	Catchment area at the proposed road crossing point (ch1500) = 1.3km^2. Small watercourse flowing through a well defined valley in an easterly direction with woodland on the southern bank and agricultural land to the north with an outflow into the North Sea. The valley floor consists of flat wetland with connectivity to groundwater (Geology, Contaminated Land and Groundwater: Chapter 38) although surface water is likely to play a key role in maintaining the supply of water to the wetland area. The burn provides an important flow into 3 fishing ponds in the downstream reaches which will be sensitive to any alteration in the water balance of the catchment. There are no known abstractions from this watercourse. Desktop assessment of the 1:25,000 OS maps indicates there is no flood risk to properties at the site of interest. Flood risk assessment using the SEPA 'Indicative River and Coastal Flood Map (Scotland)' has not been completed for this site as SEPA Flood Risk maps are not available for catchments less than 3km²	High
Coneyhatch Burn	5	Catchment area at the proposed road crossing point (ch2600) = 0.02 km^2. A catchment draining agricultural land and the southern fringe of Fishermyre wetland at the head of the Limpet Burn Catchment. Although the catchment drains in a south easterly direction there is no obvious channel for longer than 50m. Standing water and wetland, with associated vegetation, has been observed in the area of the burn. There are no known abstractions from this watercourse. Desktop assessment of the 1:25,000 OS maps indicates there is no flood risk to properties at the site of interest. Flood risk assessment using the SEPA 'Indicative River and Coastal Flood Map (Scotland)' has not been completed for this site as SEPA Flood Risk maps are not available for catchments less than 3km²	Low
Green Burn	6	Catchment area at the proposed outfall and road crossing point (ch3100) = 0.8km^2. The catchment area drains Fishermyre wetland area and agricultural land. The burn initially flows in a southerly direction before turning to flow in a north easterly direction into the Burn of Muchalls. In the upper reaches of the catchment, there is wet woodland within Fishermyre wetland area that is thought to be dependent on surface water hydrology. The burn is already culverted to cross under existing roads. There are no known abstractions from this watercourse. Desktop assessment of the 1:25,000 OS maps indicates there is a potential flood risk to properties in the Bridge of Muchalls hamlet, the A90 road bridge and a railway bridge downstream of the confluence with the Burn of Muchalls at the site of interest. Flood risk assessment using the SEPA 'Indicative River and Coastal Flood Map (Scotland)' has not been completed for this site as SEPA Flood Risk maps are not available for catchments less than 3km²	Medium

Water Feature	Annex	Description	Sensitivity
Green Ditch	7	Catchment area at the proposed crossing point of the existing side road (to be realigned) (ch3150) = 0.02 km^2. A tributary of Green Burn flowing in a southerly direction draining agricultural land to the east of the proposed route. The crossing point is near the most upstream point of the catchment. Green Burn is in close proximity to a private groundwater supply. Desktop assessment of the 1:25,000 OS maps indicates there is no flood risk to properties at the site of interest. Flood risk assessment using the SEPA 'Indicative River and Coastal Flood Map (Scotland)' has not been completed for this site as SEPA Flood Risk maps are not available for catchments less than 3km^2.	Low
Fishermyre Wetland	N/A	Catchment area = 0.8 km^2. An area of peat and wetland predominantly to the east of the proposed scheme that drains to Green Burn (Figure 39.2c). The area is recognised as important habitat for water voles and contains willow, wetland woodland and other sensitive vegetation species. The proposed scheme would pass through the eastern section of the wetland area. Surface water drains in a southeasterly direction through the moss before flowing into Green Burn. The majority of the moss would be upstream of the road alignment. The wetland area is likely to be maintained by rainfall falling directly on the moss to the northwest and groundwater as detailed in Chapter 38 (Geology, Contaminated Land and Ground Water). There are no known abstractions from this water feature, although wells are noted in the area. Desktop assessment of the 1:25,000 OS maps indicates there is no flood risk to properties at the site of interest. Flood risk assessment using the SEPA 'Indicative River and Coastal Flood Map (Scotland)' has not been completed for this site as SEPA Flood Risk maps are not available for catchments less than 3km^2.	High
Allochie Burn	8	Catchment area at the proposed road crossing point (ch4000) = less than 0.01km^2. This is a tributary of Back Burn that flows into the Burn of Muchalls. Allochie Burn flows in a southwesterly direction and has a small catchment area. At the point of crossing, the road would run along the watershed where drainage divides to the west and east. The burn is currently walled and drains agricultural land. There are no known abstractions from this watercourse. Desktop assessment of the 1:25,000 OS maps indicates there is no flood risk to properties at the site of interest. Flood risk assessment using the SEPA 'Indicative River and Coastal Flood Map (Scotland)' has not been completed for this site as SEPA Flood Risk maps are not available for catchments less than 3km^2.	Low
Burn of Muchalls	9	Catchment area at the proposed road crossing point (ch4700) = 6.7km^2. This is a relatively large watercourse flowing in an easterly direction. The lower and upper reaches have well defined valley sides, the middle reaches are flat wetland and include the highly sensitive area of Red Moss of Netherley, which is upstream of the proposed road crossing. There are four artificial ponds associated with the Burn of Muchalls, upstream of the road crossing point. These ponds would be unlikely to be affected by the proposed scheme as they are outwith the area of the scheme. The burn is thought to be in close proximity to a private water supply. At the road crossing point, the Indicative River and Coastal Flood Maps (Scotland) predict that the Burn of Muchalls will flood at the 0.5% AEP (200-year return period event). At this location and for approximately 200m upstream and downstream of the culvert, flooding is predicted to be predominantly confined to the right bank. The Burn of Muchalls is predicted to flood land within 100m of the channel. There appears to be no properties in the flood risk area as the floodplain consists of arable and pasture farmland. Aberdeenshire Council have also advised that the predicted flood risk is likely to be overestimated by the SEPA indicative flood risk maps in this particular location (see Annex 9).	Medium
Red Moss of Netherley	N/A	The moss is designated as a SSSI and a SAC. The road alignment would not be located within the catchment of the moss.	High

Water Feature	Annex	Description	Sensitivity
Burn of Blackbutts	10	Catchment area at the proposed road crossing point (ch5600) = 0.2km^2. This is the main tributary of the Burn of Muchalls, flowing in a southeasterly direction and draining predominantly agricultural land. Observations suggest that at the point of crossing near the most upstream end of the catchment the watercourse may be ephemeral, but the burn appears to have more continued flow further downstream. Desktop assessment of the 1:25,000 OS maps indicates that there is no flood risk to properties at the site of interest, but there is a potential flood risk to the Bridge of Muchalls hamlet, the A90 road bridge and a railway bridge downstream at the confluence with the Burn of Muchalls. In the upper reaches, the burn is adjacent to a private groundwater supply. Flood risk assessment using the SEPA 'Indicative River and Coastal Flood Map (Scotland)' has not been completed for this site as SEPA Flood Risk maps are not available for catchments less than 3km².	Low
Cookney Ditch	11	Catchment area at the proposed road crossing point (ch6500) = 0.2km^2. Appears to be part of an agricultural field drainage system with no obvious channel. At the point of interest, the channel is chocked with vegetation but drains in an easterly direction before discharging into the Pheppie Burn. The head of the catchment drains a small area of wetland and gorse. There are no known abstractions from this watercourse. Desktop assessment of the 1:25,000 OS maps indicates there is no flood risk to properties at the site of interest. Flood risk assessment using the SEPA 'Indicative River and Coastal Flood Map (Scotland)' has not been completed for this site as SEPA Flood Risk maps are not available for catchments less than 3km².	Low
Stoneyhill Ditch	12	Catchment area at the proposed road crossing point (ch6900) = 0.2km^2. A tributary of the Burn of Elsick, this watercourse flows in a northeast direction draining agricultural land, predominantly to the east of the proposed route. The crossing point would be located near the most upstream point of the catchment. There are no known abstractions from this watercourse. Desktop assessment of the 1:25,000 OS maps indicates there is no flood risk to properties at the site of interest. Flood risk assessment using the SEPA 'Indicative River and Coastal Flood Map (Scotland)' has not been completed for this site as SEPA Flood Risk maps are not available for catchments less than 3km².	Low
Balnagubs Burn	13	Catchment area at the proposed road crossing point (ch7550) = 0.2km^2. Another tributary of the Burn of Elsick with well defined bank lines flowing in a northeasterly direction, draining agricultural land predominantly to the east of the proposed route. The crossing point is near the most upstream point of the catchment. There are no known abstractions from this watercourse. Desktop assessment of the 1:25,000 OS maps indicates there is no flood risk to properties at the site of interest. Flood risk assessment using the SEPA 'Indicative River and Coastal Flood Map (Scotland)' has not been completed for this site as SEPA Flood Risk maps are not available for catchments less than 3km².	Low
Tributary of the Burn of Elsick	14	Catchment area at the proposed outfall and road crossing point (ch7950) = 1.0km^2. A burn draining agricultural land and flowing in an easterly direction into the Burn of Elsick. It is likely that the burn has been modified as part of a field drainage system. There is a possibility that the catchment may play a role in the water balance of a pond downstream of the confluence with the Burn of Elsick, although it is thought this is unconnected to the burn. There are no known abstractions from this watercourse. Desktop assessment of the 1:25,000 OS maps indicates there is no flood risk to properties at the site of interest. Flood risk assessment using the SEPA 'Indicative River and Coastal Flood Map (Scotland)' has not been completed for this site as SEPA Flood Risk maps are not available for catchments less than 3km².	Low

Water Feature	Annex	Description	Sensitivity
Whiteside Burn	15	Catchment area at the proposed road crossing point (ch8850) = 0.4km^2. This burn drains agricultural land and flows in an easterly direction into the Burn of Elsick. The upstream end of the burn has been piped and it is likely that the full length of the burn has been modified as part of a field drainage system. There are no known abstractions from this watercourse. Desktop assessment of the 1:25,000 OS maps indicates there is no flood risk to properties at the site of interest. Flood risk assessment using the SEPA 'Indicative River and Coastal Flood Map (Scotland)' has not been completed for this site as SEPA Flood Risk maps are not available for catchments less than 3km².	Low
Crossley Burn	16	Catchment area at the proposed road crossing point (ch9150) = 0.2km^2. A small tributary of the Burn of Elsick that flows in a southeasterly direction draining agricultural land predominantly to the east of the proposed route. The crossing point is near the most upstream point of the catchment, where the channel is heavily vegetated. Stagnant water was observed within the channel. It is thought that the full length of the burn has been modified as part of a field drainage system. There are no known abstractions from this watercourse. Desktop assessment of the 1:25,000 OS maps indicates there is no flood risk to properties at the site of interest. Flood risk assessment using the SEPA 'Indicative River and Coastal Flood Map (Scotland)' has not been completed for this site as SEPA Flood Risk maps are not available for catchments less than 3km².	Low
Cairns Burn	17	Catchment area at the proposed road crossing point (ch9200) = 0.1 km^2. This is a small tributary of Crossley Burn flowing in a south easterly direction draining agricultural land, predominantly to the west of the proposed route. The crossing point would be located near the most upstream point of the catchment where the channel is heavily vegetated and stagnant water was observed within the channel. It is thought that the full length of the burn has been modified as part of a field drainage system. There are no known abstractions from this watercourse. Desktop assessment of the 1:25,000 OS maps indicates there is no flood risk to properties at the site of interest. Flood risk assessment using the SEPA 'Indicative River and Coastal Flood Map (Scotland)' has not been completed for this site as SEPA Flood Risk maps are not available for catchments less than 3km².	Low
Circle Burn	18	Catchment area at the proposed road crossing point (ch9950) = 0.1km^2. A small tributary of the Greens of Crynoch Burn flowing in a northwesterly direction, draining agricultural land predominantly to the east of the proposed route. The crossing point would be located at the most upstream point of the catchment where the channel is heavily vegetated and flow within the channel is thought to be ephemeral. It is thought that the full length of the burn has been modified as part of a field drainage system. There are no known abstractions from this watercourse. Desktop assessment of the 1:25,000 OS maps indicates there is no flood risk to properties at the site of interest. Flood risk assessment using the SEPA 'Indicative River and Coastal Flood Map (Scotland)' has not been completed for this site as SEPA Flood Risk maps are not available for catchments less than 3km².	Low

Water Feature	Annex	Description	Sensitivity
Square Burn	19	Catchment area at the proposed road crossing point (ch10150) = 0.1km^2. A small burn flowing in a northwesterly direction, draining agricultural land predominantly to the west of the proposed route. This watercourse may be connected downstream with the Greens of Crynoch Burn. The crossing point would be located at the most upstream point of the catchment, where the channel is heavily vegetated and flow within the channel is thought to be ephemeral. It is thought that the full length of the burn has been modified as part of a field drainage system. There are no known abstractions from this watercourse. Desktop assessment of the 1:25,000 OS maps indicates there is no flood risk to properties at the site of interest. Flood risk assessment using the SEPA 'Indicative River and Coastal Flood Map (Scotland)' has not been completed for this site as SEPA Flood Risk maps are not available for catchments less than 3km².	Low
Wedderhill Burn	20	Catchment area at the proposed road crossing point (ch10400) = 0.1km^2. A tributary of the Crynoch Burn flowing in a northwesterly direction, draining agricultural land predominantly to the west of the proposed route. The crossing point would be located at the most upstream point of the catchment where the channel is heavily vegetated with limited flow. It is thought that the full length of the burn has been modified as part of a field drainage system and a large section is piped under ground before discharging into Crynoch Burn. Crynoch Burn part of the River Dee SAC. However, Wedderhill Burn catchment only accounts for approximately 1% of the total Crynoch Burn catchment. It therefore only provides a small input to the total hydrological system and is unlikely to effect the hydrological characteristics and habitats of Crynoch Burn. It is suspected that the upper reaches of this watercourse are in close proximity to a private groundwater supply. Desktop assessment of the 1:25,000 OS maps indicates there is no flood risk to properties at the site of interest. Flood risk assessment using the SEPA 'Indicative River and Coastal Flood Map (Scotland)' has not been completed for this site as SEPA Flood Risk maps are not available for catchments less than 3km².	Low
Craigentath Burn	21	Catchment area at the proposed outfall and road crossing point (ch10600) = 0.4km^2. A tributary of Crynoch Burn that flows in a northwesterly direction, draining agricultural land. The crossing point is at an area where the channel is not distinct and appears more like a wetland. No obvious flow was observed and the burn was defined by an area of standing water within the wetland. Crynoch Burn is a part of the River Dee SAC. However, Craigentath Burn catchment accounts for approximately 2% of the total Crynoch Burn catchment. Therefore, Craigentath Burn only provides a small input to the total hydrological system and is unlikely to affect the characteristics and habitats of Crynoch Burn. There are no known abstractions from this watercourse. Desktop assessment of the 1:25,000 OS maps indicates there is no flood risk to properties at the site of interest. Flood risk assessment using the SEPA 'Indicative River and Coastal Flood Map (Scotland)' has not been completed for this site as SEPA Flood Risk maps are not available for catchments less than 3km².	Low

3.2 Summary

3.2.1 In total, the Fastlink section of the proposed scheme would cross 19 watercourses and Fishermyre wetland. The catchments are generally small (areas range between 0.2 to 4.5km^2) and mainly rural in character. Average annual rainfall along the entire AWPR route varies between 770 and 840mm, with a slight east to west increase indicating a drier than average region within Scotland.

3.2.2 Hydrological soil parameters indicate that the ground conditions along the proposed Fastlink section of the AWPR are generally of average permeability. Greenfield runoff rate was calculated at 4.7-l/s/ha for the 50%AEP (1 in 2-year return period) design flows. The Greenfield runoff rate defines the discharge rate from water quality treatment ponds (refer to the Water Quality Appendix A39.3).

3.2.3 Soil parameters of the small catchments suggest middle range permeability and that they would be expected to display flow regimes of average sensitivity to rainfall. This indicates that these catchments are unlikely to be especially flashy (i.e. rainfall does not reach the watercourse particularly quickly), but they will experience appreciable flood flows during and immediately following heavy rain (something that would not be so obvious in particularly permeable catchments where rainfall takes much longer to reach the watercourse). Within the range of responsiveness, Green Burn is likely to have the fastest response to rainfall whereas the Burn of Elsick and Whiteside Burn, are slightly slower to respond. However, it is stressed that none of these catchments exhibit extreme response characteristics.

3.2.4 Existing flood risk from smaller watercourses is considered to be low where they run through rural areas. A review of the SEPA 'Indicative River and Coastal Flood Map (Scotland)' suggests there is potential flood risk on some watercourses downstream of the proposed road crossing point. An assessment of watercourses outwith the SEPA 'Indicative River and Coastal Flood Map (Scotland)' also indicates some potential existing flood risk.

3.2.5 Limpet Burn has been assigned a high sensitivity due to its connectivity to fishing ponds downstream of the proposed scheme crossing point and the connectivity of surface water to the wetland environment within the valley floor of the burn. There is also an important supply of groundwater associated with this watercourse (refer to Chapter 38).

3.2.6 A walkover survey of Fishermyre wetland took place on 26/03/2007 and observations indicated that the area had reached a good water equilibrium where the ground remains waterlogged throughout the majority of the year and there is a strong connectivity between surface water and groundwater. Fishermyre wetland is considered a highly sensitive site as a constant supply of surface water is required to maintain the local water balance, peat deposits and associated flora and fauna of the wetland. This area is also thought to be associated with an important supply of groundwater.

4 Potential Impacts

4.1 Introduction

4.1.1 This section assesses the potential impacts of the scheme on the hydrology of watercourses, without mitigation.

4.1.2 Potential impacts associated with the operational phase of the scheme are considered to be permanent. Temporary impacts, which are only apparent while the road is being built, are discussed in association with the construction phase.

4.1.3 Unless otherwise stated, the impacts referred to would be adverse impacts on the hydrological regime of a watercourse, channel morphology or natural fluvial processes and are assigned based on the criteria set out in Table 2. In addition to the potential impacts on existing watercourses, an

assessment has also been made of the likely impact of network culverts (culverts which would be required to pass drainage from one side of the road to the other). Network culverts are not considered in the baseline conditions as no watercourse currently exists at that location. Network culverts are included in the assessment of potential impacts as their introduction presents an additional flood risk to the area surrounding a proposed network culvert.

4.2 General

4.2.1 Road schemes have the potential to affect surface water hydrology as a result of:

- installation of structures such as culverts and bridges;
- increase runoff as a result of increase impermeable area (road surface);
- impeding the functionality of floodplains (flood storage and conveyance);
- realignment of watercourses;
- disturbance of hydrological features (wetlands, lochans, etc);
- alteration of catchment areas; and
- alteration of surface water runoff pathways.

4.2.2 These impacts have the potential to result in changes to:

- magnitude and timing of runoff;
- flow velocities;
- flow pathways; and
- flood risk.

Operational Impacts

4.2.3 Impacts of the scheme on surface hydrology are those that could affect the physical flow and water level regimes. Examples of such circumstances may include:

- Structures: blockage or constriction of structures may lead to localised flood risk, potential for increased sediment release and changes to erosion/depositional patterns indirectly affecting the geomorphological and ecological status of a watercourse.
- Impermeable Areas: impermeable areas increase the overall volume of water reaching the watercourse, as less is lost to infiltration. Road runoff may also reach receiving watercourses earlier than pre-scheme conditions, which may result in the flood response of the catchment becoming more ‘flashy increasing flood risk and stream power downstream.
- Outfall of Road Drainage: road drainage would drain to an outfall to discharge into a receiving watercourse. Alterations to the hydrological and flood regimes of outfall watercourses may occur if there is no suitably designed attenuation of surface water runoff. Outfall of road drainage may also have an impact on the sediment regime and water quality of the receiving.
- Increased Catchment: the proposed works may require the re-direction of one watercourse into another or the introduction of an outfall to a watercourse, which may increase local flow rates and flood risk. Alterations to flow may have implications for sedimentation patterns along the watercourse which may increase flood risk else where along the watercourse through changes in channel dimensions.
- Reduced Catchment: constriction or severing of established flow paths may lead to an increased flood risk; changes to sediment regime via changes to gradient and size of watercourse leading to impacts upon geomorphology and subsequently water quality. Alterations to the flow regime could also have associated impacts on the ecological status of a watercourse.

- Catchment Severance: the scheme may act as a barrier to current watercourse catchments, which could increase flows to some watercourses and reducing flows in others. This would be of particular concern if surface water conditions were of particular importance for an environmentally sensitive area such as a raised moss. A reduction in flows may greatly affect the geomorphological, water quality and ecological status of the watercourse.
- Stream Realignment: realignments have the potential to increase flood risk if the correct channel dimensions and gradient are not applied to the realignment design.
- Pre-Earthworks Drainage: prior to construction, it would be necessary to construct a pre-earthworks drainage system to prepare the work corridor. At this stage any small watercourses or catchment areas identified as suitable are incorporated into the pre-earthworks drainage system. The drainage system would remain in place throughout the operation of the scheme and can result in permanent re-direction of discharge for affected watercourses. Catchment areas would increase or decrease depending on the outfall point of the pre-earthworks drainage system.

Construction Impacts

4.2.4 Potential impacts during construction of the scheme would include soil compaction from works traffic, erosion and sedimentation of watercourses. Impacts on watercourses would also occur from activities such as the construction of outfall locations, pre-earthworks drainage and as a result of alterations to catchment connectivity.

4.2.5 Temporary haul roads may cause a temporary increase in runoff due to reduced infiltration rates in the area of the road.

4.2.6 Temporary outfalls and SUDS ponds would be built as part of the construction phase of the project. This could result in alterations to the hydrological and flood regimes of outfall watercourses if there is no suitably designed attenuation of surface water runoff. Temporary outfall of road drainage may also have an impact on the sediment regime of the receiving watercourse.

4.2.7 During the construction phase, other temporary works that would, or potentially may, have some bearing on the surface hydrology would include the following:

- watercourse diversions to facilitate culvert and bridge construction;
- drainage outfalls (temporary, during works); and
- alterations to drainage regimes due to runoff control measures (temporary, during works), which could include swales and geotextile-wrapped straw bale barriers.

4.2.8 The severity of the impacts would be increased during periods of intense or prolonged rainfall.

4.3 Specific Impacts

4.3.1 This section describes the scope of works that would be required for each watercourse in the study area and assesses the potential impacts from construction and operation.

Road Drainage Outfalls

4.3.2 Outfalls to discharge road drainage would be required for:

- Megray Burn;
- Green Burn;
- Burn of Muchalls; and
- Tributary of the Burn of Elsick

Watercourse Crossings

4.3.3 A buried structure is proposed for the road crossing over the Burn of Muchalls due to the size and environmental sensitivity of the burn. The structure is designed to span the watercourse with no in-channel supports and would be set back approximately 8m from the top of bank to ensure riparian connectivity through the structure. All crossings are marked on Figures 39.3a-f.

4.3.4 A buried structure is proposed for the scheme to cross over Limpet Burn. The structure is designed to span the watercourse with no in-channel supports and set back approximately 5.5m from the main channel to ensure riparian connectivity through the structure. The structure would require the realignment of 124m of Limpet Burn, resulting in a loss of 1m of stream length.

4.3.5 The scheme would cross the remaining watercourses in the study area via culverts. A total of 11 culverts would be required:

- one culvert at Megray Burn, Stoneyhill Ditch, Balnagubs Burn, Tributary of the Burn of Elsick, Whiteside Burn, Crossley Burn, Craignetath Burn; and
- two culverts each on Green Burn and Cookney Ditch.

4.3.6 Culverts would be sized to convey a range of flows and would be installed level with the existing bed, resulting in an artificial bed and banks.

Watercourse Realignments

4.3.7 The following watercourse realignments would be required:

- Megray Burn (one extensive realignment of 951m, resulting in 49m extension to the watercourse);
- Limpet Burn (one realignment of 123m, resulting in a 1m shortening of the channel);
- Green Burn (one realignment of overall length 342m, resulting in a 8m shortening of the channel);
- Green Ditch (one realignment of 36m, resulting in a 59m shortening of the channel);
- Balnagubs Burn (one realignment of 117m, overall channel length maintained);
- Cookney Ditch (one realignment of 244m, overall channel length maintained);
- Stoneyhill Ditch (one realignment of 203m, overall channel length maintained);
- Tributary of the Burn of Elsick (one realignment of 150m, overall channel length maintained);
- Whiteside Burn (one realignment of 121m, overall channel length maintained);
- Crossley Burn (one realignment of 161m, overall channel length maintained);
- Cairn Burn (one realignment of 192m, resulting in 40m shortening of channel); and
- Craigentath Burn (one realignment of 216m, overall channel length maintained).

Pre-Earthworks Drainage

4.3.8 As noted previously, certain minor watercourses and drainage ditches would not be culverted, but would be routed into pre-earthworks ditches and subsequently into the road drainage system. This is proposed for the following burns which are effectively small, ephemeral ditches:

- Coneyhatch Burn;
- Allochie Burn;
- Burn of Blackbutts; and

- Circle and Square Burn.

Catchment Severance

4.3.9 Although Wedderhill Burn would not be directly taken into the pre-earthworks drainage, it would lose 100% of its catchment to pre-earthworks drainage. This is ultimately likely to result in the loss of this watercourse as its source of flow disappears.

Network Culverts

4.3.10 At certain locations along the scheme, network culverts would be installed to pass drainage from one side of the road to the other. Network culvert sites have not been considered in the baseline conditions as no watercourse presently exists at the proposed location. The potential impacts of these structures are assessed as their introduction to a locality represents the addition of a flood risk in the surrounding area. One network culvert is proposed in the Fastlink section of the scheme, near Fishermyre Wetland at chainage 2540.

4.3.11 Potential impacts (assuming no mitigation) during operation of the scheme are presented in Table 6. Potential impacts during construction of the scheme for watercourses in the Fastlink study area are presented in Table 7.

Table 6 – Potential Operational Impacts

Water Feature	Sensitivity	Potential Impact Description (Assuming No Mitigation)	Potential Impact	
			Magnitude	Significance
Megray Burn	Low	Culvert (ch0) has potential to cause localised constriction of flow and flood risk. The culvert would be approximately 92m in length, 1.2m high and 2.4m wide.	Negligible	Negligible
		Potential risk of culvert blockage has been based on a desktop assessment of the site using OS maps. The catchment land use upstream of the culvert includes small areas of forest. Therefore, risk of culvert blockage has been assessed as medium. Due to the elevation of nearby property flood risk has been assessed as low.	Medium	Slight
		Realignment required to accommodate road alignment at this location. Potential to cause a slight increase in channel gradient. Any decrease in bank height may increase localised flood risk.	Low	Negligible
		Discharge of road drainage has the potential to increase flows. The catchment area of the outfall includes the existing catchment of the burn and the added catchment from the road (0.041km^2 of hard standing) and would also take additional runoff from the Limpet Burn (approximately 0.1km^2) catchment due to the position of the AWPR and the drainage scheme. Megray Burn catchment size would therefore increase by approximately 13%.	Medium	Slight
Limpet Burn	High	Buried bridge structure has the potential to cause a localised constriction of flow due to bridge supports and increase flood risk.	Low	Moderate
		Risk of buried bridge blockage on the main AWPR line: Potential risk of the buried bridge structure blockage has been based on a desktop assessment of the site using OS maps. The catchment land use upstream of the proposed crosingt is comprised of bracken, heather, rough grass and forestry in the upstream area of the catchment. At the point of interest, there is no flood risk as properties and agricultural land are at a significant distance and height from the proposed crossing point of the AWPR.	Low	Moderate
		Approximately 6% of the catchment area to the point where the scheme would cross for Megray Burn and Green Burn would be lost due to pre-earthworks drainage. This would result in a 4% reduction in the catchment area at the location of the Limpet Burn Fishing Ponds. Maintaining groundwater connectivity is important for this watercourse and the fishing ponds downstream.	Low	Slight/ Negligible
		Realignment has the potential to cause a slight increase in channel gradient. Any decrease in bank height may increase localised flood risk.	Low	Moderate
Network Culvert: Fishermyre	N/A	Potential to cause localised constriction of flow and flood risk. The network culvert (ch2540) would be approximately 78m in length and 0.9m in diameter.	Negligible	N/A
		Potential risk of culvert blockage has been based on a desktop assessment of the site using OS maps. The catchment land use upstream of the culvert is comprised of bracken, heather and/or rough grass. The risk of culvert blockage has been assessed as low. At the point of interest, flood risk has been assessed as low due to the elevation of nearby properties. However, it should be recognised that these drainage culverts are designed to the 1.33% AEP (1:75 yr design flood) as detailed in the DMRB HA 106/04.	Low	N/A
Coneyhatch Burn	Low	The area of catchment upstream of the road would be taken into pre-earthworks drainage. Approximately less than 1% of the total Limpet Burn catchment would be lost causing a slight reduction in flows. This catchment area would drain to the Burn of Muchalls road outfall.	Negligible	Negligible
Green Burn	Medium	Culvert (ch3125) has the potential to cause localised constriction of flow and flood risk. The culvert would be 84m in length, 1.5m high and 2.7m wide.	Negligible	Negligible

Water Feature	Sensitivity	Potential Impact Description (Assuming No Mitigation)	Potential Impact	
			Magnitude	Significance
		Potential risk of culvert blockage has been based on a desktop assessment of the site using OS maps. The catchment land use upstream of the culvert is comprised of bracken, heather and/or rough grass. The risk of culvert blockage has been assessed as low. At the point of interest, there is no flood risk.	Low	Slight
		Culvert on the realignment of the existing side road has the potential to localised constriction of flow and flood risk. The culvert would be 19m in length, 1.5m high and 2.7m wide.	Negligible	Negligible
		Potential risk of culvert blockage has been based on a desktop assessment of the site using OS maps. The catchment land use upstream of the culvert is comprised of bracken, heather and/or rough grass. The risk of culvert blockage has been assessed as low. At the point of interest there is no flood risk.	Low	Slight
		Realignment has the potential to cause a slight increase in channel gradient. Any decrease in bank height may increase localised flood risk.	Low	Slight
		Discharge of road drainage has the potential to increase flows. The catchment area of the outfall includes the existing catchment of the burn and the added catchment from the road (0.018 km^2 of hard standing) and would take additional flow from a severed area of the Limpet Burn catchment due to the position of the AWPR and the drainage scheme. This amounts to an approximate 0.2km^2 (approximately 22%) increase in the catchment draining to the point of the road outfall.	Medium	Moderate
Green Ditch	Low	Realignment has the potential to cause a slight increase in channel gradient. Any decrease in bank height may increase localised flood risk.	Negligible	Negligible
Fishermyre wetland	High	Surface water runoff from the majority of the wetland would not be able to flow to approximately 6% of the wetland due to blockage of surface water runoff pathways. Water supplied by localised rainfall to the severed area would be maintained. There is potential for the dewatering of the wetland area, which is considered a high magnitude potential impact due to the sensitivity of wetland environments.	High	Substantial
		Offset ecological mitigation for impacts on water vole habitat may require changes to drainage (refer to Chapter 40). Any potential changes to the local hydrology could result in detrimental impacts on the surface water hydrology of the wetland area.	High	Substantial
Allochie Burn	Low	The area of the catchment upstream of the road would be taken into pre-earthworks drainage. This catchment would continue to drain to Burn of Muchalls via the road drainage outfall.	Negligible	Negligible
Burn of Muchalls	Medium	Buried structure has the potential to cause a localised constriction of flow due to bridge supports and increase flood risk.	Low	Slight
		Discharge of road drainage has the potential to increase flows. There is likely to be a 0.4% increase in the catchment size at the point of the road crossing due to the position of the road and the direction of the road drainage. There would be approximately 0.065 km^2 of hard standing draining to this outfall.	Negligible	Negligible
Burn of Blackbutts	Low	The area of the catchment upstream of the road would be taken into pre-earthworks drainage. The drainage re-direction would add this flow to the Burn of Muchalls further upstream at the AWPR outfall instead of at the confluence. Potential to decrease the response time of the Burn of Muchalls.	Low	Negligible
Cookney Ditch	Low	Culvert (ch6480) has the potential to cause a possible localised constriction of flow and flood risk. The culvert would be approximately 42m in length, 1.5m high and 2.4m wide.	Negligible	Negligible

Water Feature	Sensitivity	Potential Impact Description (Assuming No Mitigation)	Potential Impact	
			Magnitude	Significance
		Potential risk of culvert blockage has been based on a desktop assessment of the site using OS maps. The catchment land use upstream of the culvert is comprised of predominantly pasture land. Risk of culvert blockage has therefore been assessed as Negligible. At the point of interest flood risk has been assessed as Low.	Low	Negligible
		Realignment has the potential to cause a slight increase in channel gradient. Any decrease in bank height may increase localised flood risk.	Low	Negligible
		Culvert that would be installed on side road has the potential to cause a possible localised constriction of flow and flood risk. The culvert on the side road would be approximately 53m in length, 1.5m high and 2.4m wide	Negligible	Negligible
		Potential risk of culvert blockage has been based on a desktop assessment of the site using OS maps. Risk of culvert blockage has therefore been assessed as low. At the point of interest, flood risk has been assessed as low.	Low	Negligible
		Realignment has the potential to cause a slight increase in channel gradient. Any decrease in bank height may increase localised flood risk.	Low	Negligible
Stoneyhill Ditch	Low	Culvert (ch6930) has the potential to cause a possible localised constriction of flow and flood risk. The culvert would be 36m in length, 1.2m high and 2.4m wide.	Negligible	Negligible
		Potential risk of culvert blockage has been based on a desktop assessment of the site using OS maps. Risk of culvert blockage has therefore been assessed as low. At the point of interest flood risk has been assessed as low.	Low	Negligible
		Realignment has the potential to cause a slight increase in channel gradient. Any decrease in bank height may increase localised flood risk.	Low	Negligible
Balnagubs Burn	Low	Culvert (ch7550) has the potential to cause a possible localised constriction of flow and flood risk. The culvert would be 48m in length, 1.2m high and 2.4m wide.	Negligible	Negligible
		Potential risk of culvert blockage has been based on a desktop assessment of the site using OS maps. The risk of culvert blockage has been assessed as low. At the point of interest, there is no flood risk.	Low	Negligible
		Realignment has the potential to cause a slight increase in channel gradient. Any decrease in bank height may increase localised flood risk.	Low	Negligible
Tributary of the Elsick Burn	Low	Culvert (ch7975) has the potential to cause localised constriction of flow and flood risk. The culvert would be 53m in length, 1.5m high and 2.7m wide.	Negligible	Negligible
		Potential risk of culvert blockage has been based on a desktop assessment of the site using OS maps. The catchment land use upstream of the culvert is comprised of pasture land and therefore is unlikely to cause culvert blockage. Risk of culvert blockage has therefore been assessed as negligible. Due to the elevation of nearby properties, flood risk has been assessed as low.	Low	Negligible
Tributary of the Elsick Burn Continued	Low Continued	Realignment has the potential to cause a slight increase in channel gradient. Any decrease in bank height may increase localised flood risk.	Low	Negligible
		Discharge of road drainage has the potential to increase flows. There is likely to be an approximate 16% increase in the catchment size at the point of the outfall due to the position of the road and the direction of the road drainage. However, the increase in the total catchment area of the Burn of Elsick to the outfall of the North Sea is less than 1%. There would be approximately 0.057km^2 of hard standing draining to this outfall.	Medium	Slight

Water Feature	Sensitivity	Potential Impact Description (Assuming No Mitigation)	Potential Impact	
			Magnitude	Significance
Whiteside Burn	Low	Culvert (ch8850) has the potential to cause localised constriction of flow and flood risk. The culvert is 62m in length, 1.2m high and 2.4m wide.	Negligible	Negligible
		Potential risk of culvert blockage has been based on a desktop assessment of the site using OS maps. The catchment land use upstream of the culvert comprises of pasture land and therefore is unlikely to cause culvert blockage. Therefore risk of culvert blockage has been assessed as Negligible. At the point of interest there is no flood risk.	Negligible	Negligible
		Realignment has the potential to cause a slight increase in channel gradient. Any decrease in bank height may increase localised flood risk.	Low	Negligible
Crossley Burn	Low	Culvert (ch9170) has the potential to cause localised constriction of flow and flood risk. The culvert is 87m in length, 1.2m high and 2.4m wide.	Negligible	Negligible
		Potential risk of culvert blockage has been based on a desktop assessment of the site using OS maps. The catchment land use upstream of the culvert comprises of pasture land and therefore is unlikely to cause culvert blockage. Risk of culvert blockage has therefore been assessed as Negligible. Due to the elevation of nearby properties, flood risk has been assessed as low.	Low	Negligible
		Realignment has the potential to cause a slight increase in channel gradient. Any decrease in bank height may increase localised flood risk.	Low	Negligible
Cairns Burn	Low	Realignment has the potential to cause a slight increase in channel gradient. Any decrease in bank height may increase localised flood risk.	Low	Negligible
Circle Burn	Low	The area of the catchment upstream of the road would be taken into pre-earthworks drainage. The drainage direction would cause this to be added to the Burnhead Burn before discharging to the Crynoch Burn instead of discharging directly from the Stranog Burn. The size of Circle Burn is unlikely to significantly alter the freshwater levels in Burnhead Burn at the point of outfall.	Negligible	Negligible
Square Burn	Low	The area of the catchment upstream of the road would be taken into pre-earthworks drainage. The catchment would still outfall to the Burnhead Burn before discharging to the Crynoch Burn. The size of Square Burn is unlikely to significantly alter the fresh water levels in the Burnhead Burn at the point of outfall.	Negligible	Negligible
Wedderhill Burn	Low	The source of Wedderhill Burn would be lost through catchment severance. The area of the catchment upstream of the road would be taken into pre-earthworks drainage, this equates to approximately 20% of the total catchment. Less than 1% of the total Crynoch Burn catchment would be lost in the road construction. The drainage direction would cause this area of the catchment to discharge to Crynoch Burn via Burnhead Burn instead of flowing through Wedderhill Burn. Burnhead Burn would be affected by both the Fastlink and Southern Leg. All assessments and impacts are reported in Chapter 24.	Medium	Slight
Craigentath Burn	Low	Culvert (ch10630) has the potential to cause localised constriction of flow and flood risk. The culvert is 67m in length, 1.5m high and 2.4m wide.	Negligible	Negligible
		Potential risk of culvert blockage has been based on a desktop assessment of the site using OS maps. The catchment land use upstream of the culvert is comprised of sparse bracken,heather, and/or rough grazing. The risk of culvert blockage has been assessed as low. Due to the elevation of nearby properties flood risk has been assessed as low.	Low	Negligible
		Realignment has the potential to cause a slight increase in channel gradient. Any decrease in bank height may increase localised flood risk.	Low	Negligible

* Negligible impacts assuming that culverts are designed to the correct flow and that DMRB standard's are applied to culvert sizing.

Table 7 – Potential Construction Impacts

Water Feature	Sensitivity	Potential Impact Description (Assuming No Mitigation)	Potential Impact	
			Magnitude	Significance
Megray Burn	Low	Construction of culvert at ch0.	Medium	Slight
		Realignment of a section of channel.	Medium	Slight
		General construction impacts.	Low	Negligible
Limpet Burn	High	Construction of buried bridge structure.	Medium	Moderate/ Substantial
		Realignment of a section of channel.	Medium	Moderate/ Substantial
		General construction impacts.	Low	Moderate
Coneyhatch Burn	Low	General construction impacts.	Low	Negligible
Green Burn	Medium	Construction of culverts at ch3125 and side road.	Medium	Moderate
		General construction impacts.	Low	Slight
		Realignment of a section of channel.	Medium	Moderate
Green Ditch	Low	General construction impacts.	Low	Negligible
		Realignment of a section of channel.	Medium	Slight
Fishermyre Wetland	High	General construction impacts. Impact would be increased as the AWPR is surrounded by an area of wetland.	Medium	Moderate/ Substantial
		Mitigation to prevent water voles from inhabiting the area during construction period must be implemented (see A40.7) If measures to prevent water voles entering the area in and around the channel is not carried out with consideration of surface water hydrology there is the possibility that channel dimensions may be changed and/or channel constriction may occur. If channel dimensions are changed and/or channel obstruction occurs due to measures to prevent water voles entering the channel this may result in increased flood risk or dewatering of downstream areas. Details of the proposed Water Vole habitat prevention scheme during construction can be found in Appendix A10.7.	Medium	Moderate/ Substantial
Allochie Burn	Low	General construction impacts.	Low	Negligible
Burn of Muchalls	Medium	Construction of buried structure.	Medium	Moderate
		General construction impacts.	Low	Slight
Burn of Blackbutts	Low	General construction impacts.	Low	Negligible

Water Feature	Sensitivity	Potential Impact Description (Assuming No Mitigation)	Potential Impact	
			Magnitude	Significance
Cookney Ditch	Low	Construction of culverts at ch6480 and side road.	Medium	Slight
		General construction impacts.	Low	Negligible
		Realignment of a section of channel.	Medium	Slight
Stoneyhill Burn	Low	Construction of culvert at ch6930.	Medium	Slight
		General construction impacts.	Low	Negligible
		Realignment of a section of channel.	Medium	Slight
Balnagubs Burn	Low	Construction of culvert at ch7550.	Medium	Slight
		General construction impacts.	Low	Negligible
		Realignment of a section of channel.	Medium	Slight
Tributary of the Elsick Burn	Low	Construction of culvert at ch7975	Medium	Slight
		General construction impacts.	Low	Negligible
		Realignment of a section of channel.	Medium	Slight
Whiteside Burn	Low	Construction of culvert at ch8850.	Medium	Slight
		Realignment of a section of channel.	Medium	Slight
		General construction impacts.	Low	Negligible
Crossley Burn	Low	Construction of culvert at ch9170.	Medium	Slight
		Realignment of a section of channel.	Medium	Slight
		General construction impacts.	Low	Negligible
Cairns Burn	Low	Realignment of a section of channel.	Medium	Slight
		General construction impacts.	Low	Negligible
Circle Burn	Low	General construction impacts.	Low	Negligible
Square Burn	Low	General construction impacts.	Low	Negligible
Wedderhill Burn	Low	General construction impacts.	Low	Negligible
Craigentath Burn	Low	Construction of culvert at ch10630.	Medium	Slight
		General construction impacts.	Low	Negligible
		Realignment of a section of channel.	Medium	Slight

4.4 Summary

Operation Impacts

4.4.1 Throughout its operation, the road has the potential to affect downstream flow regimes, particularly where significant modification to overland flow paths is likely and where culvert upgrading is proposed. Adequately designed culverts are predicted to have a Negligible impact on existing hydrological processes. Network culverts that would be installed for scheme drainage introduce a flood risk to a location that previously had no watercourse. Adequately designed network culverts are predicted to have a Negligible impact on hydrological processes. However, there remains the potential risk of culvert blockage.

4.4.2 Appropriately designed buried structures with no in-channel supports would minimise impacts on local hydrological processes of the Burn of Muchalls and Limpet Burn. However, the construction of abutments on the banks has the potential to increase flood risk for these watercourses.

4.4.3 Based on the gradient of the road, import and export of runoff from parts of other catchments may occur on a small scale. This transfer of water from one catchment to another could have significant impacts for small catchments over long periods of time.

4.4.4 Potential impacts of Moderate significance are predicted for Green Burn due to the medium sensitivity of the burn. Potential impacts on all remaining watercourses are considered to be of Slight or lesser significance.

4.4.5 Limpet Burn would lose approximately 6% of its catchment area at the point of the crossing and would normally be considered a low magnitude of potential impact based on the definitions of loss of catchment area in paragraph 4.1.5. This magnitude has been reduced to negligible due to the relatively high proportion of groundwater at this site and because the catchment losses reduce to 4% at the sensitive site of Limpet Burn Fishing Ponds further downstream.

4.4.6 During operation, potential impacts of Substantial significance are anticipated for Fishermyre wetland. Fishermyre wetland has been identified as a hydrologically sensitive site as it is a small catchment with a large area of wetland. The area contains important wetland habitats and supports a population of water voles. The blockage of surface water runoff pathways to a small area of Fishermyre wetland has the potential to result in an impact of Substantial significance. Surface water runoff from the majority of the wetland would not be able to flow to approximately 6% of the wetland due to blockage of surface water runoff pathways by the proposed AWPR. This has the potential to cause a drying out of the severed section of the wetland, which would subsequently affect the ecology of this area. Groundwater is also an important source of water for this wetland area and is considered in Chapter 38.

4.4.7 Due to their connectivity, Green Burn and Burn of Blackbutts have the potential to affect the Burn of Muchalls. Possible catchment impacts include increased or decreased catchment area draining to the Burn of Muchalls as a result of the road scheme. The Tributary of Elsick Burn is also fed by a number of watercourses, which would be affected by the road scheme. Watercourses including Stoneyhill Ditch, Balnagubs Burn, Whiteside Burn and Crossley Burn are all tributaries of the Tributary of Elsick Burn.

4.4.8 The catchment impacts resulting from changes to the drainage of these watercourses are unlikely to significantly affect either the Burn of Muchalls or the Tributary of Elsick Burn due to the number of tributaries with confluences along their length.

Construction Impacts

4.4.9 Although short term, construction impacts have the potential to lead to significant long-term consequences on the watercourses affected.

4.4.10 During construction, potential impacts of Moderate/Substantial significance are anticipated for:

- Limpet Burn, and
- Fishermyre wetland.

4.4.11 Construction impacts on Limpet Burn have been classified as being of Moderate/Substantial significance due to its connectivity and role in the water balance to the fishery ponds further downstream. Any alteration in the hydrology of Limpet Burn could have associated impacts upon the water quality, geomorphology and ecology of the ponds further downstream.

4.4.12 Construction impacts to Fishermyre wetland area have been classified as Moderate/Substantial significance. This is a consequence of the inherent problems of working within wetland areas as the connectivity of surface water pathways to all areas of the wetland is important. Any alteration in the hydrology of Fishermyre wetland could have associated impacts on the water quality, geomorphology and ecology of the area.

4.4.13 Potential construction impacts of Moderate significance are predicted for:

- Green Burn, and
- Burn of Muchalls.

4.4.14 Potential impacts on all remaining watercourses are considered to be of Slight or lesser significance.

4.4.15 Catchment impacts due to the construction of the road network may affect the Burn of Muchalls and the Tributary of Elsick Burn. These catchment impacts are unlikely to significantly affect either the Burn of Muchalls or the Tributary of Elsick Burn due to number of tributaries with confluences along their length. Decreased or increased flow, for example, in one or two small watercourse is unlikely to be a major issue.

5 Mitigation

5.1 Generic Mitigation

5.1.1 Mitigation measures are based on current good practice for highway drainage design, including the DMRB and guidance provided in Sustainable Urban Drainage Systems: Design Manual for Scotland and Northern Ireland CIRIA C521 (Construction Industry Research and Information Association (CIRIA), 2000), Control of Water Pollution from Linear Construction Projects, Report No C648 (CIRIA 2006), Control of Water Pollution from Linear Construction Projects Site Guide Report No C649 (CIRIA, 2006) and the SUDS Manual Report No. C967 (CIRIA, 2007). It is presumed that legal regulations and guidance as outlined in the Water Environment and Water Services (Scotland) Act 2003 and supported by the Controlled Activities Regulations (Scotland) 2005, and SPP7 are followed. These require that development is designed such that it does not materially increase pre-development flood risk.

5.1.2 Most impacts on the surface water hydrology of the scheme and side roads would result from the presence of culverts, bridges, watercourse realignments, pre-earthworks and road drainage outfalls. These will be designed to current industry standards and legislation and where possible will be constructed in manner most suited to the watercourse characteristics at that point (see Fluvial Geomorphology A39.2). Other guidelines are set out in more detail below.

Operation Mitigation

5.1.3 The following mitigation measures are provided to address potential operational impacts on surface water hydrology.

Crossing Structures

5.1.4 The culverts and buried structures that would be constructed on watercourses will be designed to appropriate return period flows. SEPA requires that culverts are designed to the 0.5% AEP (200-year return period event). SPP7 states that this return period already includes an allowance for climate change consequently all culverts have been designed to this standard. Culvert design further includes a freeboard allowance of 300mm over the 0.5% AEP.

5.1.5 All culverts on existing watercourses will be box depressed invert culverts, which will allow the provision of substrate on the culvert bed. The design of the culverts is in accordance with guidance from the Scottish Executive on culverts and migratory fish (SEERAD 2000).

5.1.6 Crossing structures have been designed so that current flood flow capacity will not be reduced. Culverts and buried structures installed as part of the scheme will not be smaller than existing structures on the watercourse (unless obviously over-designed).

5.1.7 Where there is potential for significant risk of culvert blockage due to surrounding land use, a suitably designed culvert trash screen could also be considered to reduce the risk of blockage. Guidance is provided in the Culvert Design Guide Report No. C168 (CIRIA 1997) and the Design and operation of trash screens, Interim Guidance Notes, (NRA, 1993). Network Culverts will be designed to the 1.33% AEP (1 in 75-year flood event) as these are part of the drainage network (DMRB HA 106/04). A one dimensional model of all proposed culverts has been constructed to test the flow capacity of the crossings. The results indicate that the culverts are suitably designed and pass the 200-years flow with spare capacity.

5.1.8 A regular maintenance regime will be implemented in order manage debris in and around the crossing structures. This work will include the removal of debris and dead vegetation from the channel and the banks upstream of the structure.

5.1.9 The abutments of buried structure proposed for the Burn of Muchalls will be set back 8m from the bank top of the watercourse. This will limit floodplain constriction during operation to ensue that the structure will not affect the hydrological function of the watercourse. Aberdeenshire Council have advised that the predicted flood risk is likely to be overestimated by the SEPA indicative flood risk maps in this particular location. The design of the bridge will not affect the conveyance and flood storage of the 0.5% AEP flow.

5.1.10 The abutments of the buried structure proposed for Limpet Burn will be set back a minimum of 5.5m from the realigned channel. The design of the crossing has been slightly constrained at this location due to the steepness and width of the gorge and the size of the floodplain upstream of the structure. This would result in a slight reduction in floodplain capacity throughout the buried structure and a change in conveyance upstream of the structure. However, due to the watercourse having relatively large floodplains confined by large embankments and that the nearest local properties and agricultural lands are located on a higher elevation there is minimal flood risk. The road crossing over Limpet Burn would therefore result in Negligible impact significance.

Realignments

5.1.11 The realignment of watercourses will maintain existing channel dimensions (width and depth) and, where possible, the overall length and gradient. Any existing flood storage areas within the realigned area will also be replaced to maintain the capacity of the watercourse, prevent flood risk and sustain connectivity to downstream areas.

Road Drainage

5.1.12 Road drainage and pre-earthworks will not enhance flood event runoff into watercourses compared to the pre-development situation and will allow for storage and attenuation before outfalling into the receiving watercourse.

5.1.13 Road drainage and pre-earthworks have been designed to minimise the transfer of water across catchments. Outfalls would be located at intervals along the route in order to avoid the transfer of surface water from one catchment to another. The drainage system has been designed to avoid flooding of water on lands on the upstream side of newly created road embankments.

5.1.14 The proposed road drainage scheme consists of three stages that ensure flood flows up to the 0.5% AEP (200-year event) are accounted for in the road drainage scheme (based on SPP7, which uses the 0.5% AEP as a guide to account for climate change). The components of the road drainage scheme are shown below:

- Filter drains: road runoff would drain into filter drains at the road edge, then into detention basins before outfalling to the receiving watercourse. The filter drains will be designed to accommodate the 50% AEP (2-year flow).
- Pre-earthwork ditches: flow above the 10% AEP threshold will be taken into pre-earthwork ditches, which have been designed to the 1.33% AEP as specified in the DMRB (reference HA106/04). This includes all network culverts required to pass drainage from one side of the AWPR to the other.
- Detention basins: designed to attenuate the 1% AEP (100-year return period event) to the pre-development Q_{MED} flow. In order to account for climate change, the basins are designed to include a freeboard allowance of 0.5% AEP (200-year event) to be stored, prior to release. The road drainage system has been designed to ensure where possible flows between the 1.33% AEP and the 0.5% AEP will flow to the detention basins prior to out falling to the receiving watercourse.

Construction Mitigation

5.1.15 Mitigation measures to be implemented during construction of the scheme include:

- guidance detailed in CIRIA reports C648 and C697 where appropriate;
- minimising the duration of construction;
- method statement detailing measures to control erosion and sediment control will be provided to SEPA prior to the commencement of works;
- areas of vegetation removal and excavation will be minimised to reduce the potential for sediment laden runoff reaching watercourses;
- work compounds will not be located on floodplain/flood storage areas;
- stockpiles will be located upslope of excavated areas;
- the siting of work compounds and stockpiles will avoid environmentally sensitive areas;
- excavation will not take place during periods of heavy rainfall;
- erosion and sediment control measures will be inspected on a regular basis and after rainfall events, for their effectiveness. Any defects found will be rectified immediately;
- the works will be conducted in a manner that will not block or reduce flow in or to local watercourses;
- construction equipment and activities will be selected to ensure minimal damage to the watercourse and the surrounding catchment.

Crossing Structures

5.1.16 The buried structure proposed for the Burn of Muchalls has been designed so that in-channel works are not required during construction. The flow regime of the watercourses will not be altered during the works to avoid increased flood risk or reduced downstream connectivity.

Temporary Realignments

5.1.17 During the installation of culverts, watercourse flows will be diverted around the works in a temporary channel. The diversion channel will be of similar size and gradient to the existing channel.

Road Drainage

5.1.18 During construction, temporary drainage systems will alleviate localised flood risk and prevent obstruction of surface runoff pathways. This will be achieved through the use of geotextile matting, ditches, or other methods detailed in the SUDS CIRIA manuals C648 and C697. A number of these temporary SUDS will be incorporated into the operational drainage network when the road is completed, but additional site specific SUDS may be required during construction and will be removed once construction is complete.

5.2 Site Specific Mitigation

5.2.1 In addition to these generic mitigation measures, site specific mitigation is specified for each watercourse for operation (refer to Table 8) and during construction (refer to Table 9). These site specific mitigation measures have been developed to address potential impacts of Slight to Substantial impact only.

Operation Mitigation

Table 8 – Mitigation Measures for Operation

Water Feature	Impact	Mitigation Measure
Megray Burn	Culvert blockage	Conduct regular maintenance, ensure culvert is clear of debris.
	Increased discharge to watercourse at outfall location	Provide road drainage (within design limits) to SUDS treatment with suitable outfall rate based on the Q_{MED}.
Limpet Burn	Buried structure	Conduct regular maintenance, ensure structure is clear of debris.
	Loss of catchment area	Although the loss of catchment would be minor, Limpet Burn is considered to be sensitive to hydrological alterations due to its connectivity with local groundwater resource. Monitoring of the wetland areas on Limpet Burn and of the fishing ponds downstream would provide an indication of any potential effects of reduced flows.
Green Burn	Culvert blockage	Conduct regular maintenance, ensure structure is clear of debris.
	Realignment	Retain flow capacity, gradient and channel roughness in realignment design, planting of embankments.
	Increased discharge to watercourse at outfall location	Provide road drainage (within design limits) to SUDS treatment with suitable outfall rate based on the Q_{MED}.
Fishermyre Wetland	Blockage of overland flow and sub-surface runoff pathways to the severed area of the moss	To ensure groundwater connectivity is maintained underneath the road, construction materials used along this section of the alignment will allow the lateral transfer of groundwater. For detailed information on this proposed mitigation refer to Geology, Contaminated Land and Groundwater Chapter 38. Monitoring of water levels prior to, during and post construction will provide an indication potential changes to the wetland area.

Water Feature	Impact	Mitigation Measure
	Construction of additional water vole habitat.	Construction of water vole habitat will consider hydrological implication to the wider catchment area during the development offset mitigation. Potential changes to water features will avoid the dewatering of the wetland area and should avoid increasing the capacity and/or the gradient of the channel beyond its existing dimensions at the fringe of the wetland area.
Burn of Muchalls	Buried structure	Conduct regular maintenance, ensure structure is clear of debris.
Tributary of the Elsick Burn	Increased discharge to watercourse at outfall location	Provide road drainage (within design limits) to SUDS treatment with suitable outfall rate based on the Q_{MED}.

* Receiving catchment is the main watercourse that is being drained to of the most sensitive catchment downstream of the point of interest.

Construction Mitigation

Table 9 – Mitigation Measures for Construction

Water Feature	Impact	Mitigation Measure
Megray Burn	Construction of culvert	Minimise duration and extent of construction. Avoid periods of high flow and extreme low flow. Temporary diversion channel to possess same capacity as that of existing channel.
	Construction of channel realignment	Maintain watercourse gradient. Ensure appropriate erosion and sediment control measures are in place during construction in order to prevent erosion of channel banks.
Limpet Burn	Construction of bridge	Minimise duration and extent of construction. Avoid periods of high flow and extreme low flow.
	Construction of channel realignment	Maintain watercourse gradient. Ensure appropriate erosion and sediment control measures are in place during construction in order to prevent erosion of channel banks.
	General construction impacts	Minimise duration of construction. Avoid periods of high flow and extreme low flow. Keep construction corridors to a minimum. Avoid stock piling of materials. Surface runoff pathways should be maintained at all times.
Green Burn	Construction of culvert	Minimise duration of construction. Avoid periods of high flow and extreme low flow. Maintain capacity of temporary channel to that of existing channel.
	Construction of channel realignment	Maintain watercourse gradient. Ensure appropriate erosion and sediment control measures are in place during construction in order to prevent erosion of channel banks.
	General construction impacts	Minimise duration of construction. Avoid periods of high flow and extreme low flow. Keep construction corridors to a minimum. Avoid stock piling of materials. Surface runoff pathways should be maintained at all times.
Fishermyre Wetland	General construction impacts	Minimise duration of construction. Avoid periods of high flow and extreme low flow. Keep construction corridors to a minimum. Avoid stock piling of materials. Surface runoff pathways should be maintained at all times. Avoid increased flow from the wetland area through increasing existing channel dimensions and gradients or through the addition of an unintentional channel during periods of high flow. Monitoring of surface water hydrology using water level recorders prior to, during and following the construction of the road to provide a clearer indication of the processes and sensitivity of the wetland area.
	Water vole relocation	In order to ensure that water voles are removed from potential construction areas, they will be re-located. Measures to prevent water voles from re-entering the

Water Feature	Impact	Mitigation Measure
		area during construction must consider potential hydrological impacts of changes to banks and channels.
Burn of Muchalls	Construction of bridge	Minimise duration of construction. Avoid periods of high flow and extreme low flow. Construction footprint should not impinge on flood flows or on the floodplain.
	General construction impacts	Minimise duration of construction. Avoid periods of high flow and extreme low flow. Keep construction corridors to a minimum. Avoid stock piling of materials. Surface runoff pathways should be maintained at all times.
Cookney Ditch	Construction of culvert	Minimise duration of construction. Avoid periods of high flow and extreme low flow. Maintain capacity of temporary channel to that of existing channel.
	Construction of channel realignment	Maintain watercourse gradient Ensure appropriate erosion and sediment control measures are in place during construction in order to prevent erosion of channel banks.
Stoneyhill Burn	Construction of culvert	Minimise duration of construction. Avoid periods of high flow and extreme low flow. Maintain capacity of temporary channel to that of existing channel.
	Construction of channel realignment	Maintain watercourse gradient. Ensure appropriate erosion and sediment control measures are in place during construction in order to prevent erosion of channel banks.
Balnagubs Burn	Construction of culvert	Minimise duration of construction. Avoid periods of high flow and extreme low flow. Maintain capacity of temporary channel to that of existing channel.
	Construction of channel realignment	Maintain watercourse gradient Ensure appropriate erosion and sediment control measures are in place during construction in order to prevent erosion of channel banks.
Tributary of the Elsick Burn	Construction of culvert	Minimise duration of construction. Avoid periods of high flow and extreme low flow. Maintain capacity of temporary channel to that of existing channel.
	Construction of channel realignment	Maintain watercourse gradient. Ensure appropriate erosion and sediment control measures are in place during construction in order to prevent erosion of channel banks.
Whiteside Burn	Construction of culvert	Minimise duration of construction. Avoid periods of high flow and extreme low flow. Maintain capacity of temporary channel to that of existing channel.
	Construction of channel realignment	Maintain watercourse gradient. Ensure appropriate erosion and sediment control measures are in place during construction in order to prevent erosion of channel banks.
Crossley Burn	Construction of culvert	Minimise duration of construction. Avoid periods of high flow and extreme low flow. Maintain capacity of temporary channel to that of existing channel.
	Construction of channel realignment	Maintain watercourse gradient. Ensure appropriate erosion and sediment control measures are in place during construction in order to prevent erosion of channel banks.
Cairns Burn	Construction of channel realignment	Maintain watercourse gradient. Ensure appropriate erosion and sediment control measures are in place during construction in order to prevent erosion of channel banks.
Craigentath Burn	Construction of culvert	Minimise duration of construction. Avoid periods of high flow and extreme low flow. Maintain capacity of temporary channel to that of existing channel.
	Construction of channel realignment	Maintain watercourse gradient. Ensure appropriate erosion and sediment control measures are in place during construction in order to prevent erosion of channel banks.

6 Residual Impacts

6.1 General

6.1.1 The long-term predicted residual impacts remaining once the mitigation described has been successfully implemented for operation are provided in Table 10. The residual impacts for construction are provided in Table 11.

6.2 Catchment Impacts

6.2.1 Catchment impacts for the Burn of Muchalls and the Burn of Elsick were discussed in Section 4 as these watercourses having confluences with other impacted watercourses. No impacts above a Slight significance are anticipated for either sub-catchment.

6.2.2 Potential catchments impacts may affect Crynoch Burn, which is reported in Appendix A24.1 (Surface Water Hydrology).

6.3 Scheme Summary

6.3.1 Following the successful implementation of mitigation, the residual impact on Fishermyre wetland would be of Slight/Negligible significance for both the operational and construction phases. Impacts on surface water pathways and water supply are not considered as significant as the supply of sub-surface flow. Groundwater (refer to Chapter 38) will be taken into consideration in the road design and the mitigation measures presented in Tables 8 and 9 will be implemented. Although the dissected wetland area would be disconnected from surface water pathways, it would continue to receive groundwater and local rainfall. Groundwater process should be maintained by suitable permeable construction materials and bunds. The severed area is also small and at the fringe of the wetland area (Figure 39.2c) which is presently bordered by an existing minor road and agricultural land and is not considered as sensitive to operation of the AWPR as the central area of the wetland (see Figure 39.c).

6.3.2 With the effective implementation of appropriate mitigation and the application of best construction practice on-site, the residual impacts of the proposed scheme on the remaining watercourses are predicted to be of Slight, Slight/Negligible or Negligible significance.

Table 10 – Residual Impacts During Operation

Water Feature	Sensitivity	Potential Impact Description	Mitigation	Residual Impact	
				Magnitude	Significance
Megray Burn	Low	Culvert (ch0) has the potential to cause localised constriction of flow and flood risk. The culvert is 92m in length, 1.2m high and 2.4m wide.	Scheme design incorporates culvert sizing for 1:200-year return period events.	Negligible	Negligible
		Potential risk of culvert blockage has been based on a desktop assessment of the site using OS maps. The catchment land use upstream of the culvert is comprised of limited forest further upstream. Therefore risk of culvert blockage has been assessed as medium. Due to the elevation of near by property flood risk has been assessed as low.	Conduct regular maintenance on the culvert. Ensure culvert is clear of debris. Remove dead vegetation from banks upstream of the culvert.	Negligible	Negligible
		Realignment has the potential to cause a slight increase in channel gradient. Any decrease in bank height may increase localised flood risk.	See Operation Mitigation Table 8 Avoid sharp bends. Retain capacity and gradient. Naturalise (e.g. sediment, plants).	Negligible	Negligible
		Discharge of road drainage has the potential to increase flows. The catchment area of the outfall includes the existing catchment, the road (0.04 km^2 of hard standing) and would take additional runoff from the Limpet Burn (approximately 0.1km^2) catchment due to the position of the AWPR and the drainage scheme. Megray Burn catchment size would therefore increase by approximately 13%.	See Operation Mitigation Table Table 8 for operational mitigation. SUDS design of drainage system. Detention basin, filter drain and treatment ponds.	Negligible	Negligible
Limpet Burn	High	Buried bridge structures have the potential to cause a localised constriction of flow due to bridge supports and increase flood risk.	See Operation Mitigation Table 8	Negligible	Slight/ Negligible
		Potential risk of the buried bridge structure blockage has been based on a desktop assessment of the site using OS maps. The catchment land use upstream of the culvert is comprised of bracken, heather, rough grass and forestry in the upstream area of the catchment. The risk of culvert blockage has been assessed as low. At the point of interest, there is no flood risk as properties and agricultural land are at a significant distance and height from the proposed crossing point of the AWPR.	Buried bridge structure is set back from the channel banks to allow flow out of bank. Conduct regular maintenance on the buried bridge structure. Ensure structure is clear of debris. Remove dead vegetation from banks upstream of the structure.	Negligible	Slight/ Negligible
		Approximately 6% of the catchment area at the culvert location would be lost to Megray Burn and Green Burn due to pre-earthwork drainage. This would result in a 4% reduction in the catchment area at the location of the Limpet Burn Fishing Ponds.	See Table 8. Maintain groundwater connectivity.	Negligible	Slight/ Negligible
		Realignment has the potential to cause a slight increase in channel gradient. Any decrease in bank height may increase localised flood risk.	See Table 8. Avoid sharp bends. Retain capacity and gradient. Naturalise (e.g. sediment, plants).	Negligible	Slight/ Negligible

Water Feature	Sensitivity	Potential Impact Description	Mitigation	Residual Impact	
				Magnitude	Significance
Network Culvert: Fishermyre	N/A	Culvert (ch2540) has the potential to cause localised constriction of flow and flood risk. The culvert is 78m in length and 0.9m in diameter.	Scheme design incorporates culvert sizing for 1:75-year return period events.	Negligible	N/A
		Potential risk of culvert blockage has been based on a desktop assessment of the site using OS maps. The catchment land use upstream of the culvert is comprised of bracken, heather and/or rough grass. The risk of culvert blockage has been assessed as low. At the point of interest flood risk has been assessed as low due to the elevation of nearby properties. However, it should be recognised that these drainage culverts are designed to the 1.33% AEP (1:75 yr design flood) as detailed in the DMRB HA 106/04.	Conduct regular maintenance on the culvert. Ensure culvert is clear of debris. Remove dead vegetation from banks upstream of the culvert.	Negligible	N/A
Coneyhatch Burn	Low	The area of the catchment upstream of the road would be taken into pre-earthworks drainage. Approximately less than 1% of the total Limpet Burn catchment would be lost causing a slight reduction in flows. This catchment area would drain to the Burn of Muchalls road outfall.	SUDS design of drainage system.	Negligible	Negligible
Green Burn	Medium	Culvert (ch3125) on the main AWPR line: Potential to cause localised constriction of flow and flood risk. The culvert would be 84m in length, 1.5m high and 2.7m wide.	Scheme design incorporates culvert sizing for 1:200-year return period events.	Negligible	Negligible
		Potential risk of culvert blockage has been based on a desktop assessment of the site using OS maps. The catchment land use upstream of the culvert is comprised bracken, heather and/or rough grass. The risk of culvert blockage has been assessed as low. At the point of interest there is no flood risk.	Conduct regular maintenance on the culvert. Ensure culvert is clear of debris. Remove dead vegetation from banks upstream of the culvert.	Negligible	Negligible
		Culvert on the realignment of the existing side road has the potential to localised constriction of flow and flood risk. The culvert would be 19m in length, 1.5 m high and 2.7m wide.	Scheme design incorporates culvert sizing for 1:200-year return period events.	Negligible	Negligible
		Potential risk of culvert blockage has been based on a desktop assessment of the site using OS maps. The catchment land use upstream of the culvert is comprised of bracken, heather and/or rough grass. The risk of culvert blockage has been assessed as low. At the point of interest there is no flood risk.	Conduct regular maintenance on the culvert. Ensure culvert is clear of debris. Remove dead vegetation from banks upstream of the culvert.	Negligible	Negligible
		Realignment has the potential to cause a slight increase in channel gradient. Any decrease in bank height may increase localised flood risk.	See Table 8. Avoid sharp bends. Retain capacity and gradient. Naturalise (e.g. sediment, plants).	Negligible	Negligible
		Potential to cause an increase in flows. The catchment area of the outfall includes the existing catchment of the burn and the added catchment from the road (0.018 km^2 of hard standing) and would take additional flow from a severed area of the Limpet Burn catchment due to the position of the AWPR and the drainage scheme. This amounts to an approximate 0.2km^2 (approximately 22%) increase in the catchment draining to the point of the road outfall.	See Operation Mitigation Table 8. SUDS design of drainage system. Detention basin, filter drain and treatment ponds.	Negligible	Negligible

Water Feature	Sensitivity	Potential Impact Description	Mitigation	Residual Impact	
				Magnitude	Significance
Green Ditch	Low	The area of the catchment upstream of the road would be taken into pre-earthworks drainage. This catchment would still drain to Green Burn via the road drainage outfall.	SUDS design of drainage system.	Negligible	Negligible
Fishermyre Wetland	High	Surface water prevented from draining to all areas of the wetland due to the development of the AWPR and associated drainage system. Surface water runoff from the majority of the wetland would not be able to flow to approximately 6% of the wetland due to blockage of surface water runoff pathways (see Figure 39.2c) although water supplied by localised rainfall to this area would be maintained. There is potential for the dewatering of the wetland area and this is considered a high magnitude potential impact due to the sensitivity of wetland environments.	See Operation Mitigation Table 8 Maintain groundwater connectivity.	Negligible	Slight/ Negligible
		Habitat creation for additional water vole habitat has potential for detrimental effect on the surface water hydrology of the wetland area if not designed appropriately.	See Table 8. Design of offset ecological mitigation will ensure no impacts on hydrology.	Negligible	Slight/ Negligible
Allochie Burn	Low	The area of the catchment upstream of the road would be taken into pre-earthworks drainage. This catchment would still drain to Burn of Muchalls via the road drainage outfall.	SUDS design of drainage system.	Negligible	Negligible
Burn of Muchalls	Medium	Bridge: Potential to cause a localised constriction of flow due to bridge supports and increase flood risk.	See Operation Mitigation Table 8	Negligible	Negligible
		Discharge of road drainage has the potential to cause an increase in flows. There is likely to be a 0.4% increase in the catchment size at the point of the road crossing due to the position of the road and the direction of the road drainage. There would be approximately 0.065km^2 of hard standing draining to this outfall.	SUDS design of drainage system. Detention basin, filter drain and treatment ponds.	Negligible	Negligible
Red Moss of Netherley	High	N/A. The road passes downstream of Red Moss and therefore has no hydrological impact on the moss.	N/A	N/A	N/A
Burn of Blackbutts	Low	The area of the catchment upstream of the road would be taken into pre-earthworks drainage. The drainage direction would cause this to be added to the Burn of Muchalls further upstream at the AWPR outfall instead of the confluence	SUDS design of drainage system.	Negligible	Negligible
Cookney Ditch	Low	Culvert (ch6480) has the potential to cause a possible localised constriction of flow and flood risk. The culvert on the AWPR mainline is 42m in length, 1.5m high and 2.4m wide.	Scheme design incorporates culvert sizing for 1:200-year return period events.	Negligible	Negligible
		Potential risk of culvert blockage has been based on a desktop assessment of the site using OS maps. The catchment land use upstream of the culvert is comprised of predominantly pasture land.	Conduct regular maintenance on the culvert. Ensure culvert is clear of debris. Remove dead vegetation from banks upstream of the culvert.	Negligible	Negligible
		Realignment has the potential to cause a slight increase in channel gradient. Any decrease in bank height may increase localised flood risk.	See Table 8. Avoid sharp bends. Retain capacity and gradient. Naturalise (e.g. sediment, plants).	Negligible	Negligible

Water Feature	Sensitivity	Potential Impact Description	Mitigation	Residual Impact	
				Magnitude	Significance
		Culvert on an existing side road has the potential to cause a possible localised constriction of flow and flood risk. The culvert on the side road would be 53m in length, 1.5m high and 2.4m wide	Scheme design incorporates culvert sizing for 1:200-year return period events.	Negligible	Negligible
		Potential risk of culvert blockage has been based on a desktop assessment of the site using OS maps.	Conduct regular maintenance on the culvert. Ensure culvert is clear of debris. Remove dead vegetation from banks upstream of the culvert.	Negligible	Negligible
		Realignment has the potential to cause a slight increase in channel gradient. Any decrease in bank height may increase localised flood risk.	Follow generic mitigation as above.	Negligible	Negligible
Stoneyhill Burn	Low	Culvert (ch6930) has the potential to cause a possible localised constriction of flow and flood risk. The culvert would be 36m in length, 1.2m high and 2.4m wide.	Scheme design incorporates culvert sizing for 1:200-year return period events.	Negligible	Negligible
		Risk of culvert blockage on the main AWPR line: Potential risk of culvert blockage has been based on a desktop assessment of the site using OS maps.	Conduct regular maintenance on the culvert. Ensure culvert is clear of debris. Remove dead vegetation from banks upstream of the culvert.	Negligible	Negligible
		Realignment has the potential to cause a slight increase in channel gradient. Any decrease in bank height may increase localised flood risk.	See Table 8. Avoid sharp bends. Retain capacity and gradient. Naturalise (e.g. sediment, plants).	Negligible	Negligible
Balnagubs Burn	Low	Culvert (ch7550) has the potential to cause a possible localised constriction of flow and flood risk. The culvert would be 48m in length, 1.2m high and 2.4m wide.	Scheme design incorporates culvert sizing for 1:200-year return period events.	Negligible	Negligible
		Potential risk of culvert blockage has been based on a desktop assessment of the site using OS maps. At the point of interest there is no flood risk.	Conduct regular maintenance on the culvert. Ensure culvert is clear of debris. Remove dead vegetation from banks upstream of the culvert.	Negligible	Negligible
		Realignment has the potential to cause a slight increase in channel gradient. Any decrease in bank height may increase localised flood risk.	See Table 8. Avoid sharp bends. Retain capacity and gradient. Naturalise (e.g. sediment, plants).	Negligible	Negligible
Tributary of the Elsick Burn	Low	Culvert (ch7975) has the potential to cause localised constriction of flow and flood risk. The culvert would be 53m in length, 1.5m high and 2.7m wide.	Scheme design incorporates culvert sizing for 1:200-year return period events.	Negligible	Negligible
		Potential risk of culvert blockage has been based on a desktop assessment of the site using OS maps. The catchment land use upstream of the culvert comprises of pasture land and therefore is unlikely to cause culvert blockage. Risk of culvert blockage has therefore been assessed as negligible. Due to the elevation of nearby properties flood risk has been assessed as low.	Conduct regular maintenance on the culvert. Ensure culvert is clear of debris. Remove dead vegetation from banks upstream of the culvert.	Negligible	Negligible

Water Feature	Sensitivity	Potential Impact Description	Mitigation	Residual Impact	
				Magnitude	Significance
		Realignment has the potential to cause a slight increase in channel gradient. Any decrease in bank height may increase localised flood risk.	See Table 8. Avoid sharp bends. Retain capacity and gradient. Naturalise (e.g. sediment, plants).	Negligible	Negligible
		Outfall location for drainage detention basin has the potential to cause an increase in flows. There is likely to be an approximate 16% increase in the catchment size at the point of the outfall due to the position of the road and the direction of the road drainage. However, the increase in the total catchment area of the Burn of Elsick to the outfall of the North Sea is less than 1%. There would be approximately 0.057km^2 of hard standing draining to this outfall.	See Table 8. SUDS design of drainage system. Detention basin, filter drain and treatment ponds.	Negligible	Negligible
Whiteside Burn	Low	Culvert (ch8850) has the potential to cause localised constriction of flow and flood risk. The culvert would 62m in length, 1.2m high and 2.4m wide.	Scheme design incorporates culvert sizing for 1:200-year return period events.	Negligible	Negligible
		Risk of culvert blockage on the main AWPR line- risk of culvert blockage has been based on a desktop assessment of the site using OS maps. The catchment land use upstream of the culvert comprises of pasture land and therefore is unlikely to cause culvert blockage. Therefore risk of culvert blockage has been assessed as negligible. At the point of interest there is no flood risk.	Conduct regular maintenance on the culvert. Ensure culvert is clear of debris. Remove dead vegetation from banks upstream of the culvert.	Negligible	Negligible
		Realignment has the potential to cause a slight increase in channel gradient. Any decrease in bank height may increase localised flood risk.	See Table 8. Avoid sharp bends. Retain capacity and gradient. Naturalise (e.g. sediment, plants).	Negligible	Negligible
Crossley Burn	Low	Culvert (ch9170) has the potential to cause localised constriction of flow and flood risk. The culvert would be 87m in length, 1.2m high and 2.4m wide.	Scheme design incorporates culvert sizing for 1:200-year return period events.	Negligible	Negligible
		Potential risk of culvert blockage has been based on a desktop assessment of the site using OS maps. The catchment land use upstream of the culvert comprises of pasture land and therefore is unlikely to cause culvert blockage. Risk of culvert blockage has therefore been assessed as negligible. Due to the elevation of nearby properties flood risk has been assessed as low.	Conduct regular maintenance on the culvert. Ensure culvert is clear of debris. Remove dead vegetation from banks upstream of the culvert.	Negligible	Negligible
		Realignment has the potential to cause a slight increase in channel gradient. Any decrease in bank height may increase localised flood risk.	See Table 8. Avoid sharp bends. Retain capacity and gradient. Naturalise (e.g. sediment, plants).	Negligible	Negligible
Cairns Burn	Low	Realignment has the potential to cause a slight increase in channel gradient. Any decrease in bank height may increase localised flood risk.	See Table 8. Avoid sharp bends. Retain capacity and gradient. Naturalise (e.g. sediment, plants).	Negligible	Negligible
Circle Burn	Low	The area of the catchment upstream of the road would be taken into pre-earthworks drainage. The drainage direction would cause this to be added to the Burnhead Burn before discharging to the Crynoch Burn instead of discharging directly from the Stranog	SUDS design of drainage system.	Negligible	Negligible

Water Feature	Sensitivity	Potential Impact Description	Mitigation	Residual Impact	
				Magnitude	Significance
		Burn.			
Square Burn	Low	The area of the catchment upstream of the road would be taken into pre-earthworks drainage. The catchment would still outfall to the Greens of Crynoch Burn before discharging to the Crynoch Burn.	SUDS design of drainage system.	Negligible	Negligible
Wedderhill Burn	Low	The source of Wedderhill Burn would be lost through catchment severance. The area of the catchment upstream of the road would be taken into pre-earthworks drainage, this equates to approximately 20% of the total catchment. Less than 1% of the total Crynoch Burn catchment would be lost in the road construction. The drainage direction would cause this area of the catchment to discharge to Crynock Burn via Burnhead Burn instead of flowing through Wedderhill burn. The Burnhead Burn is impacted by both the Fastlink and Southern Leg. All assessments and impacts are reported in the Southern Leg Water Environment (Chapter 39) and Water Quality (Appendix A39.3).	SUDS design of drainage system.	Negligible	Negligible
Craigentath Burn	Low	Culvert (ch10630) has the potential to cause localised constriction of flow and flood risk. The culvert would be 67m in length, 1.5m high and 2.4m wide.	Scheme design incorporates culvert sizing for 1:200-year return period events.	Negligible	Negligible
		Potential risk of culvert blockage has been based on a desktop assessment of the site using OS maps. The catchment land use upstream of the culvert is comprised of sparse bracken, heather and or rough grazing. The risk of culvert blockage has been assessed as low. Due to the elevation of nearby properties flood risk has been assessed as low.	Conduct regular maintenance on the culvert. Ensure culvert is clear of debris. Remove dead vegetation from banks upstream of the culvert.	Negligible	Negligible
		Realignment has the potential to cause a slight increase in channel gradient. Any decrease in bank height may increase localised flood risk.	See Table 8. Avoid sharp bends. Retain capacity and gradient. Naturalise (e.g. sediment, plants).	Negligible	Negligible

Table 11 –Residual Impacts for Construction

Water Feature	Sensitivity	Potential Impact Description	Mitigation	Residual Impact	
				Magnitude	Significance
Megray Burn	Low	Construction of culverts at ch0	See Table 9 General construction mitigation measures	Negligible	Negligible
		Construction of stream realignment	See Table 9 General construction mitigation measures	Negligible	Negligible
		General construction impacts	General construction mitigation measures	Negligible	Negligible
Limpet Burn	High	Construction of buried bridge structure	See Table 9 General construction mitigation measures	Negligible	Slight/ Negligible
		Construction of stream realignment	See Table 9 General construction mitigation measures	Negligible	Slight/ Negligible
Coneyhatch Burn	Low	General construction impacts	General construction mitigation measures	Negligible	Negligible
Green Burn	Medium	Construction of culverts at ch3125 and side road.	See Table 9 General construction mitigation measures	Negligible	Negligible
		General construction impacts	See Table 9 General construction mitigation measures	Negligible	Negligible
		Construction of stream realignment	See Table 9 General construction mitigation measures	Negligible	Negligible
Green Ditch	Low	General construction impacts	General construction mitigation measures	Negligible	Negligible
Fishermyre wetland	High	General construction impacts.	See Table 9 General construction mitigation measures	Negligible	Slight/ Negligible
		Mitigation to prevention Water Voles from inhabiting the area in and around the channel during construction period (see A40.7). If water vole prevention measures are not carried out correctly there is the possibility that channel dimensions may be changed/channel obstruction may occur. If channel dimensions are changed/ channel obstruction occurs this has the potential to result in increased flood risk. Details of the	See Table 9 Measures to prevent water voles entering the area in and around the channel during construction should be designed with consideration to the hydrology of the channel. Water Vole prevention measures should further avoid any increase in channel gradients, changes to channel dimensions and should not cause channel blockage. Details of the proposed Water Vole habitat can be found in Appendix A10.7.	Negligible	Slight/ Negligible

Water Feature	Sensitivity	Potential Impact Description	Mitigation	Residual Impact	
				Magnitude	Significance
		proposed Water Vole habitat prevention scheme during construction can be found in Appendix A10.7.			
Allochie Burn	Low	General construction impacts	General construction mitigation measures	Negligible	Negligible
Burn of Muchalls	Medium	Construction of bridge	See Table 9 General construction mitigation measures	Negligible	Negligible
		General construction impacts	See Table 9 General construction mitigation measures	Negligible	Negligible
Red Moss	High	N/A. Road passes downstream of Red Moss and therefore construction has no hydrological impact on the Moss.	N/A	N/A	N/A
Burn of Blackbutts	Low	General construction impacts	General construction mitigation measures	Negligible	Negligible
Cookney Ditch	Low	Construction of culverts at ch6480 and side road.	See Table 9 General construction mitigation measures	Negligible	Negligible
		General construction impacts	General construction mitigation measures	Negligible	Negligible
		Construction of stream realignment	See Table 9 General construction mitigation measures	Negligible	Negligible
Stoneyhill Burn	Low	Construction of culvert at ch6930.	See Table 9 General construction mitigation measures	Negligible	Negligible
		General construction impacts	General construction mitigation measures	Negligible	Negligible
		Construction of stream realignment	See Table 9 General construction mitigation measures	Negligible	Negligible
Balnagubs Burn	Low	Construction of culvert at ch7550.	See Table 9 General construction mitigation measures	Negligible	Negligible
		General construction impacts	General construction mitigation measures	Negligible	Negligible
		Construction of stream realignment	See Table 9 General construction mitigation measures	Negligible	Negligible
Tributary of the Elsick	Low	Construction of culvert at ch7975.	See Table 9 General construction mitigation measures	Negligible	Negligible

Water Feature	Sensitivity	Potential Impact Description	Mitigation	Residual Impact	
				Magnitude	Significance
Burn		General construction impacts	General construction mitigation measures	Negligible	Negligible
		Construction of stream realignment	See Table 9 General construction mitigation measures	Negligible	Negligible
Whiteside Burn	Low	Construction of culvert at ch8850.	See Table 9 General construction mitigation measures	Negligible	Negligible
		Construction of stream realignment	See Table 9 General construction mitigation measures	Negligible	Negligible
Crossley Burn	Low	Construction of culvert at ch9170.	See Table 9 General construction mitigation measures	Negligible	Negligible
		Construction of stream realignment	See Table 9 General construction mitigation measures	Negligible	Negligible
Cairns Burn	Low	Construction of stream realignment	See Table 9 General construction mitigation measures	Negligible	Negligible
		General construction impacts	General construction mitigation measures	Negligible	Negligible
Circle Burn	Low	General construction impacts	General construction mitigation measures	Negligible	Negligible
Square Burn	Low	General construction impacts	General construction mitigation measures	Negligible	Negligible
Wedderhill Burn	Low	General construction impacts	General construction mitigation measures	Negligible	Negligible
Craigentath Burn	Low	Construction of culvert at ch10630.	See Table 9 General construction mitigation measures	Negligible	Negligible
		General construction impacts	General construction mitigation measures	Negligible	Negligible
		Construction of stream realignment	See Table 9 General construction mitigation measures	Negligible	Negligible

7 Summary

7.1.1 This technical appendix has focused on the degree to which the operation and construction of the Fastlink section of the AWPR would affect the surface water hydrology of the watercourses that would be crossed by the scheme.

7.1.2 The Fastlink section of the proposed scheme has the potential to affect 19 watercourses and Fishermyre wetland. All of the watercourses along the proposed route are relatively small. The baseline hydrological characteristics of the watercourses vary considerably, according to the size of the watercourse, the degree of anthropogenic modification, the role in water balance downstream, habitats within the watercourse and flood risk.

7.1.3 During operation, residual impacts to surface water hydrology include: increased localised flood risk around culverts, bridges and realigned sections; increases or decreases to catchment supplies; and a change/blockage in surface water runoff pathways. During construction, similar temporary impacts have been identified, which may produce more pronounced effects over a shorter period of time.

7.1.4 Changes to catchment areas could be pronounced if there is an addition or reduction in the supply of water from several watercourses supplying the same catchment. In this instance it is necessary to consider impacts upon sub catchments, made up from a number of impacted watercourses. Within the Fastlink study area of the proposed scheme this is thought to be relevant for the Burn of Muchalls and the Burn of Elsick. However, with the effective implementation and maintenance of mitigation measures, the impact of the proposed scheme on each watercourse will be limited and any impacts upon these sub-catchments will have a negligible impact.

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9 Glossary

AEP	Annual exceedence probability
AREA	Catchment Drainage Area (km^2)
AWPR	Aberdeen Western Peripheral Road
Baseflow	is the continual contribution of groundwater to rivers and is an important source of flow between rainstorms.
BFIHOST	Base Flow Index derived using the HOST classification.
FARL	Index of Flood Attenuation due to Reservoirs and Lakes
FDC	Flow Duration Curve – A cumulative frequency curve that shows the percentage of time that specified discharges are equalled or exceeded.
FEH	Flood Estimation Handbook (see references (IH, 1999))
FFC	Flood Frequency Curve – A graph showing the recurrence intervals (return periods) that floods of magnitude are equalled or exceeded
HOST	Hydrology of Soil Types Classification
LF2000	Low Flows 2000
OS	Ordnance Survey
Q_{BAR}	Mean Annual Flood (m^3/s)
Q_{BF}	Bankfull Flow: the bank is defined at the point where vegetation/soil cover obviously changes between water and air
Q_{EBF}	Embankment-full Flow: the embankment (top of) is defined as the point where water would spill into wider areas (fields/road)
q green	Greenfield runoff rate (l/s/ha)
Q_{mean}	Mean Flow (m^3/s)
Q_{MED}	Median Annual Flood Flow (m^3/s) (flow with a 2-year return period)
Q_{95}	Flow that is expected to be exceeded 95% of the time (m^3/s)
Q-Tyr (eg Q-5yr)	Flow associated with a T-year return period (e.g. 5-year flow)
SAAR	1961-90 standard-period average annual rainfall (mm)
SAC	Special Area of Conservation
SPRHOST	Standard Percentage Runoff (%) derived using HOST classification
SSSI	Site of Special Scientific Interest

SUDS	Sustainable Urban Drainage Systems
URBEXT1990	FEH index of fractional urban extent for 1990.
V	Velocity (m/s)