16 Road Drainage and the Water Environment

16.1 Scope of the Assessment

Introduction

16.1.1 Uncontrolled runoff from roads can cause serious degradation of ecological and hydrological status of the receiving water environment, i.e. water quality deterioration and loss of wildlife habitat. Similarly, engineering activities, such as watercourse diversions and crossings can have an adverse impact on the water environment if appropriate mitigation measures are not employed.

16.1.2 This Chapter discusses the potential impacts of the Proposed Scheme on the water environment. It explains the methods used to assess the magnitude and significance of those impacts and identifies measures to reduce or avoid harm during construction and operation.

16.1.3 In relation to the water environment, potentially significant impacts considered in this part of the assessment include:

- Construction related pollution
- Pollution due to operational runoff
- Increased flood risk
- Changes in fluvial morphology
- Changes in groundwater quality, flows and levels
- Pollution due to contaminated soils reuse

16.1.4 Relevant information from the following chapters has been taken into account in this section:

- Chapter 10 Nature Conservation, provides information on ecological surveys carried out within the study area, including water features such as watercourses and wetland areas.
- Chapter 11 Geology and Soils, provides information on potential land contamination within the study area (including disused mineworkings) and recommends measures to protect the water environment against pollution during earthworks operations.

Study Area

16.1.5 The study area generally comprises a 1.7km wide corridor on the route of the Proposed Scheme and also includes areas at both ends of the Scheme that could potentially be affected. The whole of the study area is located within the catchment of the River Garnock.

Guidance Documents

16.1.6 Pollution prevention and flood mitigation measures pertinent to surface water and groundwater have been developed in accordance with the following guidance documents:

- DMRB, 2006, Volume 4: Geotechnics and Drainage, Section 2: Drainage, Part 1, HA103/06: Vegetated Drainage Systems for Highway Runoff, and Part 3, HD33/06: Surface and Sub-surface Drainage systems for Highways.
- Scottish Planning Policy, Flooding and Drainage, 2010.
- Planning Advice Note 61: Planning and SUDS.
- The SUDS Manual, CIRIA C697, 2007.
- SUDS for Roads, WSP, undated.
- Regulatory Method (WAT-RM-08), Sustainable Urban Drainage Systems (SUDS or SUD Systems) v4, 2012.
- Supporting Guidance (WAT-SG-53) Environmental Standards for Discharges to Surface Waters v4, 2013.
- Position Statement (WAT-PS-10-01), Assigning Groundwater Assessment Criteria for Pollutant Inputs' v2.1, June 2011.
- An Applicants Guide to Water Supply Boreholes, v1, May 2010.

16.1.7 Watercourse diversions and culverts have been designed taking into account the following guidance documents where applicable:

- Manual of River Restoration Techniques, RRC, 2002 River Diversions A Design Guide, HR Wallingford, 2001.
- WAT-RM-02 Regulation of Licence-level Engineering Activities v4.0, 2011.
- DMRB, 2004, Volume 4: Geotechnics and Drainage, Section 2: Drainage, Part 7, HA107/04: Design of Outfall and Culvert Details.
- Culvert Design and Operation Guide, C689, 2010.
- Engineering in the Water Environment: Good Practice Guide, River Crossings Second Edition (WAT-SG-25), SEPA 2010.
- River Crossings and Migratory Fish, Design Guidance, Scottish Executive.

16.2 Legislative, Regulatory and Planning Context

Legislation & Standards

16.2.1 The European Water Framework Directive (WFD) (2000/60/EC) and Groundwater Directive (80/68/EEC) through the Water Environment and Water Services (Scotland) Act 2003 (WEWS) provide regulatory controls over a wide range of activities in order to protect and improve Scotland's water environment. The main objective is to ensure that 'good status' of surface and groundwaters is achieved and that deterioration in the status of these water bodies is prevented.

16.2.2 The WFD aims to classify surface waters depending on their ecological status and sets a target that all natural water bodies achieve at least 'good ecological status' by 2015. Under the WFD the status of surface water bodies is assessed using a range of parameters, including physical, chemical, ecological, hydrological and morphological to present a comprehensive appraisal of a given aquatic ecological health.

16.2.3 Responding to WFD recommendations, the Scottish Government published 'The River Basin Management Plan for the Scotland River Basin District 2009-2015' in December

2009 highlighting the current status of existing surface water and groundwater bodies in Scotland. It also sets out an action plan to improve polluted waterbodies and to protect those presently in good condition.

16.2.4 Additionally, in November 2009 SEPA updated their 'Groundwater Protection Policy for Scotland, v3' which sets out to:

- protect groundwater quality by minimising the risks posed by point and diffuse sources of pollution; and
- maintain the groundwater resource by authorising abstraction and by influencing development, which could affect groundwater quantity.

16.2.5 The WFD classifies natural surface waterbodies as shown in Table 16.1 below.

Table 16.1 WFD Natural Surface Water Bodies General Ecological Status Classification

Ecological status	Description
High	Little or no alteration to the physico-chemical and morphological characteristics of a water body. Little or no evidence of biological distortion.
Good	Low level of biological distortion resulting from human activity. Slight deviation from biological characteristics associated with type of water body.
Moderate	Moderate signs of distortion resulting from human activity. Significantly more disturbed than under conditions of 'good status'.
Bad/Poor	Major alterations to the biological quality resulting in substantial deviation of biological communities from those associated with type of water body.

16.2.6 Environmental Quality Standards (EQS), published by SEPA, are benchmark criteria against which fresh and marine water quality can be assessed. These are principally ecological standards, specified for a range of parameters at levels required to protect aquatic life.

16.2.7 The relevant EQS for the protection of freshwater aquatic life, derived from SEPA Supporting Guidance (WAT-SG-53), is given in Table 16.2.

Table 16.2 EQS for UK Specific Zinc and Copper Concentrations in Freshwaters

Substance	Hardness [mg/l$CaCO_3$]	EQS [µg/l]
Copper (dissolved AA)	0-10 (Class 1)	1
	>10-50 (Class 2)	6
	>50-100 (Class 3)	10
	>100 (Class 4)	28
Zinc (total AA)	<10 (Class 1)	<= 8
	10-<50 (Class 2)	8
	50-<100 (Class 3)	50
	100-< 500 (Class 4)	75
	>=500 (Class 5)	125

16.2.8 The above EQS dissolved copper values supersede values given in the DMRB HD45/09 thus have been used in assessment of the long term impacts of the Proposed Scheme on surface waters. However, as the WAT-SG-53 does not prescribe dissolved zinc values for freshwaters the concentration proposed in the DMRB, 7.8 µg/l, has been used in the assessment.

16.2.9 The WFD classification for groundwater is 'good' or 'poor' considering the following determinants:

Quantitative status

- capacity of water resources to maintain healthy ecosystems and groundwater recharge against total abstractions, and

Chemical status

- groundwater quality is assessed in terms of its chemical composition (e.g. oxygen content, pH, nitrate ammonium) based on pollutant concentration and conductivity.

16.2.10 Groundwater 'vulnerability' methodology reflects the risk of general contaminants reaching the water table through the ground surface and depends on the permeability of the overlying soils in the subject area. This is divided into five categories, with Class 1 areas having the lowest risk of groundwater pollution and Class 5 the highest.

Regulation

16.2.11 The Scottish Environment Protection Agency (SEPA) is responsible for protecting the water environment in Scotland. The water environment comprises all waters, either above or below ground as defined in the WEWS Act 2003. Regulatory control is achieved through the Water Environment (Controlled Activities) (Scotland) Regulations (CAR), 2011. SEPA's 'risk-based' approach is reflected in the varying levels of authorisation, from General Binding Rules for low risk activities to a Complex Licence for high risk activities.

Planning Context

16.2.12 North Ayrshire Council is responsible under Scottish Planning Policy and the Flood Risk Management (Scotland) Act 2009 to ascertain risk of flooding associated with local waterbodies and consider flooding prior to determining planning applications. Planning requirements in terms of flooding are set out in the Planning Policy PI 8 of the North Ayrshire Local Plan, September 2012.

16.3 Methods of Assessment

16.3.1 Potential impacts on the water environment have been assessed in accordance with the Design Manual for Roads and Bridges (DMRB) (2009), Volume 11: Environmental Assessment, Section 3: Environmental Assessment Techniques, HD45/09: Road Drainage and the Water Environment.

16.3.2 The approach used in the assessment applies the prescribed methods A, D, E, and F, as set out below. Method B, which comprises a detailed assessment of the effects of routine runoff on surface waters is only required when annual average concentrations of soluble pollutant exceed the EQS values. Similarly, a Method C groundwater assessment has not been undertaken because the drainage proposals do not include soakaways or infiltration systems.

Method A – Effects of Routine Runoff on Surface Waters (Simple Assessment)

16.3.3 Method A assessment is undertaken using Highways Agency Water Risk Assessment Tool (HAWRAT). The HAWRAT procedure adopts a tiered consequential approach for sediment-bound and soluble pollutants as follows:

- Step 1: the runoff quality (prior to treatment and discharge to a water body).
- Step 2: in-river impacts (after dilution and dispersion but prior to mitigation).
- Step 3: in-river impacts (with mitigation measures).

16.3.4 Toxicity is measured as the concentration of heavy metals, such as copper and zinc. The toxicity of zinc is dependent on water hardness, i.e. the harder the water the less toxic zinc. The water hardness does not affect toxicity of copper. The chronic impact of the sediment deposition is estimated based on low flow velocity in the receiving watercourse.

16.3.5 HAWRAT predicts road runoff pollutant loading at each step of the assessment and compares it against Runoff Specific Thresholds established by field research. The tool uses a 'pass' (no short term impact) and a 'fail' (unacceptable short term impact) scoring system in reporting results of the assessment.

16.3.6 To complete the assessment process the long term risks on receiving water ecology (using annual average concentrations) are also appraised. This is done by comparing the HAWRAT results against the published Environmental Quality Standards (EQS). Dissolved copper and dissolved zinc are used as indicator metals to represent the potential for contamination.

16.3.7 The main parameters used in the assessment are as follows: two-way Annual Average Daily Traffic (AADT), Average Annual Rainfall (AAR), 95%ile flow in a given watercourse, road area drained, water hardness and physical attributes of a given watercourse.

16.3.8 The highest two-way AADT figure for the Proposed Scheme is 11592 for the 2031 growth scenario. For the purpose of the assessment a range from 10000 to 50000 in HAWRAT has been used.

Method D – Pollution Impacts from Accidental Spillages

16.3.9 Assessment of accidental spillages of polluting substances from roads is also carried out using HAWRAT such that appropriate mitigation measures are required if the annual probability of the risk of a serious pollution incident exceeds 1%. The results of the assessment are reported as 'acceptable' or 'unacceptable' risk. The risk of an acute pollution incident due to accidental spillage or vehicle fire is considered proportionate to the risk of a Heavy Good Vehicle (HGV) road traffic collision. Thus the percentage of HGV on a given road is the main parameter used in assessment of the risk of serious pollution accidents. Other parameters considered include; type and length of road, AADT and emergency services response time. If the annual event probability of accidental spillage is less than or equal to 1% the risk is considered acceptable.

Method E - Hydrological Assessment of Design Floods and Method F - Hydraulic Assessment (Flood Risk)

16.3.10 These methods concentrate on assessing flood risk associated with the Proposed Scheme. Pre and post development flows in the watercourses within the study area are calculated and potential changes in water levels and increase in flood risk assessed. Appropriate mitigation measures are required if adverse changes to the water environment, including floodplains, are predicted.

16.3.11 Flood risk associated with the River Garnock catchment has been appraised through numerous studies commissioned by North Ayrshire Council. An initial study, undertaken in 2003 by Babtie Group, concentrated on the whole River Garnock catchment at a strategic level whereas the latest study, carried out in 2012 by Halcrow, considered the Upper Garnock area only.

16.3.12 The Halcrow iSIS 1D hydraulic model was obtained from NAC and used to assist with the flood risk assessment for the Proposed Scheme. The model has been enhanced in order to predict flood extents more precisely at a local scale. Twenty surveyed sections of the River Garnock, including structures immediately upstream and downstream of the proposed viaduct crossing, have been added to the model. A further eight sections of the Caaf Water were incorporated. Modelling was undertaken for a series of annual probability events utilising Halcrow's hydrology input.

16.3.13 Flood risk associated with Coalheughglen Burn has been assessed through a hydraulic modelling study using iSIS 1D modelling software. Simulations were carried out for a range of annual probability events based on rainfall-runoff hydrology input.

16.3.14 Other sources of flooding (i.e. minor watercourses/ditches, pluvial and groundwater) have been considered based on available historic records and hydrological desk studies.

Fluvial Morphology

16.3.15 Specific methods to assess a potential impact of a road scheme on the fluvial morphology are not provided within the DMRB guidance. It is recognised however that disruption to a geomorphological pattern within a watercourse may lead to degradation of its ecological status, which would be contrary to targets presented by the WFD. Potential impacts have therefore been considered and assessed in accordance with the following guidance documents:

- Review of Impact Assessment Tool and Post Project Monitoring Guideline, Report to SEPA, Haycocks Associates, 2005 (WAT-SG-30).
- The Fluvial Design Guide, Environment Agency, 2009.
- Environmental Standards for River Morphology (WAT-SG-30) v2.1, 2012.

16.3.16 Geomorphologic characteristics and baseline conditions have been assessed through a combination of desk studies (maps, aerial photography and topographical survey) and site walkovers.

Groundwater Considerations

16.3.17 A Method C groundwater assessment has not been undertaken because the drainage proposals do not include soakaways or infiltration systems. However, potential impacts associated with groundwater quality and flows in the study area have been assessed as per below headings.

Lowering of groundwater levels due to permanent 'involuntary' abstraction (dewatering sections of the proposed road in cutting)

16.3.18 A review of the Stage 3 site investigation data (groundwater levels) has been undertaken to identify any risks associated with potential upwelling groundwater along part of the proposed cutting to the south-west of Peesweep Mount, near Blair Road.

Changing groundwater pathways due to consolidated mineworkings

16.3.19 Historic mineworkings exist in the northern part of the proposed route. The mineworkings would be consolidated to facilitate construction of the bypass. Potential long term impacts on the groundwater environment associated with the grouting activities have been assessed.

Impact on groundwater levels due to the River Garnock viaduct piers

16.3.20 Long term impacts of the viaduct piers on groundwater environment have been appraised and potential risks identified.

Contamination of surface water bodies resulting from discharge of 'abstracted' groundwater

16.3.21 Impacts of groundwater on the receiving surface water environment have been assessed in terms of environmental quality standards based on groundwater quality testing results undertaken as part of the Stage 3 site investigation. In accordance with SEPA Policy, Drinking Water Standards have been used where EQS are not available.

Construction Phase

16.3.22 Potential impacts of the construction phase of the Proposed Scheme on the water environment have been considered in accordance with the following guidance documents:

- Temporary Construction Methods, Good Practice Guide, SEPA, 2009.
- Control of Water Pollution from Linear Construction Projects, Technical Guidance (C648), 2006.

16.3.23 Potential for erosion and increased sediment load during construction has been considered in line with the Design Manual for Roads and Bridges (DMRB) (2009), Volume 11: Environmental Assessment, Section 3: Environmental Assessment Techniques, HD45/09: Road Drainage and the Water Environment.

Baseline Identification

16.3.24 Baseline conditions have been identified through consultations with statutory consultees and supplemented by desk studies, comprising a review of published documents (i.e. Envirocheck Report) and data provided by SEPA and North Ayrshire Council. Visual inspections, including photographic records, of all water features within the study area were undertaken in summer and autumn 2012.

16.3.25 The collated data together with their sources are listed in Table 16.3 below.

Table 16.3 Sources of Information for Water Environment Related Matters

Data	Source of Information (date obtained)
Rainfall	Flood Estimation Handbook CD-ROM, Version 3.0 The Centre for Ecology and Hydrology, Wallingford
Groundwater abstractions	North Ayrshire Council (2012) Land owners/occupiers (2012)
Water quality	SEPA data for River Garnock and Caaf Water (2012) River Basin Management Plans (SEPA) Site Investigation data (2013)
Sewerage discharges	SEPA (2012) Envirocheck Report (2012) Land owners/occupiers (2012/2013)
Flood mapping	Upper Garnock Flood Mapping, Final Report, 2012 NAC (2012), supplemented by MFJV flood study Flood maps (SEPA website)
Conservation areas	NAC published data (2012)
Existing road/ land drainage records	NAC and Amey (limited data) (2012), supplemented by MFJV drainage investigation Land owners/occupiers (2013)
Public sewers records	Scottish Water (2012)

Consultations

16.3.26 Consultations undertaken in connection with the Assessment are summarised as follows:

North Ayrshire Council

16.3.27 Consultations carried out to ascertain any constraints and parameters to be applied to the environmental assessment. This included local development plans, environmentally sensitive areas, groundwater/surface water abstractions and hydrology related aspects such as flood risk and acceptable road drainage/SUDS design criteria. Information obtained from the Council is listed in Table 16.3.

16.3.28 The Council has confirmed that it has no objections to the Proposed Scheme on grounds of flooding.

SEPA

16.3.29 Consultations carried out in the context of the water environment to establish SEPA requirements in relation to activities affecting the water bodies (i.e. construction of crossings, watercourse diversions, drainage discharges). The information provided by SEPA is listed in Table 16.3.

16.3.30 Initial concerns raised by SEPA, at the early stage of the design, related to construction of the Proposed Scheme within the River Garnock floodplain and issues associated with the potential artesian groundwater on route of the Scheme.

16.3.31 SEPA concerns have been addressed through a consultation meeting following a completion of the Stage 3 site investigation and development of the design.

16.3.32 SEPA also raised queries regarding the diversion of the Coalheughglen Burn and potential impact of grouting of mineworkings on the groundwater regime.

16.3.33 No requests for specific environmental assessments have been made by SEPA at this stage.

Trunk Road Operating Contractor (Amey Infrastructure Services)

16.3.34 A field survey of existing road drainage apparatus was carried out by MFJV to supplement existing road drainage records.

Scottish Water

16.3.35 Records of public sewers in the areas of interest, as listed in Table 16.3, were obtained from Scottish Water through the 'Public Utilities' consultations.

Land Owners/Occupiers

16.3.36 Formal (via consultation letters) and informal (via meetings and telephone calls) consultations with the affected land owners/occupiers were undertaken in 2012 and 2013. The consultations related to private water supplies, foul water disposal systems and land drainage potentially affected by the Scheme. There is ongoing dialogue with the land owners/occupiers regarding Accommodation Works for the Scheme.

16.3.37 Based on anecdotal information the low lying part of Highfield area is prone to flooding which is thought to be caused by existing road and agricultural runoff discharging to the Coalheughglen Burn.

Impact Assessment Criteria

16.3.38 The significance of an impact on the surface and groundwater environment is derived from a product of the importance of the waterbody and the magnitude of the potential impact.

16.3.39 The criteria used to assess each parameter are shown in Tables 16.4 and 16.5 whereas Table 16.6 shows how the two parameters are combined to estimate the significance of the predicted impact (based on Tables in HD 45/09, Annex 4). Where the significance is shown as one of two alternatives, the selection is based on reasoned professional judgement.

Table 16.4 Estimation of Importance of Water Environment Attributes

Importance	Assessment Criteria
Very High	Attribute has a high quality and rarity on regional or national scale
High	Attribute has a high quality and rarity on local scale
Medium	Attribute has a medium quality and rarity on local scale
Low	Attribute has a low quality and rarity on local scale

Table 16.5 Estimation of Magnitude of an Impact on an Attribute

Magnitude	Assessment Criteria
Major Adverse	Loss of attribute and/or quality and integrity of the attribute
Moderate Adverse	Effect on integrity of attribute, or loss of part of attribute
Minor Adverse	Some measurable change in attributes quality or vulnerability
Negligible	Effect on attribute, but of insufficient magnitude to affect the use or integrity
Minor Beneficial	Some beneficial effect on attribute or a reduced risk of negative effect occurring
Moderate Beneficial	Moderate improvement of attribute quality
Major Beneficial	Major improvement of attribute quality

Table 16.6 Estimation of Significance of Potential Impacts

		Magnitude of Impact			
		Negligible	Minor	Moderate	Major
Importance of Attribute	Very High	Neutral	Moderate/Large	Large/Very large	Very Large
	High	Neutral	Slight/Moderate	Moderate/Large	Large/Very Large
	Medium	Neutral	Slight	Moderate	Large
	Low	Neutral	Neutral	Slight	Slight/Moderate

16.3.40 Significance of the predicted impacts in the context of fluvial morphology has been determined as a function of the sensitivity of a receiving watercourse and the magnitude of the impact. Watercourse sensitivity assessment criteria adopted are summarised in Table 16.7. The criteria adopted for the magnitude of the potential impacts associated with the Proposed Scheme are shown in Table 16.8. Table 16.9 shows how the two parameters are combined to estimate the significance of the predicted impact.

Table 16.7 Fluvial Morphology - Watercourse Sensitivity Assessment Criteria

Sensitivity	Assessment Criteria
High	*Sediment regime:* Watercourse inhabited by species sensitive to changes in sediment concentration and turbidity such as migratory salmon freshwater pearl mussels *Channel morphology*: Watercourse includes varied morphological features (i.e. pools and riffles, diverse river banks) *Fluvial processes:* Watercourse highly vulnerable to changes in fluvial processes as a result of alterations. Changes to baseline conditions with significant impact on hydrology likely.
Moderate	*Sediment regime:* Watercourse supporting limited species sensitive to changes in sediment concentration and turbidity *Channel morphology:* Watercourse includes limited morphological features (i.e. pools and riffles) and relatively uniform bank types *Fluvial processes:* Watercourse potentially vulnerable to changes in fluvial processes with limited impact on habitat
Low	*Sediment regime:* Watercourse not inhabited by species sensitive to changes in sediment concentration or turbidity *Channel morphology:* Watercourses previously modified (i.e. culverted), with uniform flow and stable, uniform banks showing no morphological diversity *Fluvial processes:* Watercourse shows no sign of natural fluvial processes thus unlikely to be affected by alterations

Table 16.8 Fluvial Morphology - Magnitude Assessment Criteria

Magnitude	Assessment Criteria
High	Major impact on river bed (due to changes in sediment characteristics - erosion/deposition), sensitive habitat (due to changes in sediment load and turbidity), morphological diversity (influencing ecological quality) and interruption to natural fluvial processes (i.e. erosion, channel evolution)
Moderate	Moderate impact on sediment regime, channel morphology and natural fluvial processes
Minor	Minimal impact on habitat (as a result of slight changes in sediment pattern), channel morphology and fluvial processes. Any changes are likely to be localised
Negligible	Negligible change from baseline conditions in terms of sediment transport, channel morphology and natural fluvial processes and any impacts are likely to be highly localised

Table 16.9 Fluvial Morphology - Significance of Potential Impacts

Magnitude / Sensitivity	High	Moderate	Minor	Negligible
High	Major	Major/ Moderate	Moderate	Neutral
Moderate	Major/ Moderate	Moderate	Slight	Neutral
Low	Moderate	Slight	Neutral	Neutral

16.4 Baseline Conditions

Site Description and Topography

16.4.1 The Proposed Scheme is located to the east of Dalry and focuses on the A737 trunk road which currently passes through the town centre of Dalry. The bypass route leaves the existing A737 at the Hillend area to the south of Dalry and runs through agricultural land, between the Blairland Estate and Stoopshill Farm, before it ties back in to the existing A737 approximately 1300m north east of the Highfield area.

16.4.2 The topography in the vicinity of the Proposed Scheme varies from approximately +32mAOD within the Hillend area to +80mAOD at the tie-in to the existing A737 north east of the Highfield area, with the general ground falling west towards the River Garnock valley.

Site Hydrology

16.4.3 The Proposed Scheme falls within catchment of the River Garnock. Various natural and artificial surface and groundwater features within the area of the proposed Bypass have been identified through desk studies and field survey.

16.4.4 The water features are shown on Figure 16.1 and a summary of the water features is presented on the Water Feature Survey Identification Form included in Appendix 16.1. The significant surface water and groundwater bodies within the study area are described below. Watercourse catchment boundaries are shown on Figure 16.2.

River Garnock (W6)

16.4.5 The River Garnock rises in moorlands to the north west of Kilbirnie at some +500mAOD. It then meanders in a southerly direction for approximately 30km before joining the Firth of Clyde at the estuary of the River Irvine. The catchment area at that point is 235km^2. Major tributaries of the River Garnock include Powgree Burn, Rye Water, Caaf Water, Bombo Burn, Dusk Water and Lugton Water.

16.4.6 The River Garnock passes through the towns of Kilbirnie and Dalry (upstream of the Proposed Scheme) and Kilwinning (some 4km downstream of the Proposed Scheme). The remaining part of the catchment is essentially rural with isolated development clusters and some forestry.

16.4.7 There are a number of water supply reservoirs in the River Garnock catchment. No major Sewage Treatment Works are present within the catchment as all wastewater is taken to the Firth of Clyde via the Garnock Valley Sewer (GVS). At least one emergency overflow (CSO) to the Garnock is located some 250m south east of Dalry. Additionally, based on old mining plans, there is a historic ‘Day Level’ discharging to the River Garnock at an unconfirmed rate of 2250-2750 l/min. The ‘Day Level’ is shown as OT1 and OT2 on Figure 16.1 and described in Appendix 16.1.

16.4.8 The River Garnock is a designated salmonid water under the Surface Water (Fishlife) (Classification) (Scotland) Direction 1999. Consequently all the natural tributaries of the River Garnock have been considered as salmonid waters for the purpose of this assessment.

Caaf Water (W2)

16.4.9 The Caaf Water is a tributary of the River Garnock with a catchment area of approximately 28km^2. The Caaf Water rises on Green Hill at +370mAOD and flows south east through the Knockendon and Caaf Reservoirs before joining the River Garnock some 700m to the south east of Dalry. The catchment of the Caaf Water is essentially rural.

Coalheughglen Burn (W17)

16.4.10 The Coalheughglen Burn is a minor tributary of the River Garnock with a catchment area of approximately 1.2km^2. It rises to the east of the Highfield area and flows west to its confluence with the River Garnock. The Coalheughglen Burn passes through the residential development at Highfield partially as an open channel and partially culverted. The channel immediately upstream and downstream of Highfield has been heavily modified with vertical concrete walls apparent during the site walkover. The Coalheughglen Burn is a receptor of a number of private foul water (septic tank) discharges and there are reports of flooding problems in the Highfield area.

Bombo Burn (W9)

16.4.11 The Bombo Burn is a tributary of the River Garnock with a catchment area of approximately 8km^2. The Bombo Burn flows in a south westerly direction, passing through Bankhead Moss and the Blair Estate before it joins the River Garnock. The Bombo Burn catchment is essentially rural with occasional residential settlements.

Springs and Issues

16.4.12 A number of Springs and Issues are present in the vicinity of the Proposed Scheme. It is believed that the Springs and Issues are fed by rising groundwater and discharge to watercourses either over surface or through ground.

Wetlands and Ponds (WF1-WF7)

16.4.13 An extensive marshland area exists to the north of Highfield (WF6) and smaller marshland areas are located immediately to the east and north of the Blairland Estate (WF1, WF2). A number of small ponds (WF3, WF4, WF5 and WF7) are also located in the northern and eastern part of the study area. It is believed, based on the available site investigation data that these water features are potentially groundwater fed.

Ditches and drains

16.4.14 The majority of the drainage ditches/drains in the area of interest have been introduced and modified over time to provide drainage for agricultural land and as such have little or no ecological value.

Fluvial Morphology

16.4.15 The following section describes the geomorphologic conditions of the affected watercourses (referenced as shown on Figure 16.1). Photographs are included in Appendix 16.2.

Caaf Water (W2)

16.4.16 The watercourse lies within grassed agricultural land and has a sinuous planform. It has a relatively shallow longitudinal gradient and steep side slopes with a channel width of approximately 7m. Active bed sediment movement is evident through erosion and sediment deposition as well as development of pools and channel meanders. Banks are vegetated, with sediment deposits present on the right bank. Cattle access to the channel has resulted in localised bank slippage. Based on the evidence of morphological diversity, the watercourse is considered to be of moderate sensitivity. No works to the Caaf Water other than construction of a road drainage/SuDS outfall are intended as part of the Proposed Scheme.

River Garnock (W6)

16.4.17 The River Garnock floodplain includes agricultural land along the elevated right bank and a low lying area of dense vegetation and marshlands along the left bank. Based on the evidence of morphological diversity, the watercourse is considered to be of moderate sensitivity albeit that the main channel would be bridged over and thus unaffected by the viaduct structure.

Unnamed tributary of River Garnock (W8)

16.4.18 The watercourse lies within agricultural land with direct cattle access and has a shallow channel approximately 2m wide. The watercourse follows field boundaries and is fed by ditches. It is culverted under a number of field tracks. The watercourse shows little evidence of active fluvial processes, but localised silt deposits and developing pools with riparian vegetation are evident. Due to the character and size of the catchment, the watercourse is considered to be of low sensitivity.

Unnamed tributary of River Garnock (W15)

16.4.19 The watercourse lies within agricultural land and has a shallow straight channel with steep longitudinal gradient. Bed and banks densely overgrow with shrubs and small tree clusters. The watercourse is fed by a land drain. The watercourse resembles a drainage ditch and is considered to be of low sensitivity.

Coalheughglen Burn (W17)

16.4.20 The upstream section of the Coalheughglen Burn above Highfield lies in an open ‘U-shaped’ valley surrounded by agricultural grassed land. The straight channel and uniform banks indicate that the watercourse has been modified for agricultural purposes. The bed and banks are very overgrown.

16.4.21 The mid section of the Coalheughglen Burn, from Highfield to a second crossing under A737, is heavily modified. The lowest section is located in a deep natural valley with dense vegetation and steep longitudinal gradient. This watercourse is of low sensitivity as a consequence of the extensive modifications.

Unnamed tributary of Coalheughglen Burn (W18)

16.4.22 The watercourse lies between A737 and agricultural land and acts as an interceptor ditch for the road and field drainage. The watercourse channel is straight with uniform banks and the bed and banks are overgrown. Clay/mud deposits and occasional stones are present on the bed. There is evidence of left bank alteration or slippage caused by accessing cattle. Due to the character of the watercourse, it is considered to be of low sensitivity to geomorphologic disturbance.

Existing Watercourse Crossings

16.4.23 A number of existing watercourse crossings are present in the vicinity of the Proposed Scheme. Where a crossing is directly or indirectly affected by the construction and future operation of the proposed road, the flow capacity has been estimated in connection with the flood risk assessment. In addition to a desk study and visual inspection of the crossings, a CCTV survey was undertaken as part of the wider site drainage investigation. This is further described within the Stage 3 Scheme Assessment Report (MFJV, 2013). The location of all existing crossings is shown on Figures 16.3a and 16.3b.

Rainfall Data

16.4.24 The rainfall data used in the drainage design have been derived from the Flood Estimation Handbook (FEH) CD-ROM v.3. Considering the extent of the River Garnock catchment in relation to the scale of the Proposed Scheme, rainfall data for the Coalheughglen Burn has been adopted in the drainage design. Accordingly, the Annual Average Rainfall for the study area is 1342mm.

Flood Risk

River Garnock and Caaf Water

16.4.25 The hydraulic modelling results show that an extensive area of the river corridor between Wilson's Car Auction and Dalry would be inundated during extreme flood events. The predicted flood water levels for a range of annual probability events at the location of the proposed viaduct crossing are summarised in Table 16.10. The flood extent envelope for the River Garnock and Caaf Water is appended to the 'A737 Dalry Bypass Flood Risk Assessment Report' included in Appendix 16.3.

Table 16.10 Summary of Predicted Flood Levels in River Garnock

Location	Flood Level [mAOD]				
	Return period [yrs]				
	1 in 10	1 in 50	1 in 100	1 in 200	1 in 200 +CC
River Garnock at viaduct crossing	21.22	22.34	22.71	23.13	23.47

Coalheughglen Burn

16.4.26 The hydraulic analysis concluded that the existing culvert under the unclassified road within the Highfield area does not have sufficient capacity to convey the predicted flows in extreme rainfall events. Anecdotal information about previous flooding at Highfield suggests that historic flooding problems have been caused by a combination of circumstances including localised runoff from the unclassified roads and surrounding land and the constriction of the natural channel. The flood extent envelope for the Coalheughglen Burn is appended to the A737 Dalry Bypass Flood Risk Assessment Report included in Appendix 16.3.

Other Potential Sources

16.4.27 No other significant flooding issues were identified in the study area. However, further information on all potential sources of flooding, including minor watercourses and ditches, pluvial (surface water runoff) and groundwater is presented in the 'A737 Dalry Bypass Flood Risk Assessment Report' included in Appendix 16.3.

Surface Water Flows

16.4.28 No gauged flow information is available for the watercourses in the area of the proposed Bypass. Calculations have therefore been carried out for all watercourses potentially affected by the Proposed Scheme.

16.4.29 Low flows have been calculated using IoH Report No 101 'Low Flow Estimation in Scotland'. Peak flows for the River Garnock and Caaf Water have been derived from the flood risk assessment and in the other watercourses in accordance with the IoH Report No 124 'Flood Estimation for Small Catchments'. A summary of the estimated flows is presented in Table 16.11.

Table 16.11 Estimated Flows in the Watercourses

Watercourse	Location	Low flow (Q_{95}) [l/s]	1 in 100yr (Flood flow) [m^3/s]	1 in 200yr (Flood flow) [m^3/s]	1 in 200yr +30%CC (Flood flow) [m^3/s]
River Garnock (W6)	Downstream of proposed viaduct crossing	553	233.79	295.06	383.50
Caaf Water (W2)	At confluence with River Garnock	104	39.61	45.32	58.92
Coalheughglen Burn (W17)	Immediately downstream of existing A737	2	3.36	3.87	5.04
Unnamed tributary of Coalheughglen Burn (W18)	At confluence with Coalheughglen Burn	1.3	1.27	1.54	2.00
Unnamed tributary of River Garnock (W8)	Upstream of railway culvert	2.0	1.58	1.91	2.48
Unnamed tributary of River Garnock (W15)	At confluence with River Garnock	1.1	1.22	1.47	1.91

Groundwater Levels

16.4.30 During the Stage 3 site investigation, groundwater was encountered in both the superficial deposits and underlying rock strata at various depths. The groundwater flow regime in the rock is largely controlled by historic mine workings. Historical excavations provide extensive lateral high-permeability conduits linked vertically in places by shafts between the mines. In a number of exploratory boreholes the confined groundwater was found to be under substantial artesian pressure.

16.4.31 For assessment purposes, the Proposed Scheme has been divided into three sections:

- the northern area where the route would mostly be on a low embankment, with a shallow cut north of the Highfield roundabout;
- the central area, adjacent to Peesweep Mount and the Blairland Housing Estate, where a significant cutting is proposed; and
- the southern area, where the road would be built on an embankment with viaduct across the River Garnock Valley.

16.4.32 Details of the hydrogeological conditions along the Proposed Scheme are provided in ‘Hydrogeological Review and Risk Assessment’ report (A737MFJV/D/05), MFJV, 2013 included in Appendix 16.4.

Northern area

16.4.33 Although water was found at various depths in rock, a laterally extensive and consistent water body could not be confirmed. Groundwater is assumed to be locally controlled by mine workings which are at shallow depths at this end of the proposed route. No artesian water pressures were encountered.

16.4.34 Groundwater monitoring indicates that discontinuous perched water deposits are present in the relatively low permeability drift deposits. Upwelling groundwater is not anticipated to be a major concern as the proposed route is on an embankment.

16.4.35 The groundwater at that location has been classed as of medium importance waterbody. It is not a principal aquifer, but it is likely that local surface water features are fed by it.

Central area

16.4.36 Groundwater was recorded in both the boulder clay and bedrock along the proposed cutting. Groundwater levels in the bedrock are artesian in the south western part of the cutting. The bedrock along the northern part of the cutting contains sub-artesian groundwater with the depth increasing in a northerly direction along the route. Groundwater levels in the boulder clay are typically at 1m depth below the existing ground level. Cross sections showing the material depths and water levels are included in Appendix 16.4.

16.4.37 The maximum depth of the proposed cutting is 11.5m and following excavation a layer of approximately 8-10m of boulder clay from the base of the cutting to the top of the bedrock would remain in place. Therefore groundwater from the bedrock would not be encountered during construction. However permanent seepages through the boulder clay are anticipated during the Scheme construction and operation.

16.4.38 The groundwater at that location has been classed as of medium importance waterbody. It is not a principal aquifer, but it is likely that local surface water features are fed by it.

Southern area

16.4.39 During the ground investigation artesian groundwater conditions up to 9m above existing ground level were encountered within the Upper Linn Limestone and underlying rock strata in the River Garnock Valley. Cross sections showing the groundwater levels and ground conditions can be seen in Appendix 16.4.

16.4.40 A total of six boreholes were drilled in this area during the Stage 3 site investigation with either one or two boreholes positioned at each pier or abutment. Water strikes during drilling indicate that the water movement is dominated by fissure flow as the response times were highly variable.

16.4.41 The artesian groundwater at that location is classed as having high importance due to providing local important resource (i.e. private water supply) and supporting river ecosystem.

16.4.42 Groundwater monitoring indicates that a shallow water table between 0m to 1m depth below existing ground level is present within the alluvium deposits in the River Garnock valley.

Surface Water Quality

16.4.43 Water quality data for the River Garnock and its major tributaries was obtained from SEPA in August 2012. Two sets of data have been provided as follows:

- water body classification in accordance with WFD for various sections of the River Garnock and its tributaries; and
- chemistry data for River Garnock at Kilwinning (covering period between January 2009 and November 2011) and Caaf Water at Lynn Bridge (covering period between January 2008 and November 2011).

16.4.44 The watercourse classification is shown in Table 16.12 below and a summary of the average annual concentrations of selected chemicals are presented in Table 16.13.

Table 16.12 Water Quality Classification

Watercourse (WFD ID)	Physico-chemical status	Biological elements	Ecology status	Overall Status
River Garnock (Powgree Burn to Rye Water) (10381)	High	Moderate	Bad	Bad
Rye Water (upstream tributary of R. Garnock) (10390)	no data	Poor	Poor	Good ecological potential
River Garnock (Rye Water to Caaf Water) (10380)	High	Moderate	Moderate	Moderate
Caaf Water (10389)	High	Moderate	Bad	Moderate ecological potential
River Garnock (Caaf Water to Tidal) (10379)	High	Moderate	Moderate	Moderate

Table 16.13 Chemical Components Summary

Watercourse Year	Average annual concentration			
	pH	Hardness [mg/l $CaCO_3$]	Copper [µg/l]	Zinc [µg/l]
River Garnock at Kilwinning				
2009	7.71	58.87	9.22	18.41
2010	7.70	59.63	2.69	6.15
2011	7.79	69.48	2.68	5.65
Caaf Water at Lynn Bridge				
2008	7.68	68.57	n/a	n/a
2009	7.69	52.85	n/a	n/a
2010	7.63	45.24	n/a	n/a
2011	7.67	48.69	n/a	n/a

16.4.45 The data shows that the recorded average annual concentrations of copper are within EQS albeit that the sampling point is several kilometres downstream of the study area. The EQS zinc concentration was exceeded during year 2009.

16.4.46 Comprehensive surface water sampling and testing was undertaken during the Stage 3 site investigation to ascertain water quality in the watercourses affected by the Proposed Scheme. The location of all sampling points is shown on Figures 16.4a and 16.4b.

16.4.47 The site investigation data is presented in Appendix 16.4. Surface water samples were taken from all identified surface waters. Zinc and copper levels, pH and hardness are summarised below in Table 16.14 as comparative parameters to the published data presented above. A complete set of water quality data is included in Appendix 16.5.

Table 16.14 Site Investigation Chemical Components Summary

Watercourse	pH	Hardness [mg/l $CaCO_3$]	Copper [µg/l]	Zinc [µg/l]
S1	7.6	130	0.97	< 1.3
S2	7.5	140	1.1	< 1.3
S3	7.4	140	1.3	4
S4	7.4	140	1.1	4.4
S6	7.8	26	<0.40	2.5
S7	7.5	100	0.78	< 1.3
S8	7.7	23	<0.40	< 1.3
S9	7.6	23	<0.40	< 1.4
S10	7.5	23	<0.40	< 1.3
S11	7.5	23	<0.40	1.3

16.4.48 Site investigation data is not wholly consistent with the published historical data, albeit for smaller watercourses and at a snapshot in time. The pH levels are very similar. Hardness levels are varied with an average of 76.8mg/l $CaCO_3$, which is of a similar order of magnitude. Copper and zinc levels have been recorded much lower than those historically recorded in the River Garnock and Caaf Water.

16.4.49 Baseline levels of copper and zinc have been recorded at levels below EQS. No other contaminants were recorded at levels in excess of EQS, with the exception of dissolved aluminium, total aluminium, total iron and total manganese. The results are summarised in Table 16.15.

Table 16.15 Site Investigation Elevated Contaminants in Surface Waters

Watercourse	Aluminium Dissolved [µg/l]	Aluminium Total [µg/l]	Iron Total [µg/l]	Manganese Total [µg/l]
S1		210	1000	70
S2		2200	6800	510
S3			460	
S4		3100	19000	520
S6	26		430	
S7		3100	5600	640
S8	27			
S9	23			
S10	28			
S11	29			

16.4.50 Where total metal levels are elevated above an EQS for dissolved phase in samples which contained acceptable levels of dissolved phase metal, this is indicative of aluminium, iron and manganese being present in particulate or precipitate form in the identified surface waters. Visual inspection of these surface waters has not revealed any evidence of precipitation of contaminants.

16.4.51 Where annual average filterable iron consistently exceeds 0.3 mg/l or if deposits occur, a survey of biological quality of a given watercourse is recommended (EQS Annex G). This recommendation does not apply to this environmental impact assessment; it is only given in the context of water quality in the existing watercourse.

Groundwater Quality and Vulnerability

16.4.52 The Proposed Scheme is located within an area of groundwater having ‘good status’ in accordance with the River Basin Management Plan. The most southern part of the Scheme, between the Blairland Farm and the new Hillend roundabout, lies within an area of ‘poor’ groundwater status.

16.4.53 A report entitled ‘Development of a groundwater vulnerability screening methodology for the Water Framework Directive’ prepared by SNIFFER in September 2004 concludes that Central Scotland has a greater proportion of lower vulnerability classes due to the prevalence of low and moderate permeability deposits.

16.4.54 As the proposed road drainage associated with the Proposed Scheme would be discharged to surface water bodies, contamination risk to the underlying aquifer would be negligible.

16.4.55 Three water samples were taken from artesian boreholes in the River Garnock Valley during the Stage 2 ground investigation. All samples were recorded well below both the EQS and Drinking Water Standards with the exception of isolated instances of low pH and elevated iron and manganese.

16.4.56 The Stage 3 site investigation included a comprehensive groundwater testing schedule. Naturally occurring aluminium, iron, manganese and sulphate were encountered at many of the investigated locations in excess of EQS and Drinking Water Standards. These contaminant levels are typical of the pyritic rock formations in these Coal Measures, exacerbated by flooding of former mineworkings. In addition there were several isolated very minor exceedances of petroleum hydrocarbon fractions, benzene and the polyaromatic hydrocarbon benzo(g,h,i)perylene.

16.4.57 The anthropogenic contaminants are anomalous and, based on the great depth at which some of them have been recorded, they are thought to be the result of minor contamination during site investigation. Re-sampling and re-testing have therefore been scheduled for confirmation. No results of the repeated testing have been available at the time of this assessment.

16.4.58 The organic contaminants recorded at slightly elevated levels are not thought to be a result of the historic contaminative land uses identified in Chapter 11. Due to the presence of low permeability soils at all locations where organic contaminants were recorded and the significant depth at which some were encountered, it is more likely to be a result of minor contamination during the drilling of the boreholes in question. If these contaminants were part of a wider surface sourced pollution plume, it is reasonable to assume that much higher contaminant levels would have been encountered during the intrusive investigations. This was not the case.

16.4.59 The superficial groundwater samples tested revealed contamination comprising manganese, aluminium and iron only. However these are all indicative of groundwater from pyritic coal measures and associated mudstones, where groundwater rebound after mine dewatering ceases, flushing sulphates and metals (iron, aluminium and manganese in this case) from pores, fissures and voids.

16.4.60 Groundwater quality data, at locations of exceedance, are presented in Table 16.16 and summarised in Appendix 16.5.

Table 16.16 Site Investigation Elevated Contaminants in Groundwater

Contaminant	Maximum [µg/l]	Mean [µg/l]	Locations
Aluminium, Dissolved	48	30	2BH009, 2BH015C, G1, 2BH002, M1
Manganese, Dissolved	32000	4084	2BH002, 2BH004, 2BH002, 2BH007, 2BH006, 2BH073, 2BH004, 2BH005, 2BH017, 2BH003 2BH051, 2BH048
Sulphate as SO_4	270	na	2BH005

Contaminant	Maximum [µg/l]	Mean [µg/l]	Locations
Total Aluminium	52000	15341	2BH002, 2BH031, 2BH003, 2BH073, 2BH006, 2BH051, 2BH017, 2BH048, 2BH008, 2BH005, 2BH009, 2BH015C, 2BH007
Total Iron	150000	39765	2BH002, 2BH031, 2BH017, 2BH073, 2BH051, 2BH006, 2BH003, 2BH048, 2BH008, 2BH009, 2BH005, 2BH007, 2BH004
Total Manganese	3300	1578	2BH031, 2BH073, 2BH017, 2BH051, 2BH048

G1 refers to a private groundwater abstraction well. M1 refers to 'Day Level' mineworkings drainage channel.

16.4.61 Where total metal levels are elevated above an EQS for dissolved phase in samples which contained acceptable levels of dissolved phase metal, this is indicative of aluminium, iron and manganese being present in particulate or precipitate form in the identified groundwaters.

Existing Abstractions and Sewerage Discharges

16.4.62 Consultations with North Ayrshire Council and land owners/occupiers have identified a number of known surface or groundwater abstractions in the vicinity of the Proposed Scheme.

16.4.63 Information on existing discharges was obtained from SEPA and from the Envirocheck Report commissioned during the assessment period.

Abstractions

16.4.64 Two private groundwater abstractions have been identified near the southern extents of the Proposed Scheme. They have been confirmed as drinking water supplies. The locations of the private groundwater abstractions are shown as AB1 and AB2 on Figure 16.1.

Sewerage Discharges

16.4.65 Properties in the Highfield area, as well as other scattered rural properties near the Proposed Scheme, are served by private septic tanks as there are no public sewers present.

16.4.66 Information regarding authorised private waste water discharges (domestic and trade) was obtained from SEPA in August 2012. This information has been supplemented by data included in the Envirocheck Report, dated June 2012 and individual consultations with residents in the vicinity of the Proposed Scheme. The locations of all identified sewerage discharge points, including a number of combined sewer overflows to the River Garnock east of Dalry, are shown on Figure 16.5.

Existing Road/Land Drainage

16.4.67 Consultations with the Trunk Road Network Operator (AIS) and North Ayrshire Council provided very little information on existing road drainage. No outfalls from the existing

A737 to local watercourses have been identified in Dalry. It is therefore assumed that the surface water drainage from the existing A737 through Dalry discharges to Scottish Water combined sewers.

16.4.68 The extent of existing road drainage potentially affected by the Proposed Scheme outside Dalry and the location of existing road drainage outfalls has been determined by field surveys including a comprehensive drainage survey commissioned by the MFJV in late 2012.

16.4.69 No information on land drainage was received from the land owners/occupiers.

16.5 Predicted Impacts

Surface Water

16.5.1 This section describes the potential impacts of road drainage and engineering works on the local water environment from the following sources during the construction and operation of the Proposed Scheme:

- road surface runoff;
- accidental spillage/vehicle fire;
- flooding;
- fluvial morphology;
- groundwater quality and flows; and
- contaminated soils reuse.

Road Surface Runoff

16.5.2 The Stage 2 Engineering Assessment Report identified the following three alternative road surface drainage approaches for further consideration. The engineering aspects of all options are described in detail in the Stage 3 Scheme Assessment Report (MFJV, 2013).

- Option 1 – Catchment Boundaries. This option is based on maintaining flows in the existing watercourses. Each catchment would be served by a new outfall.
- Option 2 – Vertical Alignment. This option is based on the vertical alignment and longitudinal gradient of the proposed route and discharge to the nearest available watercourse.
- Option 3 – Water Quality. This option is based on minimising the impact on water quality in local watercourses by discharging the surface water runoff to the watercourse that provides the greatest dilution.

16.5.3 Option 3 was discounted due to excessive pipe sizes and depths. Options 1 and 2, which are similar in terms of drainage catchments, have been combined to create a single preferred drainage option.

16.5.4 DMRB guidance recommends initial assessment of the concentrations of dissolved copper and zinc in receiving waters to assess the impact of road runoff and to determine whether mitigation is required.

16.5.5 The preferred road drainage option comprises ten independent gravity drainage networks. Seven of these (Networks 1, 2, 3, 4, 6, 7, 8) would discharge directly to tributaries of the River Garnock whereas the remaining three (Networks 1a, 5 and 9) would discharge to existing drainage systems controlled by North Ayrshire Council. There are no proposals to discharge any of the proposed road drainage to ground.

16.5.6 The proposed drainage scheme also includes access/cycle tracks, cattle underpass and associated earthworks drainage with connections to the proposed road drainage or direct discharges to the water environment.

16.5.7 The proposed road drainage layout is shown on Figures 16.3a and 16.3b. Information on road length and area drained by each network is shown in Table 16.17.

16.5.8 The water impact assessment has been carried out for the direct road drainage discharges to the water environment only i.e. Networks 1, 2, 3, 4, 6, 7, 8. The impacts of Networks 1a, 5 and 9 (widened existing road) on the water environment is considered negligible due to limited road extents. However, a degree of treatment and attenuation of road runoff would be provided by filter trenches and swales.

Table 16.17 Road Drainage Data

Network	Drained road length [1] [m]	Drained road area [1] [ha]	Receiving environment [NGR]
Network 1	645	1.10	Caaf Water [229461 648321]
Network 1a	155	0.21	Existing drainage [229260 648406]
Network 2 (viaduct drainage)	305	0.49	Caaf Water [229461 648321]
Network 3	1790	1.75	Coalheughglen Burn [230457 649580]
Network 4	1260	2.69	Unnamed tributary of River Garnock [229831 648088]
Network 5 (Swale)	195	0.24	Existing drainage [230910 649525]
Network 6	1305	2.45	Unnamed tributary of River Garnock [230467 650068]
Network 7	1328	1.46	Tributary of Coalheughglen Burn [231066 650296]
Network 8	56	0.04	Unnamed tributary of River Garnock (via Network 4) [229831 648088]
Network 9	332	0.32	Existing drainage [230277 648907]

[1] Includes existing road connected to new drainage

16.5.9 A summary of the pre-mitigation Method Assessment results is shown in Table 16.18 and a full set of the assessment results is included in Appendix 16.7.

Table 16.18 Effects of Routine Runoff on Surface Water – Pre-Mitigation

Outfall no	Q_{95} water course [m^3/s]	Prior mitigation in-river impact (annual average concentration)				
		Acute				Chronic
		Copper Pass / Fail	Copper concent. [ug/l]	Zinc Pass / Fail	Zinc concent. [ug/l]	Sediment accum. Pass/Fail
PSD 1 (Networks 1&2)	0.104	Pass	0.01	Pass	0.05	Pass (alert)
PSD 2 (Networks 4&8)	0.002	Fail	0.80	Fail	2.41	Pass (alert)
PSD 3 (Network 6)	0.001	Fail	1.11	Fail	3.38	Pass (alert)
PSD 4 (Network 3)	0.003	Pass	0.42	Pass	1.26	Pass (alert)
PSD 5 (Network 7)	0.001	Fail	0.69	Fail	2.09	Pass (alert)

16.5.10 The above assessment shows that routine surface water runoff could be harmful to the smaller receiving watercourses unless appropriate mitigation measures are employed. Although predicted sediment deposition is not significant, the use of measures designed to improve the quality of road runoff would also reduce the sediment load.

16.5.11 The chronic (long term) impact of soluble metals on the water environment has also been appraised by comparison of the assessment results with published EQS values[2]. Based on historic data obtained from SEPA the water hardness (expressed as $CaCO_3$) in the receiving watercourses in the vicinity of the Proposed Scheme is Class 3. Thus the concentrations of dissolved copper and zinc are below the comparable EQS values for all proposed drainage outfalls without mitigation. This shows that the Proposed Scheme drainage would have no adverse long term impact on the receiving watercourses.

Accidental Spillage

16.5.12 The accidental spillage assessment has been carried out for the direct discharges to the surface water environment only i.e. Networks 1, 2, 3, 4, 6, 7, 8. A summary of the assessment results is shown in Table 16.19 below and a full set of the results is included in Appendix 16.8.

[2] No published dissolved zinc values exist thus proposed DMRB HD45/09 value of 7.8 ug/l has been used

Table 16.19 Pollution Impacts from Spillages – Pre- Mitigation

Outfall no	Receiving watercourse	Probability of spillage occurrence [yrs]	Acceptable risk [Yes/No]
PSD 1	Caaf Water	958	Yes
PSD 2	Tributary of River Garnock	14,924	Yes
PSD 3	Tributary of River Garnock	4215	Yes
PSD 4	Coalheughglen Burn	33,572	Yes
PSD 5	Tributary of Coalheughglen Burn	15,384	Yes

16.5.13 The above results show that the risk of an accidental spillage and resulting ecological damage is low and therefore no mitigation measures are required.

Flooding

16.5.14 The proposed viaduct over the River Garnock would be constructed on narrow piers in order to minimise interference with flood flows. The deck level would be set well above the extreme flood levels and the piers set back from the main channel and the river banks. The western embankment would be positioned outside the 1in 200yr floodplain extent. The eastern embankment of the viaduct also lies outwith the floodplain and is separated from it by the railway line embankment.

16.5.15 1D hydraulic modelling has been carried out to predict flood water levels in the River Garnock and 2D modelling to appraise the flow velocities at the location of the proposed pier structures to assist with the design of appropriate scour protection measures.

16.5.16 The hydraulic analysis concluded that due to relatively small size of the proposed piers there would be no impact on the predicted 1 in 200yr flood water levels in the River Garnock and a negligible loss of its floodplain storage.

16.5.17 A maintenance access track would be positioned within the River Garnock floodplain. The total loss of floodplain storage associated with the access track has been calculated as 40m^3. The loss would be compensated by provision of appropriate flood compensatory storage (achieved through reprofiling the ground at the western end of the proposed viaduct).

16.5.18 Due to the proposed engineering works (watercourse diversion and two new culverts) to the Coalheughglen Burn, hydraulic modelling of the burn has been undertaken to establish the existing flood risks and assess impacts of the proposed works on the existing flood extents.

16.5.19 The hydraulic modelling of the Coalheughglen Burn concluded that the existing culvert in the Highfield area (EC4) does not have sufficient capacity to convey the predicted 1 in 200yr flood flow. During such an event, the water would overtop the banks and flood the low lying areas alongside the watercourse within the residential area.

16.5.20 The modelling has also indicated that the proposed engineering works associated with the Proposed Scheme would not have an adverse impact on the existing flood water levels.

16.5.21 Details of the flood risk analysis in the aforementioned watercourses are provided in the 'A737 Dalry Bypass Flood Risk Assessment' report included in Appendix 16.3.

16.5.22 The uncontrolled discharge of surface runoff from the Proposed Scheme during storm events has the potential to increase the risk of flooding downstream. The figures presented in Table 16.20 compare the estimated 1 in 2yr peak drainage discharge and the existing 1 in 2yr 'greenfield' runoff rate for each proposed outfall.

Table 16.20 Peak Flow Comparisons

Outfall	1 in 2yr peak road runoff [l/s]	1 in 2yr 'greenfield' runoff [l/s]
PSD 1	191	17
PSD 2	223	29
PSD 3	170	26
PSD 4	190	19
PSD 5	110	16

16.5.23 The use of mitigation measures, such as attenuation storage provided by a Sustainable Drainage System, would safeguard against increased flood risk downstream due to the uncontrolled discharge of road drainage.

16.5.24 Other potential sources of flooding, including crossings of minor watercourses, are discussed in the Flood Risk Assessment Report included in Appendix 16.3.

Fluvial Morphology

16.5.25 A summary of the engineering in-river activities required to facilitate construction of the Proposed Scheme is presented in Table 16.21.

Table 16.21 Proposed Engineering Works Affecting Watercourses

Watercourse	Proposed works
Caaf Water (W2)	Construction of SuDS outfall
River Garnock (W6) floodplain	Placement of piers supporting viaduct and maintenance access track
Unnamed tributary of River Garnock (W8)	Localised diversion New culvert Construction of SuDS outfall
Unnamed tributary of River Garnock (W15)	Construction of SuDS outfall
Coalheughglen Burn (W17)	Localised diversion Two new culverts Construction of SuDS outfall
Unnamed tributary of Coalheughglen Burn (W18)	New culvert Construction of SuDS outfall
Unnamed drain (D18)	Extension of existing culvert

16.5.26 Operation of road drainage outfalls could increase bed/bank erosion leading to the disturbance of the sediment regime and habitat potential of the watercourse.

16.5.27 The potential impacts of drainage outfalls are considered to be of moderate magnitude and slight significance. The impacts would be reduced by incorporation of appropriate mitigation measures such as flow control and erosion protection.

16.5.28 New culverts can affect natural fluvial processes, morphological diversity and free passage of fish due to disturbed continuity and synthetic bed and banks. A change in the natural bed gradient may lead to either greater stream energy thus scour potential or reduced stream energy and increased sediment deposition within the culvert.

16.5.29 The potential impacts of new culverts are considered to be of moderate magnitude and slight significance. Appropriate mitigation measures would be required to protect against degradation of the affected watercourses.

16.5.30 The following watercourse diversions are proposed:

- Unnamed tributary of the River Garnock (W8) – the diversion would include a new pipe crossing and a new open channel section.
- Coalheughglen Burn (W17) – the diversion would comprise a new box culvert crossing and sections of open channel.

16.5.31 Potential impacts of watercourse diversions are considered to be of high magnitude and moderate significance. Appropriate mitigation measures would be required to prevent degradation of the watercourses due to disturbance of natural fluvial processes and, where applicable, free passage of fish.

Groundwater Flows and Quality

16.5.32 It is recognised that the Proposed Scheme construction and operation could affect and be affected by groundwater quality and quantity. A risk-based approach has been adopted (in parallel with the environmental assessment) to appraise and manage potential risks associated with the groundwater. The full Water Risk Assessment is included in Appendix 16.6.

16.5.33 A section of the proposed Bypass near the Blairland Estate would be constructed in a cutting. The substantial depth of remaining cover would contain groundwater pressures in the underlying bedrock and limit groundwater flows to minor seepage through the low permeability and high capillarity boulder clay. Any resulting drainage effects on adjacent surface water features would be restricted to a narrow zone immediately adjacent to the road corridor. Given the low permeability of the boulder clay the seepages are anticipated to be of negligible magnitude.

16.5.34 Chapter 11 has identified the presence of contaminated soils at five isolated locations These areas were specifically targeted due to their proximity to former or historic contaminative land uses.

16.5.35 Most of these soils exhibited high levels of iron, aluminium, manganese and sulphate, most likely due to the associated coal bearing rock and overburden being brought to the surface for processing. For this reason, and whatever complex hydraulic connections exist locally, all surface waters are also considered as being contaminated with these metals for the purposes of this assessment.

16.5.36 Excavations and earthworks may lead to disruption of the superficial groundwater connected to surface waters. Based on the ground investigation data the groundwater and surface water quality varies dramatically depending on location. At the location of the cutting, low permeability soils are present. Such soils are less likely to contain contaminated porewater and generate only small seepage volumes due to their low permeability and high capillarity associated. Consequently, the magnitude of the impact is considered as negligible.

16.5.37 Potentially ecotoxic soils exist in the vicinity of 2TP022 (shown on Figure 11.7). The impact may be adverse or beneficial depending upon the quality of the groundwater and that of the surface water it is in connection with. However, impact is likely to be adverse as the groundwater pollutant levels are generally higher than those in surface waters. Only very minor seepages are expected to be generated by cuttings due to the cuttings being generally in low permeability clay soils. Such soils are less likely to contain contaminated porewater due to their low permeability.

Contaminated Soils Reuse

16.5.38 If the potentially ecotoxic soils (in the vicinity of 2TP022) are excavated and reused on site they could lead to pollution of surface waters if they become hydraulically connected. The magnitude of this impact would be minor adverse due to the small volume and likely low leachability of contaminants. It can be assumed that the contaminants have been subject to leaching action for a prolonged period of time since their deposit in the infilled quarry where they currently reside.

Impact of the Scheme on Groundwater

16.5.39 Geological conditions below the proposed Bypass are typical of South Ayrshire and Dalry including extensive historic extraction of coal and ironstone minerals. Water arising from these types of mines is typified by low pH as well as high sulphate, iron and manganese concentrations which could be harmful if discharged to surface waters. However, calcite in the limestone bands also encountered should decrease the solubility of metals though this is not conclusive based on the ground investigation findings. Elevated levels of aluminium, iron and manganese were detected in the majority of groundwater and surface water samples although visual inspection of local watercourses showed little or no evidence of minewater contamination.

16.5.40 Any of the expected small volumes of potentially contaminated soil arisings from excavations which may be reused on site are unlikely to have any impact on groundwater quality due to low permeability soils present throughout the site and resultant lack of hydraulic connectivity. Furthermore, any potentially contaminated soils are likely to be reused in the southern part of the site (where the most upfilling is required) which exhibits groundwater of poor quality.

Lowering of groundwater levels due to permanent 'involuntary' abstraction (dewatering sections of the proposed road in cutting)

16.5.41 The substantial layer of boulder clay would contain groundwater pressures in the underlying bedrock and limit groundwater flows to minor seepage. Any resulting drainage effects on groundwater features would be restricted to a narrow zone immediately adjacent to the road corridor. Given the low permeability of the boulder clay the seepages are anticipated to be of negligible magnitude.

Impact on groundwater flow pathways due to consolidated mineworkings

16.5.42 Historic mineworkings in the northern part of the proposed route would be consolidated by grouting. This could have an adverse impact on existing groundwater pathways. It is anticipated that only mineworkings above the groundwater level would be grouted thus a risk of permanent change to the groundwater flow pattern is considered to be negligible.

Impact on groundwater levels due to viaduct piers

16.5.43 Based on selected construction method (see Section 16.6) the magnitude of the impact on the groundwater environment has been assessed as negligible.

Construction Phase

16.5.44 The following potential impacts associated with construction activities for the Proposed Scheme have been identified.

- erosion due to general site clearance, stripping of vegetation and topsoil from the works area leaving exposed ground surfaces;
- silt mobilisation during excavations and construction traffic movement over temporary haul roads;
- contamination due to exposed untreated topsoil stockpiles;
- pollution during stabilisation of mineworkings (fill with cement based grout)
- contamination due to accidental spillages of fuel and oil from site plant and use of construction materials;
- pollution by river engineering construction works including watercourse diversions, crossings and outfalls;
- pollution during piling operations associated with construction of viaduct piers;
- temporary lowering of groundwater table and/or changing flow regime affecting existing water features, including private water supplies; and
- surface water pollution caused by dewatering of excavations.

16.5.45 The impacts of the construction activities, grouped based on the type of receptor (surface and groundwater), have been summarised in Table 16.25 at the end of Section 16.7.

16.5.46 Working methods would be developed by the contractor in line with SEPA publications and other ‘best practice’ guidance. Method statements would contain details of intended risk mitigation measures.

16.6 Mitigation

Surface Water

16.6.1 Where mitigation is required, the following Sustainable Drainage System (SuDS) components have been incorporated into the design. Since their use is mandatory in Scotland, SuDS would provide enhanced mitigation throughout the Proposed Scheme.

An assessment of the post mitigation impacts has been carried out and the results are reported in Section 16.7.

Road Surface Drainage

16.6.2 Wherever practicable, two levels of SuDS treatment would be provided:

- roadside filter drains with catchpits providing the first level of treatment by removing a percentage of suspended solids and heavy metals, or
- swales providing the first level of treatment where the use of filter drains is not technically viable (i.e. bridge deck), and
- detention basins providing the second level of treatment by further pollutant settlement and biodegradation

16.6.3 The detention basins would serve a dual function, comprising a sediment forebay and shallow wet pools (micropools) for enhanced treatment and added ecological value, as well as providing capacity to attenuate storm flows. The sediment forebay would act as a pre-treatment facility and would be separated from the basin by a permeable bund. The micropool would be located near the outlet to reduce a risk of sediment re-suspension resulting in outlet clogging. The basins would be lined (by either a natural layer of impermeable material or a synthetic liner) to prevent runoff infiltration to the ground and/or groundwater ingress into the basins.

16.6.4 The removal efficiency for heavy metals and suspended solids in the proposed SuDS management train has been considered as 60% and 70% respectively in accordance with CIRIA 609 'Sustainable Drainage Systems'.

16.6.5 All detention basins would be preceded by a chamber with isolating valve facilitating containment of accidental spillages. An emergency overflow would be provided in case of blockage or capacity exceedance.

16.6.6 The locations of the five proposed detention basins are shown on Figures 16.3a and 16.3b and photographs of the land designated for the basins are included in Appendix 16.2.

Accidental Spillages

16.6.7 No mitigation measures are required for accidental spillage. However, incorporation of the SuDS management train, including filter trenches and detention basins with isolating valves, would further reduce the risk of pollution.

Flooding

16.6.8 SuDS detention basins would provide storage capacity to attenuate storm flows. Drainage networks, not draining via detention basins, would also provide a degree of attenuation within filter trenches/swales prior to connection to the existing drainage systems.

16.6.9 In order to mitigate the risk of downstream flooding, attenuation storage for up to 1 in 100yr storm event has been provided within the detention basins. Discharge from the basins has been restricted to an equivalent 1 in 2yr 'greenfield' runoff rate. The detention basins would also accommodate the 1 in 200yr storm events within freeboard (i.e. depth between 100yr design water level and maximum retention level). Details of the five SuDS detention basins proposed in the design which would discharge to tributaries of the River Garnock are provided in Table 16.22.

Table 16.22 SUDS Basin Details

SUDS basin ref	Contributing area [ha]	1 in 100yr attenuation storage [m^3]	1 in 2yr discharge rate [l/s]
SB 1	1.59	740	17
SB 2	2.73	1285	29
SB 3	2.45	1155	26
SB 4	1.75	810	19
SB 5	1.46	680	16

16.6.10 Where possible, watercourse crossings would be designed to accommodate the 1 in 100yr flood flow. In all cases, safe overland flood routes would be provided considering surrounding land use to avoid residential property.

16.6.11 Compensatory flood storage would be provided by reprofiling the existing ground levels at the western end of the proposed viaduct to mitigate against floodplain storage loss due to the maintenance access track. A requirement for the compensatory storage has been confirmed by the North Ayrshire Council. A location of the proposed flood compensatory storage is shown on Figure 16.3a.

Fluvial Morphology

16.6.12 The assessment concluded that the proposed river engineering activities could have an adverse impact on the water environment.

16.6.13 The following ‘best practice’ measures would be used to mitigate any potentially adverse effects:

- road drainage outfall headwalls would be set into the bank face and orientated downstream to minimise erosion potential;
- scour protection would be placed in the area of discharge;
- a layer of natural bed material would be incorporated into new culvert;
- where practicable culverts would be constructed on-line to maintain longitudinal gradient;
- sharp bends would be avoided and scour protection placed at inlets and outlets;
- for diversions, physical channel characteristics would be replicated as far as practicable;
- the length of the diversions would be similar to the existing channels affected to minimise the change in longitudinal gradient;
- obstacles in the watercourse channel would be avoided to facilitate free passage of fish;

- bank and bed protection may be required depending on ground conditions along the diversion; and
- scour protection would be provided in higher energy areas such as at viaduct pier foundations constructed in the River Garnock floodplain.

Groundwater Flows and Quality

16.6.14 It has been confirmed by the ground investigation that cuttings would take place in the low permeability clay soils present throughout the site. There is sufficient thickness of clay above cuttings that artesian or sub-artesian groundwater would not be encountered. It is therefore envisaged that due to the small volume of these seepages, no designated groundwater drainage would be required. The seepages would be intercepted by the proposed road drainage (filter trenches) and routed to the existing watercourses via SUDS. The SUDS treatment and storage would provide sufficient mitigation against adverse impacts on the surface water environment.

Contaminated Soils Reuse

16.6.15 The contaminated soils have the potential for a minor adverse impact on the surface water environment. This would be mitigated by careful earthworks management to ensure that potentially contaminated soils and/or classified as Hazardous waste (due to ecotoxicity) are only reused in areas not hydraulically connected with surface waters.

Impact of the Scheme on Groundwater

Lowering of groundwater levels due to permanent ‘involuntary’ abstraction (dewatering sections of the proposed road in cutting)

16.6.16 Groundwater seepages only would be present in cutting. Due to sufficient thickness of clay above the cutting the artesian or sub-artesian groundwater would not be encountered during the Scheme construction and operation. The magnitude of the impacts have been considered as negligible, thus no mitigation measures have been proposed

Impact on groundwater flow pathways due to consolidated mineworkings

16.6.17 Historic mineworkings in the northern part of the proposed route would be consolidated by grouting. This could have an adverse impact on existing groundwater pathways. It is anticipated that only mineworkings above the groundwater level would be grouted thus a risk of permanent change to the groundwater flow pattern is considered as negligible.

Impact on groundwater levels due to viaduct piers

16.6.18 Based on selected piling system (see Construction Phase in Section 16.6) the generation of artesian groundwater would be avoided thus the magnitude of the impact on the groundwater environment has been assessed as negligible.

Construction Phase

16.6.19 Construction operations can cause watercourse pollution, mainly discolouration and siltation, having potentially detrimental impact on ecology and local habitat. Best working practices would therefore be adopted, in accordance with the following SEPA guidelines, to mange pollution risks to the water environment:

- SEPA's Good Practice Guides (WAT-SG-25, WAT-SG-26, WAT-SG-28, WAT-SG-29).
- WAT-SG-31: SEPA Special Requirements for Civil Engineering Contracts for the Prevention of Pollution.
- WAT-SG-32: SEPA Guidance on the Special Requirements for Civil Engineering Contracts.

Pollution Prevention Guidelines (PPGs)

- PPG 1 General Guide to the Prevention of Pollution.
- PPG 5 Works and Maintenance in or Near Water.
- PPG 6 Working at Construction and Demolition Sites.
- PPG 21 Pollution Incident Response Planning.

16.6.20 Construction stage drainage and associated SuDS measures would be separated from permanent drainage systems. Additional land may be required for SuDS during the construction stage so that permanent detention basins are well established and appropriately planted prior to connection of the new road drainage.

16.6.21 A Water Management Plan and Monitoring Protocol would be developed by the appointed contractor as part of the site wide Environmental Management Plan in consultation with SEPA and North Ayrshire Council prior to construction works commencing.

16.6.22 Specific measures would be required to minimise the potential risk of pollution during stabilisation (grouting) of disused mineworkings:

- further investigations to establish the full extent of grouting;
- use of dye testing to establish isolation of voids from water bodies;
- use of gravel to form curtain walls to contain grout;
- use of gravel and / or dense grout to fill voids; and
- close monitoring of potentially affected watercourses.

16.6.23 Extensive dewatering (artesian water) during construction of viaduct pier foundations in the River Garnock floodplain would be avoided by adopting the following piling methods. Only normal construction dewatering is anticipated.

- use of permanently cased piles founded in rock below Upper Linn Limestone (ULL). Structurally, the pile would span any solution features in the ULL thus their grouting can be avoided.
- construction of piles with the bores full of drilling fluid (high density or pressurised drilling fluids). The fluids would be designed to be balanced against the water pressure at depth thus precluding their flow into the water environment.

16.6.24 The selected piling method would also minimise a risk of pollution of the groundwater.

16.7 Residual Effects

16.7.1 A discussion of residual impacts pertinent to the water environment is provided below using the same order as previous sections. A summary of pre and post mitigation effects is provided in Table 16.25 at the end of this section.

Surface Water

Road Surface Drainage

16.7.2 Results of the water risk assessment with SuDS mitigation included are summarised in Table 16.23. A full set of the results is included in Appendix 16.7.

Table 16.23 Effects of Routine Runoff on Surface Water – Post Mitigation

Outfall no	Post mitigation in-river impact (annual average concentration)				
	Acute				Chronic
	Copper [Pass / Fail]	Copper concent. [ug/l]	Zinc [Pass/ Fail]	Zinc concent. [ug/l]	Sediment accum. [Pass/Fail]
PSD 1 (SB 1)	Pass	0.01	Pass	0.02	Pass (alert)
PSD 2 (SB 2)	Pass	0.32	Pass	0.96	Pass (alert)
PSD 3 (SB 3)	Pass	0.45	Pass	1.35	Pass (alert)
PSD 4 (SB 4)	Pass	0.17	Pass	0.50	Pass (alert)
PSD 5 (SB 5)	Pass	0.28	Pass	0.84	Pass (alert)

16.7.3 The assessment shows that the proposed mitigation measures are appropriate and that potentially adverse impacts of routine surface water runoff on the existing water environment have been avoided.

16.7.4 After mitigation, the concentrations of dissolved copper and zinc remain below the comparable EQS values for all proposed drainage outfalls, confirming that the proposed Bypass would have no adverse long term impact on the receiving watercourses.

Accidental Spillages

16.7.5 A summary of the assessment results for accidental spillage risk with SuDS mitigation measures included are summarised in Table 16.24 below. A full set of the results is included in Appendix 16.8.

Table 16.24 Pollution Impacts from Spillages – Post Mitigation

Outfall no	Receiving watercourse	Probability of spillage occurrence [yrs]	Acceptable risk [Yes/No]
PSD 1	Caaf Water	2396	Yes
PSD 2	Tributary of River Garnock	37311	Yes
PSD 3	Tributary of River Garnock	10537	Yes
PSD 4	Coalheughglen Burn	83931	Yes
PSD 5	Tributary of Coalheughglen Burn	43840	Yes

Flooding

16.7.6 SuDS have been designed to ensure that downstream flood risk is not increased as a result of the Proposed Scheme, i.e. no residual effects on downstream flood risk in receiving watercourses due to peak discharge restricted to the 1 in 2yr Greenfield runoff rate for design events up to and including the 1 in 100yr (with the 1 in 200yr events accommodated within the freeboard).

16.7.7 The following measures would ensure that there is no increase in flood risk elsewhere when the Proposed Scheme is implemented:

- culverts on the Coalheughglen Burn and minor watercourses would accommodate flood flows without overtopping – no residual flood risk up to design capacity if adequately maintained;
- overland flood routes provided at SUDS and culvert crossings would be designed to convey flows away from residential and other higher risk properties in the event of blockage;
- the viaduct on the River Garnock has been designed to ensure negligible impact on water levels – no encroachment into main channel, discrete piers on floodplain set back from the main channel; and
- compensatory flood storage to compensate for floodplain storage loss due to the maintenance access track has been provided.

Fluvial Morphology

16.7.8 The predicted significance of post mitigation impacts would be negligible or slight. Adoption of ‘best practice’ in the selection and design of road drainage outfalls, culverts and crossings, and watercourse diversions, incorporating appropriately designed scour and erosion protection would ensure that disruption of channel morphology is minimised.

Groundwater Flows and Quality

16.7.9 The predicted significance of the impact of groundwater on surface water environment has been assessed as neutral due to the limited volume of groundwater seepage intercepted.

Contaminated Soils Reuse

16.7.10 The predicted significance of post mitigation impacts would be neutral. Careful materials management, planning and implementation would minimise the risk of any site won reused contaminated soils impacting on surface waters.

Impact of the Scheme on Groundwater

16.7.11 No significant adverse effects on the groundwater regime are anticipated in the permanent condition with or without mitigation. The assessment has concluded that the risk of potential impact to groundwater levels adjacent to the proposed route and to surface water quality downstream of the road drainage discharges is negligible resulting in no significant change from baseline conditions.

Construction Phase

16.7.12 The adoption of best working practices and strict compliance with relevant SEPA Pollution Prevention Guidelines (PPG) by the appointed works contractor would minimise the risk of adverse effects on the water environment during the construction phase. Specific consultation with SEPA and/or CAR authorisation would be required for works that have a potential impact on the water environment including (but not limited to) working methods associated with the following activities:

- foundation construction for River Garnock Crossing;
- stabilisation (grouting) of redundant mineworkings;
- road construction in cutting at Blair Road; and
- watercourse diversions and crossings.

Conclusions

16.7.13 With the inclusion of the proposed design and mitigation measures, the assessment has concluded that impacts on the water quality, fluvial morphology, hydrology, and flood risk of surface waters and on the water quality, flows and levels of groundwater would be generally neutral or beneficial and no greater than slight beneficial at some locations.

Table 16.25 Summary of Potential Impacts and their Significance on the Water Environment

Feature	Attribute	Potential Impact	Waterbody Importance / Sensitivity	Pre-mitigation Impacts		Mitigation Measures	Post-mitigation Impacts	
				Magnitude	Significance		Magnitude	Significance
River Garnock (W6)	Salmonid water	Water quality due to road drainage discharge through tributaries	Medium	Negligible	Neutral	SuDS (detention basins, filter trenches and/or swales) for runoff treatment and spillage containment	Negligible	Neutral
		Disruption to channel morphology due to sediment transport via tributaries	Moderate	Negligible	Neutral	• Mimic existing conditions for watercourse diversions • Scour protection at new culvert inlets/ outlets • Correct headwall positioning and scour protection at discharge points	Negligible	Neutral
	Flood storage and conveyance of flow	Flooding due to viaduct piers and access track positioning within floodplain and road drainage discharge to tributaries of River Garnock	Very High	Negligible	Neutral	• Flood compensatory storage • SuDS (detention basins) for attenuation of runoff	Negligible	Neutral
		Loss of floodplain storage	Very High	Negligible	Neutral	Flood compensatory storage	Negligible	Neutral

Table 16.25 (cont.) Summary of Potential Impacts and their Significance on the Water Environment

Feature	Attribute	Potential Impact	Waterbody Importance / Sensitivity	Pre-mitigation Impacts		Mitigation Measures	Post-mitigation Impacts	
				Magnitude	Significance		Magnitude	Significance
Caaf Water (W2)	Tributary of River Garnock	Water quality due to road drainage discharge	Medium	Negligible	Neutral	SuDS (detention basin, filter trenches and swales) for treatment and spillage containment	Minor Beneficial	Slight (beneficial)
		Disruption to channel morphology due to construction of outfall	Moderate	Moderate	Moderate	Correct headwall positioning and scour protection at discharge point	Negligible	Neutral
	Conveyance of flow	Flooding due to road drainage discharge	High	Negligible	Neutral	SUDS (detention basin) for attenuation of runoff	Negligible	Neutral

Table 16.25 (cont.) Summary of Potential Impacts and their Significance on the Water Environment

Feature	Attribute	Potential Impact	Waterbody Importance / Sensitivity	Pre-mitigation Impacts		Mitigation Measures	Post-mitigation Impacts	
				Magnitude	Significance		Magnitude	Significance
Tributary of River Garnock (W8)	Field drain interceptor	Water quality due to road drainage discharge	Medium	Minor adverse	Slight (adverse)	SuDS (detention basin and filter trenches) for treatment and spillage containment	Negligible	Neutral
		Disruption to channel morphology due to construction of outfall	Low	Moderate	Slight	Correct headwall positioning and scour protection at discharge point	Minor	Neutral
		Disruption to channel morphology due to new culvert	Low	Moderate	Slight	• On-line culvert • Scour protection at new culvert inlet/ outlet • Incorporation of natural bedding	Minor	Neutral
		Disruption to channel morphology due to watercourse realignment	Low	High	Moderate	• Mimic existing conditions (i.e. length and gradient) for watercourse diversion • Avoid sharp bends and obstacles	Moderate	Slight

Table 16.25 (cont.) Summary of Potential Impacts and their Significance on the Water Environment

Feature	Attribute	Potential Impact	Waterbody Importance / Sensitivity	Pre-mitigation Impacts		Mitigation Measures	Post-mitigation Impacts	
				Magnitude	Significance		Magnitude	Significance
Tributary of River Garnock (W8) (cont.)	Conveyance of flow	Flooding due to road drainage discharge, new culvert and watercourse realignment	Low	Minor adverse	Neutral	• SuDS (detention basins) for attenuation of runoff • Design culvert and watercourse diversion to convey predicted flood flows • Provision of designated overland flood route	Minor Beneficial	Neutral
Tributary of River Garnock (W15)	Effluent discharge and field drain interceptor	Water quality due to road drainage discharge	Low	Minor adverse	Neutral	SuDS (detention basin and filter trenches) for treatment and spillage containment	Negligible	Neutral
		Disruption to channel morphology due to construction of outfall	Low	Moderate	Slight	Correct headwall positioning and scour protection at discharge point	Minor	Neutral
	Conveyance of flow	Flooding due to road drainage discharge	Low	Minor adverse	Neutral	SuDS (detention basin) for attenuation of runoff	Negligible	Neutral

Table 16.25 (cont.) Summary of Potential Impacts and their Significance on the Water Environment

Feature	Attribute	Potential Impact	Waterbody Importance / Sensitivity	Pre-mitigation Impacts		Mitigation Measures	Post-mitigation Impacts	
				Magnitude	Significance		Magnitude	Significance
Coalheughglen Burn (W17)	Effluent discharge and road drainage interceptor	Water quality due to road drainage discharge	Medium	Minor adverse	Slight (adverse)	SuDS (detention basin and filter trenches) for treatment and spillage containment	Negligible	Neutral
		Disruption to channel morphology due to construction of outfall	Low	Moderate	Slight	Correct headwall positioning and scour protection at discharge point	Minor	Neutral
		Disruption to channel morphology due to new culverts	Low	Moderate	Slight	• On-line culverts (where practicable) • Scour protection at new culvert inlets/ outlets • Incorporation of natural bedding	Minor	Neutral
		Disruption to channel morphology due to watercourse realignment	Low	High	Moderate	• Mimic existing conditions (i.e. length and gradient) for watercourse diversion • Avoid sharp bends and obstacles	Moderate	Slight

Table 16.25 (cont.) Summary of Potential Impacts and their Significance on the Water Environment

Feature	Attribute	Potential Impact	Waterbody Importance / Sensitivity	Pre-mitigation Impacts		Mitigation Measures	Post-mitigation Impacts	
				Magnitude	Significance		Magnitude	Significance
Coalheughglen Burn (W17) (cont.)	Conveyance of flow	Flooding due to road drainage discharge, new culvert and watercourse realignment	Medium	Minor adverse	Slight (adverse)	• SuDS (detention basins) for attenuation of runoff • Design culverts and watercourse diversions to convey predicted flood flows • Provision of designated overland flood route	Negligible	Neutral
Tributary of Coalheughglen Burn (W18)	Road drainage interceptor	Water quality due to road drainage discharge	Low	Minor adverse	Neutral	SuDS (detention basin and filter trenches) for treatment and spillage containment	Negligible	Neutral
		Disruption to channel morphology due to construction of outfall	Low	Moderate	Slight	Correct headwall positioning and scour protection at discharge point	Minor	Neutral
		Disruption to channel morphology due to new culvert	Low	Moderate	Slight	• On-line culvert • Scour protection at new culvert inlet/ outlet • Incorporation of natural bedding	Minor	Neutral

Table 16.25 (cont.) Summary of Potential Impacts and their Significance on the Water Environment

Feature	Attribute	Potential Impact	Waterbody Importance / Sensitivity	Pre-mitigation Impacts		Mitigation Measures	Post-mitigation Impacts	
				Magnitude	Significance		Magnitude	Significance
Tributary of Coalheughglen Burn (W18) (cont.)	Conveyance of flow	Flooding due to road drainage discharge and new culvert	Low	Minor adverse	Neutral	• SuDS (detention basins) for attenuation of runoff • Design culvert to convey predicted flood flows • Provision of designated overland flood route	Negligible	Neutral
Unnamed Drain (D18)	Existing drainage interceptor	Disruption to channel morphology due to extended culvert	Low	Moderate	Slight	• On-line culvert extension • Scour protection at culvert inlet/ outlet • Incorporation of natural bedding	Minor	Neutral
	Conveyance of flow	Flooding due to extension of existing culvert	Low	Negligible	Neutral	Dimension of culvert extension to be no less than existing culvert	Negligible	Neutral

Table 16.25 (cont.) Summary of Potential Impacts and their Significance on the Water Environment

Feature	Attribute	Potential Impact	Waterbody Importance / Sensitivity	Pre-mitigation Impacts		Mitigation Measures	Post-mitigation Impacts	
				Magnitude	Significance		Magnitude	Significance
Surface waterbodies	Local habitat	Water quality due to discharge of contaminated groundwater	Medium	Negligible	Neutral	SuDS (detention basin and filter trenches) - no specific treatment required	Negligible	Neutral
		Water loss due to lowered groundwater levels in the area of cutting	Medium	Negligible	Neutral	No mitigation required due to anticipated small volumes of groundwater (seepage only)	Negligible	Neutral
		Water quality due to mobilisation of contaminated soils	Medium	Minor adverse	Slight (adverse)	Careful earthworks management – reuse of contaminated soils in areas not hydraulically connected with surface waters	Negligible	Neutral
		Water quality due to grouting of mineworkings	Medium	Negligible	Neutral	• Use of gravel to form curtain walls to contain grout • Use of gravel and/or dense grout to fill voids • Dye testing to establish isolation of voids from waterbodies • Monitoring of potentially affected watercourses	Negligible	Neutral

Table 16.25 (cont.) Summary of Potential Impacts and their Significance on the Water Environment

Feature	Attribute	Potential Impact	Waterbody Importance / Sensitivity	Pre-mitigation Impacts		Mitigation Measures	Post-mitigation Impacts	
				Magnitude	Significance		Magnitude	Significance
Artesian groundwater	Private water supply	Water quality / contamination due to viaduct piers construction	High	Negligible	Neutral	Selected construction method (piling system), i.e. permanently cased piles and pressurised drilling fluid	Negligible	Neutral
		Lowering of groundwater table due to viaduct piers construction	High	Negligible	Neutral	Selected construction method (piling system), i.e. permanently cased piles and pressurised drilling fluid	Negligible	Neutral
Shallow groundwater	Feeding surface water features	Water quality due to mobilisation of contaminated soils	Medium	Negligible	Neutral	Careful earthworks management – reuse of contaminated soils in areas with no evidence of shallow groundwater	Negligible	Neutral
		Lowering of groundwater table due to seepages in road cutting	Medium	Negligible	Neutral	No mitigation required due to anticipated small volumes of groundwater (seepage only)	Negligible	Neutral
		Flooding caused by blocking off existing pathways due to consolidation of mineworkings	Medium	Negligible	Neutral	No mitigation required – grouting anticipated above groundwater table.	Negligible	Neutral
		Water quality due to grouting of mineworkings	Medium	Negligible	Neutral	• Use of gravel to form curtain walls to contain grout • Use of gravel and/or dense grout to fill voids	Negligible	Neutral