9 Water Environment

This chapter describes the baseline surface water environment, assesses the potential impacts of the proposed scheme during both construction and operational phases, and outlines measures for mitigating these impacts. The assessment considers the potential impacts of the proposed scheme in terms of surface water hydrology, flood risk, coastal and fluvial geomorphology and water quality.

There are several environmentally sensitive waterbodies within the study area. These include the Firth of Forth which has two SPA designations (the Firth of Forth SPA and Forth Islands SPA), along with a Ramsar designation and a number of smaller SSSI designations. St. Margaret's Marsh is designated as a SSSI due to saltmarsh wetland and reedbed habitat, which in turn provide important habitats for breeding and migratory wintering birds. The River Almond is designated as salmonid waters as is one of its tributaries within the study area, i.e. Niddry Burn.

Identification of baseline conditions and the impact assessment were carried out using a range of sources including consultation, desk-based assessments, site walkover and topographic survey. Hydrodynamic modelling of Swine Burn and Niddry Burn was undertaken to assess the impact of flood risk where new and extended culverts are proposed. In addition, coastal modelling was carried out to assess potential impacts of sediment release during dredging and piling works within the Firth of Forth.

Mitigation during construction will include adherence to relevant SEPA Pollution Prevention Guidelines (PPGs). With the implementation of the proposed mitigation during construction, residual impacts on all waterbodies would be reduced to Slight or Negligible significance.

Mitigation for the operational phase will include Sustainable Drainage Systems (SUDS) for receiving waterbodies and provision of appropriate compensatory flood storage. With the inclusion of the proposed mitigation measures during operation, residual impacts on all waterbodies would be reduced to either Slight or Negligible significance.

9.1 Introduction

9.1.1 This chapter presents the assessment of the proposed scheme in terms of the surface water environment, which includes hydrology, flood risk, fluvial and coastal geomorphology, and water quality, as defined in paragraph 9.2.1. The chapter is supported by the following appendices, which are cross-referenced in the text where relevant:

- Appendix A9.1: Hydrodynamic Modelling;
- Appendix A9.2: Surface Water Hydrology;
- Appendix A9.3: Hydraulic Modelling and Input to Design;
- Appendix A9.4; Fluvial Geomorphology; and
- Appendix A9.5: Water Quality.

9.1.2 Water is a resource that is essential to all animal and plant life. It is also necessary for industry, agriculture, waste disposal, many forms of transport, recreation and sport. The maintenance and improvement of the quality of our drinking water, watercourses, groundwater resources and coastal waters is central to UK Government and European policy.

9.1.3 The assessment methodologies are explained, including details of the main sources of information that were utilised. The baseline conditions are then described, representing the existing or Do Minimum scenario which is the situation if the proposed scheme were not to proceed and the existing Forth Road Bridge and associated road infrastructure continued to be used.

9.1.4 Potential impacts, both direct and indirect, that may occur as a consequence of the proposed scheme are considered. Potential impacts to waterbodies and the Firth of Forth are assessed separately, as are impacts from the construction phase and those arising during scheme operation

9.1.5 Mitigation to avoid, reduce or offset the potential impacts is described. These mitigation measures are informed by published guidance and best practice. Residual impacts are then identified assuming the implementation of the proposed mitigation.

9.2 Approach and Methods

Structure of Assessment

9.2.1 In line with the holistic approach of the Water Framework Directive (WFD) (2006/60/EC) described in paragraph 9.2.6 and recommended best practice, the assessment of potential impacts on the surface water environment in this chapter includes:

- Hydrology and Flood Risk: the assessment of potential impacts on the flow of water on or near the land surface, which is intrinsically linked to hydrogeology, water quality, geomorphology and ecology.
- Fluvial and Coastal Geomorphology: the assessment of landforms associated with river channels and estuaries and the sediment transport processes which form them. Fluvial and coastal processes create a wide range of morphological forms which provide a variety of habitats within and around river/estuarine channels and shorelines. As a result, geomorphology is integral to river and estuarine/coastal management.
- Water Quality: the assessment of the chemical status of various parameters within the water column and their interactions.

9.2.2 Geomorphology in the context of solid and drift geology is considered separately in Chapter 8 (Geology, Contaminated Land and Groundwater). Additionally, whilst the relevant fisheries designations have been considered in this chapter, potential impacts on ecology are considered in detail in Chapter 10 (Terrestrial and Freshwater Ecology) and Chapter 11 (Estuarine Ecology).

9.2.3 To undertake this impact assessment, the Water Environment, Geology/Groundwater and Ecology teams worked closely together throughout the assessment process to cover interactions between these topics.

9.2.4 For information on commercial and recreational use of the water environment and potential impacts refer to Chapter 7 (Land Use).

Legislative Context

9.2.5 The 2000/60/EC ‘Water Framework Directive’ (WFD) which is transposed into Scottish law by the ‘Water Environment and Water Services (Scotland) Act 2003’ (WEWS Act) (Scottish Executive, 2003), aims to classify surface waters according to their ecological status and sets targets for restoring/improving the ecological status of waterbodies. Water quality and hydromorphology are characteristics against which ecological status is to be assessed. Under the WFD (2006/60/EC), the status of water is assessed using a range of parameters including chemical, ecological, physical, morphological and hydrological measures to give a holistic assessment of aquatic ecological health. Furthermore, there is a requirement under the WFD (2006/60/EC) that natural waterbodies must attain at least ‘good ecological status’ by 2015. Certain waterbodies may be designated as artificial/heavily modified and will have less stringent targets to meet, however, these will still need to demonstrate ‘good ecological potential’ by 2015 (SEPA, 2002).

9.2.6 To help fulfil the aims of WFD (2006/60/EC), a new planning process called river basin planning will be used to manage the water environment. This involves production of a River Basin Management Plan (RBMP) for the Scotland river basin district and supplementary area management plans (AMPs) outlining how the water environment will be managed and improved to meet WFD (2006/60/EC) objectives. Draft RBMP and AMPs, including the Forth AMP, have been published for consultation by SEPA in 2008/2009. The final plans will be published in December 2009.

Consideration has been given to the requirements of the WFD (2006/60/EC) during assessment of the sensitivity of watercourses and selection of mitigation measures.

9.2.7 In addition to the WEWS Act, legislation passed in 2005; the Water Environment (Controlled Activity) (Scotland) Regulations 2005 (Scottish Executive, 2005) (referred to hereafter as CAR), controls engineering works in or in the vicinity of inland surface waters, as well as point source discharges, abstractions and impoundments, supporting implementation of the WFD (2006/60/EC) in Scotland. There are three different levels of authorisation under CAR: General Binding Rules (GBR), Registration, and Licence (either simple or complex). The level of authorisation increases as the activity poses a higher risk of impact on the water environment. The level of authorisation under CAR for the proposed scheme will depend on the activities proposed, but based on discussions with SEPA is likely to range from GBR covering construction activities, to simple licences for road drainage discharges (draining over 1km in length), river crossings and river realignment.

9.2.8 Environmental standards for river morphology have been established (SEPA, 2007). These standards are used to determine whether the impact of an engineering activity would result in a deterioration in (2006/60/EC) status by establishing 'capacity limits' for future channel modification. These tests are conducted by SEPA during the CAR application process. Although CAR applications are a separate process to EIA, regular consultation has been undertaken with SEPA to ensure that the Stage 3 environmental assessment and the progression of the proposed scheme design take into account the anticipated requirements of CAR. Design and assessment were also informed by the guidance provided in 'The Water Environment (Controlled Activities) (Scotland) Regulations 2005: A Practical Guide' (SEPA, 2008a).

Study Area

9.2.9 The baseline study area for the water environment is shown on Figures 9.1 and 9.2.

9.2.10 The study area for the assessment is 1km around land-based elements of the proposed scheme, and approximately 3km either side of the proposed Main Crossing location within the Firth of Forth. In addition, a wider study area (from Kincardine Bridge to Fidra near North Berwick) has been used for the purposes of the hydrodynamic modelling (Appendix A9.1: Hydrodynamic Modelling). Due to the sensitive nature of the estuarine environment and associated international ecological designations along extensive sections of the shoreline, these study areas are considered appropriate to assess direct and indirect effects of the proposed scheme beyond the immediate environs of the project. This follows guidance within DMRB HA 205/08 (Highways Agency et al., 2008) which states that the chosen study area should be defined on a 'case-by-case basis' reflecting the project and area over which impacts can be considered to have the potential to occur. This is more pertinent for sensitive receptors which may be located well beyond the footprint of the proposed scheme.

9.2.11 The study area for the assessment includes St. Margaret's Marsh on the north shore of the Firth of Forth and the following eight watercourses in the study area to the south of the Firth of Forth:

- Linn Mill Burn;
- Swine Burn;
- Tributary of Swine Burn;
- Niddry Burn;
- Tributary of Niddry Burn;
- River Almond;
- Ferry Burn; and
- Dolphington Burn.

9.2.12 Other waterbodies include Brankholm Burn, Keithing Burn, and an unnamed ditch (south of Masterton Junction). These waterbodies fall within the 1km survey extent, however due to the limited proposed scheme in the northern section, are considered to be outwith the impacted area and are therefore not considered further in the assessment.

Determination of Baseline Conditions

9.2.13 Baseline conditions were identified through a combination of consultation, desk-based assessment and site walkovers. In addition, for the purposes of determining existing flood level conditions along the Swine Burn and Niddry Burn, topographic surveys and hydrodynamic modelling were undertaken along appropriate reaches of these watercourses.

9.2.14 The desk-based assessment has taken into account relevant DMRB guidance, legislation and regulations including the following:

- Forth Draft Area Management Plan 2009-2015 (SEPA, 2009b);
- River Geomorphology: A Practical Guide (Environment Agency, 1998a);
- Review of Impact Assessment Tools and Post Project Monitoring Guidelines, Report to SEPA (Haycocks Associates, 2005);
- Scottish Planning Policy (SPP) 7: Planning and Flooding (Scottish Executive, 2004);
- WFD (2006/60/EC) policy guidance 'The Future for Scotland's Waters, Guiding Principles on the Technical Requirements of the Water Framework Directive' (SEPA, 2002);
- DMRB Volume 4, Section 2: Drainage (Highways Agency et al., 2006a); and
- DMRB Volume 11, Section 3, Part 10 (HA 216/06): Road Drainage and the Water Environment (Highways Agency et al., 2006b).

<u>Consultation</u>

9.2.15 Details of the consultation process are provided in Chapter 6 (Consultation and Scoping) with a summary of key issues raised through consultation provided in Appendix A6.3 (Summary of Key Issues). Consultations of particular relevance to this assessment were undertaken with regulatory bodies and key stakeholders including:

- Marine Scotland (formerly Fisheries Research Services) (locations of shellfisheries and nursery areas, migratory/resident fish species and migratory periods for sensitive species within the Firth of Forth and agreed assessment methodologies);
- SEPA (water quality monitoring data (2002-2006), WFD (2006/60/EC) risk designations, designated fisheries reaches, areas of flood risk, flood risk assessment methodology, consented point discharges, licensed abstractions and agreed assessment methodologies);
- SNH (key areas for sensitive species, e.g. salmonids, and agreed assessment methodologies); and
- The City of Edinburgh Council and West Lothian Council (flood risk recommendations, floodplain identification, historic flood models, areas with historical flood problems and hydrochronology records).

9.2.16 In addition, regular consultation was undertaken with SEPA and SNH during the EIA process to discuss design and environmental considerations and subsequent mitigation requirements in order to inform design. Details of consultation are provided in Chapter 6 (Scoping and Consultation), however the main topics of discussion are summarised below:

- options for, and requirements of, watercourse crossings and realignments;
- road drainage and treatment requirements (Sustainable Drainage Systems; SUDS), including the Main Crossing drainage;

- proposals and impacts of construction activities on the water environment;
- modelling requirements for the Firth of Forth;
- engineering and drainage requirements for CAR; and
- coastal/estuarine geomorphology approach and assessment.

Desk-based Assessment

9.2.17 Data were collated from the following sources:

- Ordnance Survey (OS) maps;
- Flood Estimation Handbook (FEH) CD-ROM v.2 (CEH, 2006);
- SEPA Indicative River and Coastal Flood Map (Scotland) (SEPA, 2009a); and
- SEPA water quality monitoring data and designated fisheries information contained in Forth Draft Area Management Plan (SEPA, 2009b).

Site Walkovers

9.2.18 Walkover surveys of the study area were undertaken in April, May, October and November 2008 and March 2009 to visually inspect watercourses and surface waterbodies in order to gain an understanding of the local topography, hydrological regime, hydrological features, sediment processes and characteristics of the surface water environment. This information augmented and informed the desk-based assessments.

Topographic Survey

9.2.19 A topographic survey was undertaken to map the ground elevations and general features within a 1km corridor along the proposed alignment. This survey information provided ground elevation contour information at 1m intervals.

Findings of the Ground Investigation

9.2.20 Ground investigations (GI) have been undertaken for the proposed scheme, as described in Chapter 8 (Geology, Contaminated Land and Groundwater). Relevant information from the GI was used in the water environment assessment.

9.2.21 A river survey was also undertaken to collect detailed river crossing and hydraulic structure information along the Swine Burn and Niddry Burn. The channel cross-sections were collected at intervals of 200m or less, while hydraulic structure cross-sections were collected at both the upstream and downstream faces of the structure. The cross-section information extended up to 10m into the floodplain on each side of the channel. This information was used to develop hydrodynamic models used in the prediction of flood extents along these watercourses.

Hydrodynamic Modelling

9.2.22 As part of the flood risk assessment and culvert sizing programme along Niddry Burn and Swine Burn, one-dimensional (1-D) hydrodynamic models were constructed to refine indicative information provided by SEPA flood mapping regarding existing flood extents along reaches near the proposed crossings. These were then interrogated as part of the impact assessment. Further details of the hydrodynamic models are provided in paragraphs 9.2.37 and 9.2.38.

Impact Assessment

9.2.23 The impact assessment has been carried out using the general approach outlined in Chapter 5 (Overview of Assessment) and described below, with the level of significance of an impact determined based on the sensitivity of the surface water feature (receptor) and the magnitude of potential impact, during both construction and operation.

9.2.24 Further assessments of the impacts of the proposed scheme on the water environment may be required pre-construction as part of the CAR process, as described in paragraphs 9.2.7, 9.2.8 and 9.5.10.

Sensitivity

9.2.25 The sensitivity of the receiving environment was categorised on a scale of 'low' to 'high', in accordance with the criteria provided in Table 9.1. In defining these criteria, guidance such as the DMRB (Highways Agency et al., 2006b) has been consulted. Impacts are adverse unless stated otherwise.

9.2.26 Each discipline (Hydrology and Flood Risk, Fluvial and Coastal Geomorphology, and Water Quality) has evaluated the sensitivity or vulnerability of each watercourse by a separate set of criteria, as listed in Table 9.1. The sensitivities assigned to each waterbody are relevant to the surveyed reach and not the entire catchment.

Table 9.1: Criteria to Assess the Sensitivity of Water Features

Sensitivity	Criteria
High	**Hydrology and Flood Risk:** a watercourse with direct flood risk to the adjacent populated areas, critical social infrastructure units such as hospitals, schools, safe shelters or other land use of great value, e.g. strategic transportation or utility infrastructure. A watercourse/hydrological feature with hydrological importance to: i) sensitive and protected ecosystems; ii) critical economic and social uses (e.g. water supply, navigation, recreation, amenity etc.); iii) the flooding of property (or land use of great value) that has been susceptible to flooding in the past or is likely to be flooded in the future. A watercourse/ floodplain/ hydrological feature that provides critical flood alleviation benefits. **Fluvial Geomorphology:** Sediment regime: a watercourse supporting a range of species and habitats sensitive to a change in suspended sediment concentrations and turbidity such as migratory salmon or freshwater pearl mussels. Channel morphology: a watercourse exhibiting a range of morphological features such as pools and riffles, active gravel bars and varied river bank types. Such morphological variability is a primary determinant of ecological diversity. Natural fluvial processes: a watercourse which may be highly vulnerable to changes in fluvial processes as a result of modifications. Watercourse response likely to involve changes to baseline conditions with a high impact on ecology. **Coastal Geomorphology:** a waterbody supporting a range of species and habitats sensitive to changes in erosion, sediment transport and deposition. Includes sites with international and UK statutory nature conservation designations due to water-dependent ecosystems. Diverse shoreline/estuarine morphology, including many natural features such as sand banks, intertidal mudflats and saltmarshes. Such morphological variability (geodiversity) is a primary determinant of ecological diversity. Higher likelihood of morphological adjustment, such as excessive erosion and sediment deposition, as a direct result of modification. **Water Quality:** receptor of high environmental importance, e.g. a large or medium-sized watercourse with pristine or near pristine water quality (SEPA water quality A1: excellent) or national or higher value e.g. nature conservation designation due to water-dependent ecosystems, such as Special Protection Area (SPA), Special Area of Conservation (SAC) and Site of Special Scientific Interest (SSSI), or designated for freshwater ecological interest (designated salmonid fishery). Water quality complies with Dangerous Substances Directive (DSD) Environmental Quality Standards (EQS). Water quality not significantly anthropogenically affected.
Medium	**Hydrology and Flood Risk:** a watercourse with a possibility of direct flood risk to less populated areas without any critical social infrastructure units such as hospitals, schools, safe shelters and/or utilisable agricultural fields. A watercourse/hydrological feature with some but limited hydrological importance to: i) sensitive or protected ecosystems; ii) economic and social uses (e.g. water supply, navigation, recreation, amenity etc); iii) the flooding of property (or land use of value) that may potentially be susceptible to flooding. A watercourse/floodplain/hydrological feature that provides some flood alleviation benefits. **Fluvial Geomorphology:** Sediment regime: a watercourse supporting limited species sensitive to a change in suspended sediment concentrations or turbidity. Includes non-statutory sites of regional or local importance designated for water-dependent ecosystems. Channel morphology: a watercourse exhibiting limited morphological features such as pools and riffles, few active gravel bars and relatively uniform bank types.

Sensitivity	Criteria
	Natural fluvial processes: a watercourse which may be vulnerable to changes in fluvial processes which are likely to have a limited impact on habitat quality. This also includes watercourses which may be vulnerable to localised change in process rates but which are not located upstream of important ecological sites. **Coastal Geomorphology:** a waterbody supporting some species and habitats sensitive to changes in erosion, sediment transport and deposition. Includes non-statutory sites of regional or local importance designated for water-dependent ecosystems. Moderate morphological diversity (geodiversity). Evidence of localised modification such as shoreline protection, but natural features such as sand banks and intertidal flats are present. Potential for morphological adjustment, such as erosion and sediment deposition, as a direct result of modification, but which would have limited environmental impact. **Water Quality:** Receptor is of medium environmental importance or of local/regional value. For example, SEPA water quality A2 (good) or B (fair), designated cyprinid fishery, salmonid species may be present and catchment locally important for fisheries. Likely to exhibit a measurable degradation in water quality as a result of anthropogenic factors.
Low	**Hydrology and Flood Risk:** a watercourse passing through uncultivated agricultural land. A watercourse with minimal hydrological importance to: i) sensitive or protected ecosystems; ii) economic and social uses (e.g. water supply, navigation, recreation, amenity); iii) flooding of property (or land use of value). A watercourse/floodplain/hydrological feature that provides minimal flood alleviation benefits. **Fluvial Geomorphology:** Sediment regime: a watercourse which does not support any significant species sensitive to changes in suspended solids concentration or turbidity. Channel morphology: a watercourse exhibiting no morphological diversity; uniform flow, gravel bars are absent and bank types uniform and stable. Such watercourses may have been subject to past modification such as bank protection and culverting. Natural fluvial processes: a watercourse which shows no evidence of active fluvial processes and is not likely to be affected by modification to boundary conditions. **Coastal Geomorphology:** a waterbody which does not support any significant species sensitive to changes in erosion, sediment transport and deposition. No designated sites within waterbody. Waterbodies exhibiting no morphological diversity (geodiversity); shoreline type is uniform and stable. Evidence of modification such as a sea defence, realignment and/or deepening. Very limited potential for morphological adjustment, such as erosion and sediment deposition, as a direct result of modification. **Water Quality:** receptor is of low environmental importance. For example, SEPA water quality B (fair), C (poor) or D (seriously polluted); likely to be affected by anthropogenic factors, and fish sporadically present or restricted, no designated fisheries.

Impact Magnitude

9.2.27 The magnitude of impact is influenced by timing, scale, size and duration of change to the baseline conditions, as defined in Table 9.2.

Table 9.2: Criteria to Assess the Magnitude of the Predicted Impact on Water Features

Magnitude	Criteria
High	Major shift away from baseline conditions. **Hydrology and Flood Risk:** major changes to flow regime (low, mean and/or high flows – at the site, upstream and/or downstream). An alteration to a catchment area in excess of a 25% reduction or increase. Significant increase in the extent of “medium to high risk” areas (classified by the Risk Framework of Scottish Planning Policy 7 (SPP7). This means there would be significantly more areas/properties at risk from flooding by the 0.5% or greater annual exceedance probability (AEP) (1 in 200-year return period) flow. **Fluvial Geomorphology:** Sediment regime: major impacts to the river bed over this area due to deposition or erosion. Major impacts to sensitive species or habitats as a result of changes to suspended sediment load or turbidity. Channel morphology: major impacts on channel morphology over this area leading to a reduction in morphological diversity with consequences for ecological quality. Natural fluvial processes: major interruption to fluvial processes such as channel planform evolution or erosion and deposition. **Coastal/Estuarine Geomorphology:** major changes to the geodiversity and/or the hydro-morphological elements of the waterbody including: Estuarine sediment regime: major changes to any part of the shoreline, intertidal area and subtidal bed of the estuary leading to impacts to habitats and/or sensitive species as a result of changes in erosion,

Magnitude	Criteria
	transport and deposition of suspended sediment and/or bedload. Shoreline, intertidal and subtidal morphology: major changes to any part of the shoreline, intertidal area and subtidal bed of the estuary leading to a reduction in morphological diversity with consequences for geodiversity or ecological quality. Estuarine processes: major changes/interruption to estuarine processes such as shoreline evolution or erosion and deposition. **Water Quality:** major shift away from the baseline conditions, fundamental change to water quality condition either by a relatively high amount for a long-term period or by a very high amount for an episode such that watercourse ecology is greatly changed from the baseline situation. Equivalent to downgrading from Class A to C or D, or from B to D or any change that downgrades a site from good status as this does not comply with the WFD (2006/60/EC). Potential failure of dissolved copper and total zinc concentrations (Method B Detailed Assessment of Pollution Impacts from Routine Runoff, DMRB HA 216/06 (Highways Agency et al., 2006b)). Calculated accidental spillage risk greater than 2% AEP (1 in 50 years or more frequent) (Method D Assessment of Pollution Impacts from Accidental Spillages, DMRB HA 216/06 (Highways Agency et al., 2006b)).
Medium	Moderate shift away from baseline conditions. **Hydrology and Flood Risk:** moderate shift away from baseline conditions and moderate changes to the flow regime. An alteration to a catchment area in excess of 10% but less than 25%. Moderate increase in the extent of “medium to high risk” areas (SPP7). **Fluvial Geomorphology:** Sediment regime: moderate impacts to the river bed and sediment patterns over this area due to either erosion or deposition. Changes to suspended sediment load or turbidity resulting in a moderate impact on sensitive habitats or species. Channel morphology: moderate impact on channel morphology. Natural fluvial processes: moderate interruption to fluvial processes such as channel planform evolution or erosion. **Coastal/Estuarine Geomorphology:** moderate changes to the geodiversity and/or hydro-morphological elements of the waterbody including: Estuarine sediment regime: moderate changes to any part of the shoreline, intertidal area and subtidal bed of the estuary caused by erosion (scour) and/or deposition leading to impacts to habitats and/or sensitive species as a result of changes in erosion, transport and deposition of suspended sediment and/or bedload. Shoreline, intertidal and subtidal morphology: moderate changes to estuarine morphological diversity. Estuarine processes: moderate changes/interruption to estuarine processes such as shoreline evolution or erosion and deposition. **Water Quality:** a moderate shift from the baseline conditions that may be long-term or temporary. Results in a change in the ecological status of the watercourse. Equivalent to downgrading one class, for example from C to D. Potential failure of dissolved copper or total zinc concentrations (Method B Detailed Assessment of Pollution Impacts from Routine Runoff, DMRB HA 216/06 (Highways Agency et al., 2006b)). Calculated accidental spillage risk greater than 1% AEP and less than 2% AEP (between 1 in 50 years and 1 in 100 years) (Method D Assessment of Pollution Impacts from Accidental Spillages, DMRB HA 216/06 (Highways Agency et al., 2006b)).
Low	Slight shift away from baseline conditions. **Hydrology and Flood Risk:** slight changes to the flow regime. An alteration to a catchment area in excess of 1% but less than 10%. Slight increase in the extent of “medium to high risk” areas (SPP7). **Fluvial Geomorphology:** Sediment regime: slight changes to sediment transport resulting in minimal impacts on species or habitats as a result of changes to suspended sediment concentration or turbidity. Minor impacts to sediment patterns over this area due to either erosion or deposition. Channel morphology: limited impact on channel morphology. Natural fluvial processes: slight change in fluvial processes operating in the river; any change is likely to be highly localised. **Coastal/Estuarine Geomorphology:** slight changes to the geodiversity and/or hydro-morphological elements of the waterbody including: Estuarine sediment regime: slight changes to any part of the shoreline, intertidal area and subtidal bed of the estuary caused by erosion (scour) and/or deposition leading to impacts to habitats and/or sensitive species as a result of changes in erosion, transport and deposition of suspended sediment and/or bedload. Shoreline, intertidal and subtidal morphology: limited changes to estuarine morphological diversity. Estuarine processes: slight changes/interruption to estuarine processes such as shoreline evolution or erosion and deposition any changes are likely to be localised.

Magnitude	Criteria
	Water Quality: minor shift away from the baseline conditions. Changes in water quality are likely to be relatively small, or be of a minor temporary nature such that watercourse ecology is slightly affected. Equivalent to minor but measurable change within a class. No failure of EQS for dissolved copper or total zinc concentrations (Method B Detailed Assessment of Pollution Impacts from Routine Runoff, DMRB HA 216/06 (Highways Agency et al., 2006b)). Calculated accidental spillage risk greater than 0.5% AEP and less than 1% AEP (between 1 in 100 years and 1 in 200 years) (Method D Assessment of Pollution Impacts from Accidental Spillages, DMRB HA 216/06 (Highways Agency et al., 2006b)).
Negligible	Minimal change from baseline conditions. **Hydrology and Flood Risk:** negligible changes to the flow regime (i.e. changes that are within the monitoring errors). An alteration to a catchment area of less than 1% reduction or increase in area. Negligible change in the extent of “medium to high risk” areas (SPP7). **Fluvial Geomorphology:** <u>Sediment regime:</u> negligible changes to sediment transport resulting in negligible impacts on species or habitats as a result of changes to suspended sediment concentration or turbidity. No discernible impact to sediment patterns and behaviour over the development area due to either erosion or deposition. <u>Channel morphology:</u> no significant impact on channel morphology in the local vicinity of proposed site. <u>Natural fluvial processes:</u> no change in fluvial processes operating in the river; any change is likely to be highly localised. **Coastal/Estuarine Geomorphology:** no significant changes to the geodiversity and/or hydro-morphological elements of the waterbody: <u>Estuarine sediment regime:</u> no significant changes to sediment transport resulting in negligible impacts on species or habitats as a result of changes to suspended sediment concentration or turbidity. No discernible impact to sediment patterns and behaviour over the development area due to either erosion or deposition. <u>Shoreline, intertidal and subtidal morphology:</u> no significant impact to estuarine morphological diversity. <u>Estuarine processes:</u> no significant changes/interruption to estuarine processes such as shoreline evolution or erosion and deposition. Any changes are likely to be localised. **Water Quality:** very slight change from the baseline conditions such that no discernible effect upon the watercourse ecology results. No change in classification. Negligible change in dissolved copper or total zinc concentrations (Method B Detailed Assessment of Pollution Impacts from Routine Runoff, DMRB HA 216/06 (Highways Agency et al., 2006b)). Calculated accidental spillage risk less than 0.5% AEP (less frequent than 1 in 200 years) (Method D Assessment of Pollution Impacts from Accidental Spillages, DMRB HA 216/06 (Highways Agency et al., 2006b)).

<u>Impact Significance</u>

9.2.28 The significance of impact was determined as a function of the sensitivity of the receiving environment and the magnitude of the impact, as outlined in Table 9.3.

Table 9.3: Matrix for Determination of Impact Significance

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

<u>Interactions with Ecology/Geology, Contaminated Land and Groundwater</u>

9.2.29 In line with the WFD (2006/60/EC) and as mentioned in paragraph 9.2.5, the individual discipline sensitivities and the overall Water Environment sensitivities assigned to each watercourse were discussed with the project team’s ecological, groundwater and geological specialists to take into consideration the links between physical processes and direct/indirect impacts on receptors, both cause and effect.

9.2.30 Direct impacts on the flow and sediment regime, morphological diversity or water quality of a waterbody can cause indirect ecological impacts. In addition, intrusion of groundwater into surface waterbodies such as through artificial cuttings, and mobilisation/disturbance of contaminated sediment and pollutants may have direct impacts on surface water quality and quantity, and cause indirect ecological impacts.

9.2.31 To avoid repetition between each chapter, all direct assessments of impacts on groundwater and geology are reported in Chapter 8 (Geology, Contaminated Land and Groundwater), and on ecology in Chapter 10 (Terrestrial and Freshwater Ecology) and Chapter 11 (Estuarine Ecology).

9.2.32 As part of the criteria to assess the sensitivity of the surface water environment, water-dependent ecological designations of waterbodies have been considered.

Specific Methodologies

Hydrology and Flood Risk

Baseline Assessment

9.2.33 For each watercourse along the route of the proposed scheme the following estimates have been calculated for existing hydrology and flood risk baseline conditions:

- 95-percentile flow (Q95);
- 50-percentile flow(Q50);
- median annual maximum flood (QMED);
- mean annual maximum flood (QBAR); and
- flood design peak flows including the 1% and 0.5% Annual Exceedance Probability (AEP) flows (1 in 100-year and 1 in 200-year return periods, respectively).

9.2.34 SEPA flood mapping was used where appropriate to assess the baseline flood risk of land associated with different watercourses and along the Firth of Forth. The SEPA 'Indicative River and Coastal Flood Map (Scotland)' mapping provides an estimate of the areas of Scotland with a 0.5% AEP (1 in 200-year return period) or greater probability of being flooded in any given year (SEPA 2009a). The indicative SEPA flood maps may not provide delineation of flood extents accurately for individual properties or specific locations, but do provide indicative floodplain boundaries to identify areas of potential risk.

9.2.35 For watercourses with floodplain extents excluded from the SEPA Indicative Flood Maps (with catchments smaller than $3km^2$), flood risk was determined through a desk-based assessment of each potentially affected watercourse. The desk-based flood risk assessment was based on the distance, position and elevation difference (assessed using 1:25,000 OS plans and 1:1,250 detailed design plans) between the proposed culvert and any properties upstream of the proposed culvert entrance. Identification of land use upstream of the culvert was also required as wooded areas can potentially produce more debris that can block culverts. This approach was used to identify properties that could potentially be at risk during extreme events.

9.2.36 In addition to the use of SEPA Indicative Flood Maps and detailed mapping, the 1-D hydraulic models were used to assess the impact to flood risk at the proposed new crossing along Swine Burn, at the extension of the existing culvert along Swine Burn, and potential culvert extensions along Niddry Burn and the Tributary of Niddry.

9.2.37 Interrogation of the 1-D hydrodynamic models of the Swine Burn and Niddry Burn (refer to paragraph 9.2.22 above) was undertaken to refine understanding of the 0.5% AEP (1 in 200-year return period) flood depth and extent for these watercourses. The models were constructed using the ISIS software package and utilised inputs of the following information:

- (i) 0.5% AEP (1 in 200-year return period) hydrographs derived using Flood Estimation Handbook (FEH) methodology;

- (ii) channel and hydraulic structure information as collected through the topographic survey; and
- (iii) other hydraulic and connectivity information, which was established during a site walkover.

9.2.38 All necessary hydrological catchment characteristics were obtained from OS maps, soils, geological and land use maps and the FEH CD-ROM Version 2 (CEH, 2006).

9.2.39 It is noted that all waterbodies that would be crossed by the proposed scheme, except for the Firth of Forth, are relatively small, ungauged catchments. Flow estimation on ungauged watercourses is generally subject to significant uncertainties. To increase the confidence in the standard desk-based flow and flood risk estimates, each watercourse was carefully inspected during site visits in April, May, October and November 2008. The hydrological analyses used desk-based procedures and gauged data from donor/analogue catchments.

9.2.40 Appendix A9.2 (Surface Water Hydrology) identifies the flow parameters and methodologies that were used to calculate these estimates and provides information on the key baseline parameters for each of the watercourses on which there could be an impact.

Impact Assessment

9.2.41 In line with HA 216/06 guidance (Highways Agency et al., 2006b), where a new road scheme has the potential to significantly affect floodplain capacity, an assessment (details provided in Appendix A9.3: Flood Risk) has been undertaken on the following.

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

9.2.42 Post-development changes to catchment parameters were determined by recalculating parameters for the catchments with the proposed scheme in place. The parameters assessed were catchment area size and extent of urbanisation (refer to Section 9.4 and Table 9.16).

9.2.43 The potential impacts of watercourse realignments were assessed through 1-D hydraulic modelling to estimate potential impacts on changes in water levels along the watercourse based on the proposed channel dimensions and grade.

9.2.44 In the assessment, the proposed new culvert along Swine Burn is considered to be a flood flow culvert. Flood flow culverts are designed to convey the 0.5% AEP (1 in 200-year return period) flows with 0.3m freeboard capacity. The impacts of the culvert installation on flood levels along the Swine Burn are based on output from 1-D hydraulic modelling software.

Allowance for climate change

9.2.45 Guidance on allowance for climate change has been taken from a scoping study regarding climate change and hydrological parameters (SEPA, 2005). SEPA does not define a specific value, but suggests that the sensitivity of flows within flood risk analysis could be carried out up to a 20% increase for the east of Scotland. This is considered the maximum change and evidence suggests that by 2050 there is more likely to be an increase of approximately 15% in the east of Scotland (Price & McKenna, 2003). Recent SEPA guidance suggests that local authorities can request analysis of the climate change scenario including 0.5% AEP (1 in 200-year return period) +20% flows to evaluate the impact of the development with consideration of climate change if it can be justified (SEPA, 2008b). In this study, we have consulted with local authorities where appropriate to gain advice on climate change requirements.

9.2.46 SPP7 (Scottish Executive 2004) states that the threshold 0.5% AEP (1 in 200-year return period) and the 0.1% AEP (1 in 1000-year return period) floods includes an allowance for climate change. SPP7 (Scottish Executive 2004) also indicates that developments should now be designed to the

0.5% AEP (1 in 200-year return period) design flood event instead of the 1% AEP (1 in 100-year return period) design flood event to allow for possible future climate change increases.

9.2.47 It should be recognised that further guidance based on the UK Climate Impacts Programme 2009 (UKCIP09) was recently released but was not available during this assessment. The UKCIP09 is the fifth generation of UK climate change scenarios, describing how the climate of the UK might change during the 21st century. It will employ recent advances in climate science to better quantify some of the uncertainties associated with climate modelling, and will reflect UK Meteorological Office Hadley Centre scientists' latest understanding of how the climate system operates and how it might change in the future. In light of the new climate change scenarios, new guidance is likely to be released which might lead to differing advice from the above points.

9.2.48 The assessments and recommendations provided in this chapter are based on current SPP7 (Scottish Executive 2004) guidance, and advice provided by SEPA in November 2008 and City of Edinburgh Council in February 2009 during the consultation process. The flood risk assessment is based on the 0.5% AEP (1 in 200-year return period) design flow which, as discussed above, provides an allowance for climate change (paragraph 9.2.45). For Swine Burn and Niddry Burn a sensitivity analysis has been carried out whereby the 0.5% AEP (1 in 200-year return period) flows have been increased by 20%.

Fluvial Geomorphology

Baseline Assessment

9.2.49 The baseline assessment combined a desk-based assessment and field survey.

9.2.50 The desk study utilised existing data sources to identify current known geomorphological conditions and trends in river behaviour. A summary description of data sources is provided in Table 9.4.

Table 9.4: Data Sources Examined During the Desk Study

Data Source	Information Provided
Contemporary OS Plans	Basic contextual information, such as elevation, relative relief and an indication of channel gradient.
Geological Maps (solid and drift plus soils)	Enabled an understanding of the likely channel boundary conditions. This, in addition to the soils data, helped indicate the likely quantity and calibre of sediment released.
Geological Borehole Data	Augmented geological maps.
Aerial Photography	Basic contextual information about the site such as land use and vegetation types. Also provided information on the distribution of geomorphological features which helped the contemporary and past geomorphological processes to be understood.
Hydrological Data (where available)	Were used as the basis of sediment transport calculations to provide an indication of the likely impact of changes to channel morphology, in particular the channel gradient. Flood event hydrographs described the response of catchments to rainfall events, which can influence the nature and severity of erosional and depositional responses.
Historical Maps	Allowed changes in river channel planform to be determined over periods of up to 150 years, which provided an understanding of the nature of fluvial processes and allowed trends in channel behaviour to be elucidated.
Topographic Survey (where available)	Cross-sectional survey provided useful information about channel structure and gradient which were used, in conjunction with field study, to determine the dominant function of differing sections of channel such as zone of net erosion, transport or deposition.

9.2.51 The field study was designed to build on the findings of the desk study to determine the geomorphological forms and processes at each site. Walkover surveys were undertaken in April and November 2008 in the study area to visually inspect the watercourses.

9.2.52 The range of geomorphological information collected during the field study is summarised in Table 9.5.

Table 9.5: Information Obtained During Field Study

Data Source	Information Provided
Geomorphological Mapping	Geomorphological mapping, which involved producing a map of geological features, is a well established technique for characterising river channels. This allowed: • the pattern of existing erosion and deposition to be recorded; • the dominant function of differing sections of channel to be determined (sediment source, transfer and sink); and • the spatial arrangement of morphological forms to be determined allowing inferences to be made about contemporary and past geomorphological processes, thus enabling the identification of trends in channel behaviour. The impact of past management practices were also examined enabling inferences to be made about the potential consequences of interference to be made.
Boundary Condition Information	Determining the nature of boundary materials (bed and bank) enabled an insight to be gained into the intrinsic controls on patterns of erosion and deposition. This allowed the likelihood of morphological adjustments to channel interference to be determined.
Space for Time Substitution	This involved examining neighbouring watercourses, with similar geomorphological characteristics, which were subject to past modification such as realignment. This enabled the sensitivity of watercourses to modification to be determined and the likely morphological response predicted.

9.2.53 Combining the results of the desk and field study enabled the baseline conditions at the site to be determined in terms of sediment regime and fluvial processes together with an understanding of the morphological structure of the river channel. Establishing detailed baseline conditions provided the basis for determining the impacts of both construction and operation of the proposed scheme.

Impact Assessment

9.2.54 As DMRB HA 216/06 (Highways Agency et al., 2006b) does not outline a specific methodology to enable the geomorphological impacts to be evaluated, the methodology adopted in this appraisal was developed using the guidelines from Research and Development Programmes of the National Rivers Authority, Environment Agency and SNH including Environment Agency (1998a) and Sear et al. (2003). The approach to the assessment of impacts on fluvial geomorphology was also agreed with SEPA.

<u>Coastal Geomorphology</u>

Baseline Assessment

9.2.55 The baseline coastal geomorphological assessment was conducted using a review of map and admiralty chart data and the relevant published literature available, followed by a site visit.

9.2.56 The coastal and estuarine morphology of the Firth of Forth is intrinsically connected to the hydrodynamic conditions that prevail within the estuary. Therefore in addition to the outputs of the development, validation and calibration of the three dimensional (3-D) modelling of hydrodynamic conditions within of the Firth of Forth (refer to Appendix A9.1: Hydrodynamic Modelling) have also been utilised to inform the coastal/estuarine geomorphology baseline assessment.

Impact Assessment

9.2.57 As outlined above, hydrodynamic conditions within the Firth of Forth are directly linked to the coastal/estuarine geomorphology. Thus potential changes in the hydrodynamic conditions that could result from the construction, and subsequent operation, of the Main Crossing within the waterbody could be reflected by changes to the physical shape and form (i.e. the morphology) of the estuary. Therefore the outputs of the 3-D modelling of the impacts of the proposed scheme on hydrodynamic conditions in the Firth of Forth (Appendix A9.1: Hydrodynamic Modelling) have been utilised to inform the coastal/estuarine geomorphology impact assessment.

9.2.58 Following initial outputs and results of the hydrodynamic modelling, agreement was reached with SEPA, SNH and Marine Scotland (Appendix A6.3) to the effect that hydrodynamic conditions within the Firth of Forth would be altered by the proposed scheme to such a negligible extent (i.e. very little change from baseline conditions) that additional modelling of sediment erosion, transport and deposition patterns was not necessary.

9.2.59 As noted above, DMRB HA 216/06 (Highways Agency et al., 2006b) does not outline a specific methodology for evaluation of geomorphological impacts, and the methodology adopted for consideration of coastal geomorphology of the Firth of Forth was therefore developed using guidelines from DEFRA's Estuaries Guide (DEFRA, 2008) in consultation with the relevant regulatory bodies (SEPA, SNH and Marine Scotland; please refer to Appendix A6.1 and A6.3).

Water Quality

Baseline Assessment

9.2.60 The baseline water quality assessment was conducted using classification data received from SEPA, and water chemistry spot sampling undertaken at strategic locations along minor watercourses. These spot samples were undertaken in April and September 2008, and were used in this assessment to give an indication of the water chemistry of smaller watercourses not monitored by SEPA.

9.2.61 Baseline conditions for waterbodies are reported by SEPA in accordance with their current River, Estuarine and Coastal water quality classification schemes (refer to Appendix A9.5: Water Quality). This categorises waterbodies by monitoring water chemistry, biology, aesthetic condition and concentration of toxic substances. There are five river water quality classes comprising A1 (excellent), A2 (good), B (fair), C (poor) and D (seriously polluted). In addition, there are four estuarine and coastal water quality classes comprising A (excellent), B (estuarine: good/coastal: fair), C (unsatisfactory) and D (seriously polluted). The class allocated to a particular reach of a waterbody defaults to the poorest class determined from the water chemistry, biology, aesthetics and toxicity assessments.

9.2.62 SEPA has recently introduced a new risk-based WFD (2006/60/EC) classification system, which is a holistic approach to monitoring for a range of different pressures, helping to identify and monitor any pressures on waterbodies which may threaten the aims of the WFD (2006/60/EC). These pressures are generally anthropogenic and may include point source discharges, abstractions and morphological alterations such as culverts, realignments and impoundments. The new classification system for rivers, lochs, transitional and coastal waterbodies is based on an ecological classification system with five quality classes (High, Good, Moderate, Poor, Bad). It has been devised following EU and UK guidance and is underpinned by a range of biological quality elements, supported by measurements of chemistry, hydrology (changes to levels and flows) and morphology (changes to the shape and function of waterbodies). SEPA's WFD (2006/60/EC) classification of waterbodies is due to be released later in 2009, and therefore results from SEPA's previous water quality classification system have been used in this assessment. Where information is available on pressures and impacts on waterbodies for the (2006/60/EC) classification system, this has been provided in the baseline assessment.

Impact Assessment Methodology

9.2.63 Potential impacts during the construction phase are assessed qualitatively, with the exception of a sediment plume modelling assessment to investigate the impacts of potential increased suspended sediment concentrations within the Firth of Forth that could result from the dredging works associated with construction of the Main Crossing. Refer to Appendix A9.1 (Hydrodynamic Modelling) for details. However where impacts are relevant to water quality during the construction phase, the results of the assessment are summarised within this chapter.

9.2.64 The assessment of water quality impacts during the longer-term operational phase of the proposed scheme was carried out based on the methods set out in the DMRB HA 216/06 (Highways Agency et al., 2006b) and through liaison with SEPA. Cognisance has been taken of more recent research such as ‘Pollutant Build up and Runoff on Highways; Expanding the Current Methodology for Additional Determinants’ (Patel & Drieu, 2005). Refer to Appendix A9.5 (Water Quality) for further information on the water quality impact assessment methodology.

9.2.65 The impacts of road drainage on the quality of the receiving waters were quantified by assessing the build up of dissolved copper and total zinc, as well as the risk of accidental spillage in design year 2032 of the proposed scheme (15 years after year of opening). Dissolved copper and total zinc are used as indicators of the level of impact as they are generally the main metallic pollutants associated with road drainage and can be toxic to aquatic life in certain concentrations. Lead is not included as it has low solubility, and, when in its insoluble form, its low toxicity means that biological impacts would not be anticipated. There is little information available on background levels of other pollutants in watercourses against which the effects of routine runoff can be assessed (Highways Agency et al., 2006b). Flows in receiving watercourses are generally represented using low flow estimates provided by CEH (refer to Appendix A9.2: Surface Water Hydrology). These methods, whilst simple, tend to err on the conservative side.

9.2.66 Two separate calculations have been undertaken, as detailed below:

- pollution calculations (routine runoff assessment); and
- risk of accidental spillage (resulting in a serious pollution incident).

9.2.67 In addition a modified assessment of routine runoff has been undertaken for the Firth of Forth as a result of drainage from the proposed Main Crossing over the estuary channel (i.e. from low water mark on the south shore to low water mark on the north shore). This is based on the DMRB HA 216/06 guidance (Highways Agency et al., 2006b). There is no requirement to undertake, or published guidance to inform, such an assessment to an estuary however it has been included to give a holistic assessment of potential impacts to the water quality of the Firth of Forth, as agreed with SEPA in March 2009. The methodologies for these assessments are detailed in Appendix A9.5 (Water Quality).

Limitations to Assessment

9.2.68 There are certain limitations within each discipline with regards to the assessment methodologies, as outlined in the following paragraphs.

Hydrology and Flood Risk

9.2.69 Continuous monitoring of hydrological data in the study area is available for the River Almond. The remaining smaller watercourses are ungauged. The highest degree of accuracy is obtained where long-term monitoring data exists. For the proposed crossing points over smaller, ungauged watercourses, uncertainties are inherently larger. However, suitable recognised methodologies have been applied to these ungauged catchments to provide estimates of flows.

9.2.70 Flood risk related to groundwater sources is not specifically addressed in this chapter, as flood risk discussion is predominantly focussed on fluvial sources and drainage systems.

Water Quality

9.2.71 Spot sampling of a limited number of chemical parameters (dissolved oxygen, pH and conductivity) was undertaken at smaller watercourses not monitored by SEPA. These results provide only a snapshot of the water chemistry conditions in the watercourse at the time the sample was obtained and do not provide information in regards to the long-term health of a watercourse. However to provide a more robust assessment, information obtained from site visit observations, surrounding land use and any downstream designations have also been taken into consideration during the assessment.

9.3 Baseline Conditions

9.3.1 In this section, the baseline conditions are described and a level of sensitivity assigned to waterbodies (Table 9.1).

9.3.2 The paragraphs below describe the baseline situation for all waterbodies in the study area. The baseline conditions reflect the Do Minimum Scenario, which is based on an assumption of no proposed scheme and continued use of the Forth Road Bridge and associated road infrastructure. A summary is provided of the existing road drainage network for the Forth Road Bridge and approach road infrastructure (as well as any existing treatment levels, where applicable) and the sensitivity of each waterbody for each discipline is provided.

9.3.3 For fluvial geomorphology, the overall sensitivity of each watercourse to disturbance defaults to the highest susceptibility to change out of the natural fluvial processes, sediment regime and morphological diversity of the existing channel.

9.3.4 The waterbodies described below (and where applicable, the locations and SEPA sampling classifications) are shown on Figure 9.1, catchment areas on Figure 9.2, and 200-year flood extents on Figure 9.4. In addition, areas of potentially contaminated land are shown on geology Figure 8.1, and designated nature conservation sites on ecology Figure 10.1.

9.3.5 There are no known public/private surface water supplies or drinking water abstractions from waterbodies within the study area based on consultation with SEPA in January 2009. However, one surface water private water abstraction was identified within the study area, at Dundas Loch. This was recorded during consultation undertaken to identify private water supplies (PWS) and is used for irrigation purposes. All remaining PWS identified were groundwater abstractions and are assessed in Chapter 8 (Geology, Contaminated Land and Groundwater).

Watercourse/Waterbody Descriptions

<u>St. Margaret's Marsh</u>

9.3.6 St. Margaret's Marsh is located on the north shore of the Firth of Forth, to the west of the A90 and Forth Road Bridge. This area has developed on reclaimed intertidal land formed by the tipping of dredged waste during the development of Rosyth Naval Base from 1905-1945, and later from domestic waste by Dunfermline Burgh. Dunfermline Burgh also built Dunfermline Waste Water Treatment Works (WWTW) on the northern part of the site (SNH, 1999). Refer to Chapter 8 (Geology, Contaminated Land and Groundwater) for more details.

9.3.7 The site, covering an area of approximately 26.4ha, has been designated as a Site of Special Scientific Interest (SSSI) due to saltmarsh wetland and reedbed habitat. This environment provides important habitat for breeding and wintering birds, including curlew. In addition, Jacobs Arup ecologists recorded fish fry in the drainage ditches during surveys in autumn of 2008 (refer to Chapter 10: Terrestrial and Freshwater Ecology, and Figure 10.1: Designated Nature Conservation Sites).

Hydrology and Flood Risk

9.3.8 Based on evidence gathered from reports provided by Fife Council, as-built drawings from the existing A90 and a site visit, the marsh appears to be fed solely from local aquifers and direct precipitation. As inferred within Chapter 8 (Geology, Contaminated land and Groundwater) three groundwater bodies exist at the marsh; any surface water collecting within the marsh is attributable to the perched groundwater table. The drainage system from the existing A90 does not appear to discharge into the marsh area.

9.3.9 St. Margaret's Marsh is considered to be of medium sensitivity for hydrology and flood risk.

Water Quality

9.3.10 St. Margaret's Marsh originally comprised a natural intertidal zone, and was artificially infilled prior to the 1960s. The specific nature of the infill material is not known, however, it is believed to comprise marine sediments from the vicinity of the nearby Rosyth Naval Base. Low level radioactive waste has been historically discharged from the Rosyth Naval Base as part of nuclear submarine maintenance operations under formal discharge consent with SEPA (SEPA, 2004).

9.3.11 The eastern extent of St. Margaret's Marsh was used as a landfill for general and domestic waste between 1958 and 1972. The GI included the eastern boundary of St. Margaret's Marsh and identified extensive made ground and general refuse deposits. It is considered likely that the actual footprint of the former landfill extends beyond the marsh under the proposed scheme. An investigation in 2007 indicated that low concentrations of hydrocarbons were present in shallow and deep groundwater across the marsh; the analysis of deeper groundwater at the former landfill to the northeast of the marsh identified elevated concentrations of metals including copper, lead, nickel and zinc (Environ UK, 2007).

9.3.12 Further information on potential contamination within the area is provided in Chapter 8 (Geology, Contaminated Land and Groundwater).

9.3.13 St. Margaret's Marsh is considered to be of high environmental importance and has been assigned a high sensitivity for water quality.

<u>Linn Mill Burn</u>

9.3.14 Linn Mill Burn is a small gravel bed watercourse of approximately 3.5km in length, originating near Duddingston Wood. With a catchment of approximately 3.0km^2, it flows in a northerly direction through a rural catchment to the south shore of the Firth of Forth. Downstream of Society Road the watercourse follows natural drainage paths out onto the pebbly shoreline.

9.3.15 The underlying bedrock of the Linn Mill Burn catchment is predominantly Carboniferous Limestone Series (sedimentary rock) with pockets of igneous intrusive rocks (Basalt dolerite, camptonite and allied types). The catchment also comprises superficial glacial till deposits.

Hydrology and Flood Risk

9.3.16 SEPA flood risk mapping does not indicate a risk of fluvial flooding for this burn, although there is risk of tidal flooding from the Firth of Forth at its confluence with the coastline. The upper section of Linn Mill Burn traverses cultivated agricultural land and runs near South Queensferry WWTW; whereas the downstream reach flows through the residential development before discharging into the Firth of Forth. A report produced by the City of Edinburgh Council (2001) suggested that a culvert crossing through the residential development upstream of Society Road should be upgraded due to potential flood risk caused by blockage. No other evidence of past flooding along the Linn Mill Burn has been identified through discussions held in March 2009 with flood risk officials at the City of Edinburgh Council.

9.3.17 Based on this assessment, this reach of Linn Mill Burn has some hydrological importance as it runs near residential property and the WWTW, and may provide some flood alleviation value and may pose some flood risk within the residential area. It is therefore considered to be of medium sensitivity for hydrology and flood risk.

Water Quality

9.3.18 Linn Mill Burn is not classified under the SEPA water quality classification scheme. Spot sampling at two locations (NGR NT 1056 7733 and NT 1144 7871) by Jacobs Arup in 2008 suggest excellent (A1) for dissolved oxygen (DO) and pH levels. However, Linn Mill Burn is considered likely to receive anthropogenic pressure from agricultural activities. This watercourse does not support any designated water-dependent ecosystems.

9.3.19 Linn Mill Burn is considered to be of local or low environmental importance and has been assigned a low sensitivity for water quality.

Swine Burn

9.3.20 Swine Burn has a catchment area of $10km^2$ and is a tributary of the River Almond. The watercourse, which is approximately 8km in length, flows in a southeasterly direction through a predominantly rural catchment which includes agricultural land (Appendix A9.4, Photograph 1.1), and mixed and broadleaf woodland.

9.3.21 SEPA advised in January 2009 that Swine Burn is identified as WFD (2006/60/EC) risk status 1a (significantly at risk) and receives anthropogenic pressure from point sources of pollution (sewage disposal, mining and quarrying of oil shale and a refuse disposal activity), as well as realignments (morphological alterations) related to construction of the M9 and M9 Spur.

Hydrology and Flood Risk

9.3.22 The Swine Burn has hydrological connectivity with the Hopetoun fishery pond located within Swineburn Wood, the Humbie Reservoir and a reservoir located southwest of Kirkliston (referred to as Pike's Pond hereafter). From Humbie Reservoir to Kirkliston, the risk of flooding is shown by SEPA flood mapping as limited to land just outwith the banks.

9.3.23 In the reach of the Swine Burn upstream of where it is crossed by the M9 Spur, the channel traverses cultivated agricultural land, and undeveloped forested land in the lower portion of this reach. The culverts currently located along this reach (at Overton Road and the M9 Spur) have been shown to control flow during high return period events, based on hydrodynamic modelling findings. These flood modelling findings suggest that the culverts restrict flow into the reach of Swine Burn downstream of the M9 Spur crossing. As a result, the land adjacent to the burn along this reach includes flood storage areas (see 200 year flood extents shown on Figure 9.4). Based on this assessment, this reach of the Swine Burn contains limited hydrological importance, but its adjacent floodplains are shown to provide some flood alleviation benefit.

9.3.24 The reach of the Swine Burn located downstream of the existing M9 Spur culvert discharges into Pike's Pond. This reservoir then discharges over a cascade, through park land and is culverted through a planned residential development area currently under construction (where the Maltings Distillery was located). Finally, the Swine Burn flows under the existing B800 roadway and discharges into the River Almond. SEPA flood mapping presents the 0.5% AEP (1 in 200-year return period) flood extents outside the channel of the Swine Burn along this reach (SEPA, 2009). Based on discussions with the flood officer at the City of Edinburgh Council in March 2009 and anecdotal evidence of historical flooding, the area of greatest flood risk is near the confluence with the River Almond.

9.3.25 Based on this assessment, this reach of the Swine Burn contains some hydrological importance, and the reservoirs and parkland floodplains could provide some flood alleviation benefit. Therefore it is considered to be of medium sensitivity for hydrology and flood risk.

Fluvial Geomorphology

9.3.26 For most of its length Swine Burn is a gravel-bed stream with a moderate to low gradient. The channel has been extensively modified by straightening, deepening and re-sectioning; the watercourse shows little variation in form. The bed is generally smothered by fine sediment and this results in limited flow diversity. The watercourse is interrupted by Humbie Reservoir and Pike's Pond, which act as sinks for fine sediment.

9.3.27 In the vicinity of the M9 however, the burn has a sinuous planform and shallow gravel-bed channel with pools and riffles. These features provide a high degree of morphological diversity. The channel has fragmentary tree lining. There is some large woody debris in the channel, from fallen trees and branches which snags fly tipped material (Appendix A9.4, Photograph 1.2). Downstream of the minor road bridge at NT 1100 7460 there is a significant amount of rubbish tipped on the floodplain and within the channel (Appendix A9.4, Photograph 1.2). The banks of Swine Burn are fairly cohesive and are steep as a result of clay being present in the soil. Remnants of bank protection are present in the form of sections of historic walling which comprises moss covered laid stone (typically the size of cobbles). The bed comprises sand and fine gravels with some silt on the margins. In places the historic walling has failed and the stones have fallen onto the channel bed.

9.3.28 Where Swine Burn runs parallel to the M9 embankment, which forms an artificial valley side (Appendix A9.4, Photograph 1.3), there is evidence of past channel straightening. In addition to this, the left hand bank appears to have been modified by past quarrying with rock waste material (spoil) present on the valley side. However, the watercourse has subsequently re-adjusted its morphology towards a more natural form. At this location, the watercourse has a two-stage cross-sectional form. Field evidence and historical maps indicate that historical channel modifications involving channel straightening, widening and deepening occurred prior to 1856 and were designed to improve flow conveyance. Subsequent readjustment involved the deposition of sediment within the channel, forming alternate side bars, which were subsequently colonised by vegetation forming berms, which provide a degree of sinuosity.

9.3.29 The section of Swine Burn in the vicinity of the proposed scheme (with the exception of the section described above running parallel to the M9) has a relatively high morphological diversity with a more natural planform (as a result of the development of berms); natural cross-section for a cobble stream; varied flow types; and varied bank top vegetation. This high morphological diversity is maintained by active sediment transport on the bed of the channel. The relatively high morphological diversity of the watercourse and evidence of historic adjustment to engineering means the watercourse has a medium sensitivity to disturbance.

Water Quality

9.3.30 Swine Burn is classified under SEPA’s water quality classification scheme as Class A2 (good), apart from a localised downgraded stretch of Class C (poor) upstream of its confluence with the River Almond in the vicinity of the distillery (approximate NGR NT 1228 7430). The watercourse is a key tributary of the River Almond which is designated as a salmonid fishery river and in addition to the pressures highlighted above, is considered likely to receive anthropogenic pressure from agriculture and road drainage.

9.3.31 Swine Burn is considered to be of medium environmental importance and has been assigned a medium sensitivity for water quality.

<u>Tributary of Swine Burn</u>

9.3.32 This short watercourse originates in Ross’s Plantation to the west of the M9 near Charles Bridge. The tributary is crossed by the M9 downstream of the Charles Bridge culvert and discharges into the main stem of the Swine Burn approximately 50m north of this culvert.

Hydrology and Flood Risk

9.3.33 Site visit observations and historical maps of the area indicate that this watercourse may have once been connected to Niddry Burn. This may also explain the past channel modifications (walling and channel enlargement) along Swine Burn downstream of the confluence with this tributary. However, it currently only receives local drainage from a small woodland area (Ross’s Plantation) upstream of the M9 crossing.

9.3.34 Based on site observations, the existing culverts along this tributary appear to be oversized for the existing flow regime through the channel. No residential properties are located near or in this catchment area. Based on these observations, the Tributary of the Swine Burn contains minimal hydraulic importance and minimal flood alleviation benefit. It is therefore considered to be of low sensitivity for hydrology and flood risk.

Fluvial Geomorphology

9.3.35 This gravel-bed stream has been extensively modified by straightening and culverting (Appendix A9.4, Photograph 1.4). Immediately downstream of the culvert the banks are concrete lined for approximately 25m. After this reach there is a short section of scour protection. The banks of the tributary are clay rich earth and are generally covered by vegetation. The bed consists of silt, sand and gravel. There is some woody debris within the channel.

9.3.36 The channel has been extensively modified through culverting and realignment giving an artificial channel form. This watercourse has low sensitivity to geomorphological disturbance.

Water Quality

9.3.37 The Tributary of Swine Burn is not classified under SEPA's water quality classification scheme and no spot sampling was undertaken. This small watercourse acts predominantly as a drainage channel and is considered likely to receive anthropogenic pressure from agriculture, forestry and road drainage. It does not support any designated water-dependent ecosystems.

9.3.38 The Tributary of Swine Burn is considered to be of local or low environmental importance and has been assigned a low sensitivity for water quality.

Niddry Burn

9.3.39 Niddry Burn, located to the west of Kirkliston, is a tributary of the River Almond. It is approximately 7km in length and has a catchment area of 20.64km^2. The catchment has a predominantly rural land use.

9.3.40 SEPA advised in May 2008 that Niddry Burn is identified as WFD (2006/60/EC) risk status 1a (significantly at risk) and receives anthropogenic pressure from diffuse sources of pollution (mixed farming) and point sources of pollution (sewage disposal), as well as morphological alterations caused by historical straightening of the watercourse. SEPA advised in January 2009 that Niddry Burn has a draft WFD (2006/60/EC) status of moderate.

Hydrology and Flood Risk

9.3.41 Immediately upstream of the M9 crossing, the Niddry Burn traverses predominantly cultivated agricultural land and runs within 20m of residential property (located approximately 1km upstream of the existing M9 crossing). Current SEPA flood risk mapping does not present a flood risk zone along this reach of the Niddry Burn. However, results of the site walkover have identified that the connectivity between the Niddry Burn and the Tributary of Swine Burn was erroneously represented in the SEPA flood maps, and subsequently, the Niddry Burn flood risk zone was misrepresented. Findings from the flood modelling exercise suggest that the floodplain extends outside the banks of the Niddry Burn (see 200 year flood extents shown on Figure 9.4) and that there are some residential properties in the area at risk of flooding from the 0.5% AEP event (1 in 200-year return period). Due to the flat topography adjacent to the Niddry Burn and the hydraulic control provided at the existing M9 culvert, some flood storage exists upstream of the M9 culvert.

9.3.42 Based on this assessment, this reach of the Niddry Burn contains limited hydrological importance, but its floodplains are shown to provide some flood alleviation benefit. It is considered to be of medium sensitivity for hydrology and flood risk.

Fluvial Geomorphology

9.3.43 This gravel-bed burn has been subject to localised modifications in the form of localised realignment and culverting (Appendix A9.4, Photograph 1.5). Immediately upstream of the M9 culvert, both banks of the channel have full bank protection for approximately 30m. Despite the localised modifications, the watercourse has good morphological diversity and evidence of active bed sediment movement. The channel bed is characterised by pools and riffles and occasional exposed gravel bars are also present. Although the channel appears to have been modified in the past, by straightening, the watercourse is re-naturalising towards a more natural morphology through sediment deposition and erosion. This is driving localised channel migration and an increase in sinuosity. This adjustment has lead to the formation of a low river terrace on the left hand bank of the channel (Appendix A9.4, Photograph 1.6).

9.3.44 Despite localised modification, Niddry Burn shows evidence of active morphological adjustment through sediment transport, erosion and deposition which has allowed the development of diverse channel morphology. The watercourse is therefore considered to be of medium sensitivity to geomorphological disturbance.

Water Quality

9.3.45 Niddry Burn is classified under SEPA's water quality classification scheme as Class B (fair). However, it is included in the designation with the River Almond as proposed salmonid waters under the Freshwater Fisheries Directive (2006/44/EC). As well as the pressures highlighted above, the watercourse is also considered likely to receive anthropogenic pressure from agriculture and road drainage.

9.3.46 Niddry Burn is considered to be of high environmental importance and has been assigned a high sensitivity for water quality.

Tributary of Niddry Burn

9.3.47 The Tributary of Niddry Burn originates at NGR NT 0980 7350 and is approximately 2.5km in length, draining a small catchment. The watercourse flows in an easterly direction past Newliston, through two online ponds impounded by weirs near Newliston House before crossing the M9 and finally discharging into Niddry Burn approximately 180m upstream of the Niddry Burn and River Almond confluence. SEPA confirmed in March 2009 that this impounded is authorised under CAR. The ponds are associated with Newliston House and appear to be ornamental features.

Hydrology and Flood Risk

9.3.48 The Tributary of Niddry Burn appears to be an engineered channel that conveys flow from ponds located on the Newliston Estate in an easterly direction. It crosses the M9 and discharges into the main stem of the Niddry Burn approximately 200m east of the M9 crossing. This mildly sloped channel traverses predominantly cultivated agricultural land. Current SEPA flood risk mapping does not identify a flood risk zone along this watercourse due to its small catchment area (less than $3km^2$). However, results of hydraulic analysis suggest that some flood attenuation is provided along the banks of this watercourse upstream of the M9 crossing. Results from hydrological analysis indicate that peak flows from this watercourse are substantially lower than those of Niddry Burn (approximately 5% of peak flows from the Niddry Burn) and are attenuated by the M9 crossing. As a consequence, flows from the Tributary of Niddry Burn are not expected to exacerbate flood risk potential along Niddry Burn. Based on this assessment, this reach of the Tributary of Niddry Burn contains minimal hydrological importance, and minimal flood alleviation benefit for higher flood risk areas along Niddry Burn. It is therefore considered to be of low sensitivity for hydrology and flood risk.

Fluvial Geomorphology

9.3.49 The watercourse has a straight planform due to human modifications, presumably to improve land drainage adjacent to the channel. The watercourse now has the characteristics of a drainage ditch. Most of the land use is arable farmland, with pockets of improved grassland. Bank top vegetation is predominantly long grasses, with occasional clumps of trees.

9.3.50 Due to the highly modified nature of this watercourse, relatively small catchment and flow regulation by upstream ponds, which reduce downstream sediment supply, the tributary is considered to be of low sensitivity to geomorphological disturbance.

Water Quality

9.3.51 This Tributary of Niddry Burn is not classified under SEPA's water quality classification scheme. Spot sampling undertaken just upstream of the confluence with Niddry Burn (NGR NT 1224 7391) by Jacobs Arup in 2008 suggest excellent (A1) dissolved oxygen (DO) and pH levels. However, the small burn, acting predominantly as a field drainage channel, is considered likely to receive anthropogenic pressure from agricultural activities and road drainage. It does not support any designated water-dependent ecosystems.

9.3.52 The Tributary of Niddry Burn is considered to be of local or low environmental importance and has been assigned a low sensitivity for water quality.

River Almond

9.3.53 The River Almond is the largest watercourse near the proposed scheme, approximately 50km long, rising in the Cant Hills above Harthill (approximate NGR NS 8740 6280) and draining to the Firth of Forth at Cramond. It has a catchment area of approximately 388km² and receives flow from the Niddry Burn and Swine Burn.

9.3.54 The watercourse is identified as WFD (2006/60/EC) risk status 1a (significantly at risk).

9.3.55 SEPA assesses and monitors the pressures in upstream and downstream reaches from Maitland Bridge, which is immediately upstream of the confluence of Niddry Burn and the River Almond (NGR NT 1235 7388). SEPA advised in May 2008 that upstream of Maitland Bridge, the River Almond receives anthropogenic pressure from a diffuse source (urban development) and point sources of pollution (sewage disposal), as well as morphological alterations. Downstream of Maitland Bridge, the river receives anthropogenic pressure from diffuse sources (BOD, DO and phosphorus related to air transport, urban development and livestock farming), point sources of pollution (DO and phosphorus related to sewage disposal), as well as a morphological alteration caused by an embankment, related to flood defence.

9.3.56 SEPA advised in January 2009 that the River Almond in the location of the proposed scheme has a draft WFD (2006/60/EC) status of poor.

Hydrology and Flood Risk

9.3.57 SEPA flood mapping indicates that the 0.5% AEP (1 in 200-year return period) floodplain near the confluences with the Niddry Burn and Swine Burn extends over the existing B800 roadway and some residential development. The flood officer at the City of Edinburgh Council has confirmed past flood events in this area (including flooding of some residential property), which are attributed to high water levels within the River Almond (as provided by City of Edinburgh Council in March 2009). A flood study has previously been developed to include the River Almond downstream of Kirkliston from Newbridge to Crammond Brig and from the City Bypass to the Airport to investigate flood risks at the airport. In addition, the City of Edinburgh Council has cooperated with Edinburgh Airport to improve flood protection from the River Almond near the airport (City of Edinburgh Council, 2001).

9.3.58 As described above, the River Almond poses a flood risk to critical infrastructure, some minor roadways and some residential development. As such, it is considered of high hydrological importance, its floodplains provide some flood alleviation benefit and is therefore considered to be of high sensitivity for hydrology and flood risk.

Fluvial Geomorphology

9.3.59 In the vicinity of the M9, the River Almond is a moderate to low gradient gravel-bed river with an irregularly sinuous planform, which has been historically realigned and re-sectioned in places. The bankfull width is approximately 30m and channel depth is approximately 3m. The channel banks have been engineered and re-profiled, giving the channel a trapezoidal cross section (Appendix A9.4, Photograph 1.7). The dominant flow type at the site of survey is smooth glide, reflecting the engineered channel form and relatively deep water. The banks are protected by boulders placed along the bank toe. The bank faces are well vegetated and young trees are growing on the river bank face on both sides of the channel. There is one bridge pier in the channel and an existing outflow. There is also an existing outfall at this location. This river is crossed by the M9.

9.3.60 The relatively large size of this watercourse means that modifications to channel form could trigger morphological adjustment. However, as the existing channel has been modified and for a watercourse of its size, it shows limited morphological diversity. The watercourse is considered to be of medium sensitivity to geomorphological disturbance.

Water Quality

9.3.61 The watercourse is classified under SEPA's water quality classification system as Class B (fair) upstream and in the vicinity of the proposed scheme, downgrading to Class C (poor) from Hallyards (NGR NT 1300 7380) to the Firth of Forth. SEPA advised in March 2009 that in the vicinity of the proposed scheme there is a licensed point source discharge of treated sewage effluent from Breastmill to the south of Kirkliston, outfalling at NGR NT 1233 7379. The River Almond is designated as proposed salmonid waters under the Freshwater Fisheries Directive (FWFD; 2006/44/EC), and is designated as a Site of Importance for Nature Conservation (SINC) at county/authority level. Fish species of conservation concern have been recorded in the watercourse, including Atlantic salmon, sea trout and brown trout as referred to in Chapter 10 (Terrestrial and Freshwater Ecology).

9.3.62 Studies have shown an overall improvement in the classification of stretches between 1996 and 2006 (SEPA, 2006a, 2006b). Nutrient concentrations have significantly improved, with only 14% of measured stretches achieving good status for nutrients in 1999, compared with 100% in 2004. There have also been significant improvements (i.e. reductions) in ammonia and phosphorus concentrations (SEPA, 2006a). Indeed, in 2006 the river supported trout populations and kingfishers were established around it, which are indicators of improving water quality (SEPA, 2006b).

9.3.63 Historically mine waters contributed to poor water quality in the River Almond catchment. Although most mining operations have ceased and remediation projects are ongoing, abandoned operations still pose a threat to water quality, particularly in terms of iron concentrations (SEPA, 2006a, 2006b).

9.3.64 The River Almond is used as a water resource and water is abstracted from the river at Almondell Country Park to feed the Union Canal (SEPA, 2006a).

9.3.65 The River Almond is considered to be of high environmental importance and has been assigned a high sensitivity for water quality.

Ferry Burn

9.3.66 Ferry Burn is a small watercourse which originates to the south of South Queensferry in Ferry Muir and drains a heavily urbanised catchment. Ferry Burn is approximately 1km long, with a catchment area of approximately 2.3km², and flows in a northerly direction through sections of both open and culverted channel towards the Firth of Forth.

Hydrology and Flood Risk

9.3.67 The upper portion of the Ferry Burn catchment is predominantly agricultural; while the lower portion is heavily urbanised with medium density housing development. The upper portion of the catchment drains through a network of pipe drains into a manhole directly upstream of the M9 Spur motorway. This flow is conveyed under the under the M9 Spur and into a channel which flows through the urban portion of the catchment. The channel crosses a number of culverts, enters a wooded area known as Jocks Hole, and discharges into the Firth of Forth. Flooding concerns along the Ferry Burn are related to blockage of the culverts in the urban section of the channel.

9.3.68 Based on this assessment, Ferry Burn has some hydrological importance as it runs near residential property, and has some flood attenuation capacity at the Jocks Hole area. Therefore Ferry Burn is considered to be of medium sensitivity for hydrology and flood risk.

Fluvial Geomorphology

9.3.69 Where the channel of Ferry Burn is open, it comprises a gravel and sandy bed with earthy and vegetated banks (Appendix A9.4, Photograph 1.10). The watercourse discharges into the Firth of Forth through a sewer pipe which extends out into the estuary (Appendix A9.4, Photograph 1.11). Ferry Burn is fed by local drainage ditches and receives drainage from agricultural ditches and the motorway embankment.

9.3.70 Ferry Burn has a low sinuosity as a result of extensive channel modifications. These modifications are principally in the form of historic channel straightening and realignments to drain the periphery of residential areas. The extensive modification and culverting means the watercourse has a low sensitivity to geomorphological disturbance.

Water Quality

9.3.71 Ferry Burn is not classified under SEPA's water quality classification scheme and no spot sampling was undertaken. This small watercourse is considered likely to receive anthropogenic pressure from existing road drainage. It does not support any designated water-dependent ecosystems.

9.3.72 Ferry Burn is considered to be of local or low environmental importance and has been assigned a low sensitivity for water quality.

Dolphington Burn

9.3.73 Dolphington Burn is located south of South Queensferry. The watercourse originates within the Dundas Estate and flows in an easterly direction to the south of Dalmeny. It has a catchment area of approximately 3.7km².

9.3.74 The watercourse is identified as WFD (2006/60/EC) risk status 1a (significantly at risk). SEPA advised in March 2009 that Dolphington Burn receives anthropogenic pressure from agriculture and urban wastewater, including licensed point source discharges of treated sewage effluent from Dundas Home Farm and Dalmeny WWTW.

Hydrology and Flood Risk

9.3.75 Dolphington Burn appears to be an engineered channel that conveys local drainage in an easterly direction under the existing M9 Spur. The reach of the Dolphington Burn upstream of the M9 Spur traverses cultivated agricultural land; whereas the section downstream of the M9 Spur is crossed by two railway lines before being culverted under a sewage works and oil storage depot. SEPA flood mapping indicates that the 0.5% AEP (1 in 200-year return period) flood risk zone generally extends outwith the northern banks of the Dolphington Burn for the reach downstream of the rail crossing at Dalmeny. There are no properties located near the watercourse.

9.3.76 Based on this assessment, this reach of the Dolphington Burn has some hydrological importance as it is culverted under Dalmeny WWTW, but appears to currently provide minimal flood alleviation value. It is therefore considered to be of medium sensitivity for hydrology and flood risk.

Fluvial Geomorphology

9.3.77 Dolphington Burn is a low lying stream with no visible valley sides. Downstream of the A90 trunk road, to the east of Dalmeny, the watercourse becomes Cockle Burn, which flows directly into the outer Firth of Forth. The watercourse flows through a mixture of mixed woodland and agricultural land and has several tributaries, primarily field drains. It is a gravel-bed stream, with earthy banks (Appendix A9.4, Photograph 1.8).

9.3.78 The watercourse has a straight channel as a result of extensive channel modifications (Appendix A9.4, Photograph 1.8). These modifications are principally in the form of historic channel straightening and realignments to follow tracks and field boundaries. The burn is culverted in several locations as it passes beneath roads, railways and the Oil Storage Depot at Dalmeny. The watercourse was culverted and realigned during the construction of the M9 Spur (Appendix A9.4, Photograph 1.9). There is also evidence that the watercourse is periodically dredged to improve flow conveyance. As a result of this extensive modification, the watercourse has a very uniform morphology with little evidence of active fluvial processes. However, there is evidence of localised active adjustment in response to the channel engineering, such as beneath the recently completed M9 Spur.

9.3.79 Underneath the M9 Spur road bridge Dolphington Burn has been straightened, deepened and re-profiled. The banks are steep and free from vegetation. As a consequence of this modification the toe of the bank (lower 0.3m) has been eroded by recent high flows releasing sediment downstream, which has created localised areas of deposition.

9.3.80 As this watercourse has been extensively modified through realignment, re-sectioning and crossing structures it is considered to be of low sensitivity to geomorphological disturbance.

Water Quality

9.3.81 Dolphington Burn is classified under SEPA’s water quality classification scheme as Class B (fair) upstream of the oil storage depot and sewage works (NGR NT 1440 7678), degrading to Class C (poor) downstream. The watercourse does not support any designated water-dependent ecosystems.

9.3.82 Dolphington Burn is considered to be of local or low environmental importance and has been assigned a low sensitivity for water quality.

<u>Firth of Forth</u>

9.3.83 The Forth is sometimes referred to as an estuary upstream of the existing Forth Road Bridge and a firth downstream of the Forth Road Bridge (Figure 9.1). However, as noted in the ES glossary, for the purposes of this assessment and for consistency with other ES chapters, the term ‘Firth of Forth’ is used when referring to this waterbody.

9.3.84 The Firth of Forth, on the east coast of Scotland, is a sheltered inlet of the North Sea and extends from the estuary of the River Forth. It has a total catchment area of 4,530km^2. From the tidal water limit west of Stirling to North Berwick it covers an area of 1,670km^2.

9.3.85 At Stirling the waters are shallow and brackish, i.e. a mix of sea and freshwater from the river. Expanses of intertidal mudflats are exposed at low tide that are rich feeding areas for birds. The channel between North and South Queensferry has historically been bridged first by the Forth Rail Bridge and then later by the Forth Road Bridge. A deep channel allows large ships to pass under the bridges to the ports of Rosyth and Grangemouth. Downstream of the bridges, the Firth of Forth widens out and the shores become sandy and rocky, interspersed with fishing villages.

9.3.86 The waterbody in the vicinity of the proposed Main Crossing is identified as WFD (2006/60/EC) risk status 2a (probably not at risk). It is not considered as a whole to be heavily modified. The Firth of Forth receives anthropogenic pressures from morphological alterations such as dredging (resulting in sediment removal) and land reclamation. SEPA advised in January 2009 that the Firth of Forth in the area of the Main Crossing has a draft WFD (2006/60/EC) status of moderate.

9.3.87 The Firth of Forth is an important estuarine water resource and is of international ecological importance. It includes two Special Protection Areas (SPAs), a Ramsar site and several Sites of Special Scientific Interest (SSSI), designated for its various habitats for water-dependent sensitive species (intertidal mudflat, saltmarsh and rocky shores) and significant populations of migratory and wintering birds (refer to Chapter 11: Estuarine Ecology). Reports to Inform an Appropriate Assessment (IIAA) of impacts to the two SPAs, i.e. the Firth of Forth SPA and the Forth Islands SPA, have been prepared and submitted for statutory consultation, as required by Article 6 of the Habitats Directive (92/43/EEC). Imperial Dock Lock SPA at the mouth of the Firth of Forth is also considered within the Forth Islands IIIAA reports.

Hydrology and Flood Risk

9.3.88 The coastline in the survey area is shown by SEPA indicative flood mapping to be at risk of flooding from the sea on both the north and south shores of the Firth of Forth.

9.3.89 The Firth of Forth is considered to be of high sensitivity for hydrology and flood risk due to its critical economic and social uses.

Coastal Geomorphology

9.3.90 The Firth of Forth is a fjard type estuary which is described as an indented drowned feature fringing rocky, glaciated lowlands (DEFRA, 2008). The estuary was created predominantly by glacial action excavating deep basins as it scoured the landscape, exploiting existing river valleys. Following the last ice age some 7000 years ago, the ice retreated and sea-levels rose, flooding the Forth valley up to Menteith and Aberfoyle. Following ice retreat, the land rose through a process of glacio-isostatic readjustment and the flat fertile lands (the Carselands) at the head of the Firth of Forth emerged from the water. They were at first covered in peat, however the area was gradually reclaimed to become fertile farmland and subsequently became in demand for industrial development and transport links. The diverse morphological nature of the Firth of Forth includes saltmarshes, dune systems, maritime grasslands, heath and fen, cliff slopes, shingle and brackish lagoons.

9.3.91 Extensive mudflats occur particularly in the inner estuary, notably upstream at Kinneil Kerse and Skinflats on the south shore and Torry Bay on the north shore. Typically, the flats support a rich invertebrate fauna, with eelgrass (*Zostera* spp.) growing on the main mudflats, these features provide important food sources for the large numbers of migrating and wintering waterbirds that depend on the estuary. In the outer estuary, the shoreline diversifies, with sandy shores, some rocky outcrops, mussel beds and some artificial sea walls. The North Berwick coast includes cliffs and dune grassland, with extensive dune systems at Aberlady.

9.3.92 The proposed crossing is within the 'Lower Forth Estuary' waterbody (ID 200435) in the Scotland River Basin District as classified by SEPA (2008c), as shown on Figure 9.1. Its typology is defined as transitional, partly mixed/stratified, mesohaline/polyhaline, strongly mesotidal and sheltered.

9.3.93 The morphology of the shoreline and channel of the Firth of Forth (in the location of the proposed Main Crossing) has historically been modified by engineering structures including the protruding walls and associated infrastructure of the Port of Rosyth (north shore) and Port Edgar (south shore); land claim and sea defence structures at North Queensferry and St. Margaret's Marsh (north shore) and South Queensferry (south shore); engineered bridge structures relating to the Forth Road Bridge and Forth Rail Bridge affect both the North and South shorelines of the Firth of Forth, as well as the in-channel morphology.

9.3.94 Overall, the Firth of Forth is considered to be of high sensitivity for coastal/estuarine geomorphological disturbance.

Water Quality

9.3.95 Most of the Firth of Forth, including the waters surrounding the proposed Main Crossing, is classified under the SEPA estuarine water quality classification system as Class B (good). However, there are some intertidal areas further afield that are downgraded to Class C (unsatisfactory) as a result of historic discharges. SEPA advised in March 2009 that in the location of the proposed Main Crossing there is a licensed point source discharge of treated sewage effluent from South Queensferry WWTW, outfalling at NGR NT 1186 7951.

9.3.96 SEPA advised in January 2009 that there are no designated bathing waters (Bathing Water Directive (2006/7/EC)) in the vicinity of the proposed scheme. The nearest are Aberdour (Silver Sands) (NGR NT 200 853) and Portobello West (NGR NT 310 740), both located in the outer Firth of Forth.

9.3.97 Studies have shown a substantial reduction in total load of biochemical oxygen demand (BOD) to the Firth of Forth between 1983 and 2001. This is mainly due to a continuous reduction in discharges of organic waste to the Firth of Forth achieved through improvements to effluent treatment (SEPA 2000, 2006b). Data gathered between 1980 and 1999 have indicated that the length of Firth of Forth affected by low dissolved oxygen (DO) concentrations has decreased and that there has been a decrease in the duration of the oxygen sag. These are both indicators of improving water quality (SEPA, 2000). Fish populations have increased in the upper estuary in line with increasing DO concentrations, including the appearance of smelt in 1991, a species sensitive to low dissolved oxygen concentrations (SEPA, 2000).

9.3.98 Water samples collected on quarterly surveys from the Firth of Forth between 1986 and 1996 have shown that all dissolved trace metals fell well within their respective Environmental Quality Standards (EQS) values. However, this is partly due to the turbid nature of the Firth of Forth which results in particle-reactive elements being removed from solution (i.e. exist in particulate form). Over the sampling period there has been a significant reduction in the concentrations of many of the metals sampled, particularly cadmium, mercury, lead and zinc (SEPA, 1998). Chapter 8 (Geology, Contaminated Land and Groundwater) and Chapter 11 (Estuarine Ecology) provide further information on potential contamination and sediment-bound contaminant concentrations within the sediments of the Firth of Forth.

9.3.99 Road drainage from the existing Forth Road Bridge discharges directly to the Firth of Forth through regular outfalls which extend below the level of the deck. This is considered to have a marginal impact on water quality due to the size and high dilution capacity of the waterbody, and the high level outfalls promote dispersal over the estuary.

9.3.100 The Firth of Forth, which supports internationally-designated water-dependent ecosystems, is considered overall to be of high environmental importance and has been assigned a high sensitivity for water quality.

Existing road drainage network

9.3.101 Table 9.6 summarises the road drainage network on existing roads that are to be upgraded as part of the proposed scheme. Current levels of road drainage treatment, where known, are included.

Table 9.6: Existing Road Drainage Network

Road Name	New Drainage Watercourse	New Drainage Run Number	Existing Road Drainage Length (m)	Approximate Existing Road Drainage Area (m^2)	Existing Drainage/Level of Treatment
Existing M9 (ch2500 -2200)	Swine Burn	Run A	300	3,850	Gullies and perforated pipes prior to direct outfall.
Existing M9 Spur		Run E	1,230	27,675	Combination of filter drains, and gullies and perforated pipes prior to outfall into ditches.
Existing M9 (ch2500 – 2180)	Tributary of Swine Burn	Run B	320	3,835	Gullies draining to ditch prior to direct outfall.
Existing M9 (ch1290 – 2200) & M9 to M9 spur links	Niddry Burn	Run C	1,910	38,442	Gullies and perforated pipes draining to ditches prior to direct outfall.
Existing M9 (ch610 – 1290)	River Almond	Run D	680	21,100	Gullies and perforated pipes draining to ditches prior to direct outfall.
Existing A90 & Ferrytoll Junction	Firth of Forth (north section)	Run Q	6,120	72,992	Combination of: • kerb and/or gullies, porous pipes and rubble drains; and • filter drains and/or gullies.

9.3.102 The information indicates that a proportion of existing drainage either outfalls directly to a watercourse with no treatment or undergoes one or two levels of treatment before discharge, i.e. perforated pipes, filter drains or rubble drains. Overall, the current road drainage system provides limited or no SUDS:

- treatment of pollutants found in road drainage runoff;
- control of surface water runoff rates; and
- accidental spillage containment.

9.3.103 The existing drainage systems are potentially affecting the baseline water quality of Swine Burn, the Tributary of Swine Burn, Niddry Burn and Ferry Burn. Due to the level of dilution provided by the River Almond and the Firth of Forth, baseline water quality in these waterbodies is not likely to be significantly affected by existing road drainage.

Summary of waterbody sensitivities

9.3.104 Table 9.7 summarises the sensitivities assigned to each waterbody, for each surface water discipline, using the criteria outlined in Table 9.1.

Table 9.7: Sensitivity of Surface Water Features for the Proposed Scheme

Watercourse/Waterbody	Discipline	Sensitivity
St. Margaret's Marsh	Hydrology and Flood Risk	Medium
	Water Quality	High
Linn Mill Burn	Hydrology and Flood Risk	Medium
	Water Quality	Low
Swine Burn	Hydrology and Flood Risk	Medium
	Fluvial Geomorphology	Medium
	Water Quality	Medium
Tributary of Swine Burn	Hydrology and Flood Risk	Low
	Fluvial Geomorphology	Low
	Water Quality	Low
Niddry Burn	Hydrology and Flood Risk	Medium
	Fluvial Geomorphology	Medium
	Water Quality	High
Tributary of Niddry Burn	Hydrology and Flood Risk	Low
	Fluvial Geomorphology	Low
	Water Quality	Low
River Almond	Hydrology and Flood Risk	High
	Fluvial Geomorphology	Medium
	Water Quality	High
Ferry Burn	Hydrology and Flood Risk	Medium
	Fluvial Geomorphology	Low
	Water Quality	Low
Dolphington Burn	Hydrology and Flood Risk	Medium
	Fluvial Geomorphology	Low
	Water Quality	Low
Firth of Forth	Hydrology and Flood Risk	High
	Coastal/Estuarine Geomorphology	High
	Water Quality	High

9.4 Potential Impacts

Introduction

9.4.1 This section describes the potential impacts on the water environment that could arise in the absence of mitigation, during both the construction and operational phases of the proposed scheme. Residual impacts taking into account proposed mitigation are then provided in Section 9.6.

9.4.2 Generic potential impacts for each discipline are described, followed by specific impacts on water features, firstly during the construction and then the operational phases of the proposed scheme. Specific potential impacts to the water environment are summarised in Table 9.20 at the end of Section 9.4.

9.4.3 Construction impacts are generally relatively short-term. However, some potential construction impacts such as deposition of sediments in watercourses can have longer-term impacts. Operational impacts are those that occur during scheme operation; they are generally long-term or permanent and would influence the waterbodies after the proposed scheme is complete. Potential impacts on the water environment are described separately for each of the three specialist disciplines as detailed in Section 9.2 (Approach and Methods). Unless otherwise stated, the impacts considered are adverse and are assigned significance based on the criteria set out in Table 9.3.

Generic Construction Impacts – Watercourses

Hydrology and Flood Risk

9.4.4 Potential impacts during construction of the proposed scheme could include soil compaction from works traffic, alteration of runoff pathways, erosion and sedimentation of watercourses, dewatering of watercourses and increased flood risk.

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

9.4.6 The construction phase of the project could result in alterations to the hydrological and flood regimes of receiving watercourses. Temporary discharge of working area drainage may also have an impact on the sediment regime of the receiving watercourse.

9.4.7 During the construction phase, other temporary works that could affect surface hydrology include the following:

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

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

9.4.9 Construction works materials and plant placed within the floodplain of watercourses may increase localised flood risk and could be damaged during a flood event.

Fluvial Geomorphology

9.4.10 Potential impacts during the construction phase mostly relate to suspended solids. In addition, weather conditions would also influence the severity of impacts. The majority of these impacts would worsen during intense or prolonged rainfall events during the construction phase.

9.4.11 Table 9.8 outlines potential generic impacts on the geomorphology during the construction of the proposed scheme. The main potential impacts relate to an increase in fine sediment delivery, a reduction in morphological diversity and a change in natural fluvial processes of river channels.

Table 9.8: Potential Impacts on Geomorphology during the Construction Phase

Source of Impact	Potential Impacts
Suspended Solids Increased fine sediment supply to watercourses is likely to occur during construction works. This may result from: • runoff from vegetation free surfaces; • construction and operation of temporary roads; • plant and vehicle washing; • excavations; • earthworks; and • excavation of road drainage.	**Sediment Regime** A possible increase in turbidity and siltation may occur. **Channel Morphology** A reduction in diversity due to increased fine sediment supply and deposition is likely. The ecology of gravel bed rivers could also be affected. **Natural Fluvial Processes** Loss of dynamic activity due to siltation could result.

Source of Impact	Potential Impacts
Vegetation Clearance Vegetation clearance during construction may reduce the stability of the river channels, increasing the potential for erosion and associated sediment release. Sediment release is likely to be greatest where vegetation clearance is required on slopes and would be particularly significant where woodland clearance is required.	**Sediment Regime** An increase in supply of fine sediment through bank instability, especially during the winter months is likely. **Channel Morphology** Reduced morphological diversity due to bank collapse and sediment deposition may occur. **Natural Fluvial Processes** Bank instability due to bank erosion may increase. Increased sediment delivery may impact on any sites of ecological importance located downstream.
Culvert Installation The watercourse crossings would involve culverting.	**Sediment Regime** Installation would increase the volume of sediment directly entering the channel and consequently increase turbidity. **Channel Morphology** Channel bed would be disturbed in the vicinity of the installation. **Natural Fluvial Processes** Localised erosion and deposition may occur, planform change may be constrained. A prevention of channel migration may have consequences both for WFD (2006/60/EC) targets and detrimental effects on habitat diversity.
Channel Realignment Realignment is proposed for Swine Burn.	**Sediment Regime** An increase in sediment supply would occur during cutting a new course. A subsequent increase in channel erosion is likely if the channel is straightened and gradient is increased. **Channel Morphology** Bedforms that have developed over a long period of time may be disturbed. The new channel would lack morphological diversity. **Natural Fluvial Processes** Channel instability may be induced due to the new courses. Fluvial processes are likely to be exacerbated by realignment, particularly during high flows.
Outfalls The construction of outfalls within the banks of watercourses may lead to sediment release.	**Sediment Regime** Installation could increase the volume of sediment directly entering the channel and consequently cause an increase in turbidity. **Channel Morphology** Construction activities may lead to localised modifications to the channel morphology although this is likely to be highly site-specific. **Natural Fluvial Processes** The stability of the river banks may be reduced during installation leading to the potential for higher rates of erosion. This is likely to be highly site-specific.

Water Quality

9.4.12 During the construction phase, pollution from mobilised suspended solids would present the greatest risk, however there would also be a risk from accidental spillage of fuels, lubricants and hydraulic fluids from construction plant (Highways Agency et al., 2006b).

9.4.13 In addition to sedimentation impacts on water quality identified in Table 9.8, Table 9.9 lists the potential sources and impacts of construction activities on water quality. These water quality impacts are likely to be short-term during the construction period. However, impacts could have a longer term indirect effect on aquatic ecology (refer to Chapter 10: Terrestrial and Freshwater Ecology, and Chapter 11: Estuarine Ecology).

Table 9.9: Potential Impacts on Water Quality during the Construction Phase

Source of Impact	Potential Impacts
Oils, Fuels and Chemicals Spillage from storage tanks or leakage from mobile or stationary plant.	Oils form a film on the water surface resulting in an adverse effect on water quality. These oils can interfere with the gills of fish and cause loss of buoyancy to water birds as well as toxicity to other organisms. The oils/chemicals may also enter groundwater (assessed in Chapter 8: Geology, Contaminated Land and Groundwater).
Concrete, Cement and Admixtures Accidental release into watercourses of the materials or from the washings of plant and machinery or spillage during concrete pouring.	Concrete and cement are highly alkaline and must not be allowed to enter any drain, watercourse or groundwater. Potential for adverse effects on aquatic organisms if pH elevated to/maintained above 8.5.
Sewerage Accidental/uncontrolled release of sewage from sewers through damage to pipelines during service diversion.	Pollution to watercourses/groundwater (also refer to Chapter 8: Geology, Contaminated Land and Groundwater).
Contaminated Land and Sediment If not managed properly, disturbance of contaminated materials could lead to pollution of ground and surface waters.	Dependent on types and concentrations of contaminants. Potential loss or deterioration of aquatic fauna and flora. Deterioration of groundwater quality reducing its resource potential and potentially affecting groundwater-supported habitats (also refer to Chapter 8: Geology, Contaminated Land and Groundwater).

Specific Construction Impacts – Watercourses

9.4.14 The assessment of construction impacts on watercourses was generally carried out qualitatively and has been considered in the context of the general discussion of potential construction impacts above. For the purposes of this assessment, the combination of different engineering activities that are likely to be carried out within the vicinity of a watercourse, as well as the extent of the proposed works, was taken into consideration. This was particularly relevant for Swine Burn where multiple activities, and associated works, are proposed. Available dilution of the watercourses was taken into consideration when assessing the potential impact of total suspended solids and accidental spillage during construction. Flow patterns, fisheries status and environmental status were also considered in the assessment.

9.4.15 The following components of the proposals could affect specific waterbodies as described below and as summarised in Table 9.20 at the end of Section 9.4. An outfall is proposed in the tidal mouth of Linn Mill Burn – as a result, the impacts associated with construction of this outfall form part of the Firth of Forth impact assessment only.

Construction activities

9.4.16 Table 9.10 provides a list of key construction works proposed on or near each of the waterbodies. The assessment below provides a qualitative assessment of the potential impact on the surface water features, based on these activities. Construction works proposed on or near the Firth of Forth are summarised in Table 9.11.

Table 9.10: Construction Activities on Waterbodies

Waterbody	Construction Activities
St. Margaret's Marsh	• Construction of SUDS. • Road widening and earthworks associated with the new and upgraded A90 and Ferry Toll Junction road infrastructure, including realignment of the B981. • Temporary access roads and platforms required for construction of the Main Crossing and north viaduct (access roads to Main Crossing in the north are to be retained for maintenance during operation). • Construction of site compound (approximate NGR NT 1150 8180) and construction-related activities to be undertaken within the compound.
Linn Mill Burn Catchment	• Road and earthworks associated with the new and upgraded road infrastructure. • Construction of site compound (approximate NGR NT 1160 7822) and construction-related activities to be undertaken within the compound.
Swine Burn	• Road and earthworks associated with the new upgraded M9, M9 Spur and M9 Junction 1A road infrastructure. • New depressed invert box culvert crossing under 'M9 EB to M9 NB Interchange Link' (ch2055 M9 to ch490 M9 Spur) (approximately 50m length). A depressed invert will allow the continuity of the natural bed through the structure which will benefit the morphological and ecological environment (refer to Specific Operational Mitigation section for more details). • Culvert length extension under M9 Spur (164m total length; approximate extension of 20m). • Watercourse realignment (approx. 451m length). • Construction of two new outfalls (Runs A and E) and SUDS. • Construction of site compound (approximate NGR NT 1129 7485) and construction-related activities to be undertaken within the compound.
Tributary of Swine Burn	• Road and earthworks associated with the upgraded M9 and M9 Junction 1A road infrastructure. • Construction of one new outfall (Run B) and SUDS.
Niddry Burn	• Road and earthworks associated with the upgraded M9 and M9 Junction 1A road infrastructure. • Culvert extension under M9 (95.6m total length; approximate extension of 7m on each side of carriageway). • Construction of one new outfall (Run C) and SUDS.
Tributary of Niddry Burn	• Road and earthworks associated with the upgraded M9. • Culvert extension under M9 (62m total length; approximate extension of 5m on each side of carriageway).
River Almond	• Road and earthworks associated with the upgraded M9. • Construction of one new outfall (Run D) and SUDS.
Ferry Burn	• Road and earthworks associated with the new and upgraded A90 and Queensferry Junction road infrastructure. • Construction of one new outfall (Run J) and SUDS.
Dolphington Burn	• Road and earthworks associated with the upgraded A90, realigned A8000 and dedicated bus links to the existing Forth Road Bridge.

<u>Hydrology and Flood Risk</u>

9.4.17 St. Margaret's Marsh – potential construction impacts include temporary alteration of the hydrological regime into St. Margaret's Marsh depending on the discharge location of runoff from the construction zone. Because the proposed construction area is moderate when compared to the size of the St. Margaret's Marsh catchment; (St. Margaret's Marsh SSSI (Figure 10.1a) covers an area of 26.4ha), the potential construction impact of these works on St. Margaret's Marsh would be of medium magnitude and Moderate significance.

9.4.18 Linn Mill Burn – outfall construction and widening of the shore side of Society Road are not expected to impact flood risk along Linn Mill Burn if runoff is directed into the Firth of Forth. However, other construction activities may lead to temporary increases in runoff rates into Linn Mill Burn. The potential impacts of the construction works in the Linn Mill Burn catchment area would be of low magnitude and Slight significance.

9.4.19 Swine Burn – construction of slip road crossings across the Swine Burn and construction of a realigned channel may lead to temporary increases in runoff rates due to soil compaction, exposure of bare soils, temporary diversion of flow, and increases in impermeable surfaces. In addition, localised increases in flood risk can be expected if plant/materials are placed within the floodplain. The potential impacts would be of medium magnitude and Moderate significance.

9.4.20 Tributary of Swine Burn and Ferry Burn – construction of new SUDS features and new outfalls may lead to temporary increases in runoff rates. The potential impacts associated with the construction works would be the following:

- Tributary of Swine Burn: low magnitude and Negligible significance.
- Ferry Burn: would not be directly impacted by the proposed development but may receive additional drainage from part of new roadway works southwest of South Queensferry; therefore low magnitude and Slight significance.

9.4.21 Niddry Burn – construction works related to potential culvert lengthening, a new SUDS feature and new outfall may lead to temporary increases in runoff rates and localised increases in flood risk if plant/materials are placed within the floodplain. The potential impacts associated with the construction works would be of medium magnitude and Moderate significance on Niddry Burn.

9.4.22 Tributary of Niddry Burn – construction works related to potential culvert lengthening may lead to temporary increases in runoff rates and localised increases in flood risk if plant/materials are placed within the floodplain. The potential impacts would be of low magnitude and Negligible significance on the Tributary of Niddry Burn.

9.4.23 River Almond – potential impacts on the River Almond are attributed to construction works along watercourses draining into the River Almond as well as construction of a new SUDS pond. These construction impacts are expected be of negligible magnitude and Negligible significance on the River Almond.

9.4.24 Dolphington Burn – there would be no direct impact on Dolphington Burn as new road drainage would be directed into existing SUDS ponds. However, there may be a slight increase in flood flows due to increased impermeable areas during construction works. The potential impacts would be of negligible magnitude and Negligible significance.

<u>Fluvial Geomorphology</u>

9.4.25 Swine Burn – channel realignment, the installation of a new culvert, an extension to the existing culvert and outfall construction would require in-channel works. This process would potentially release a substantial volume of suspended sediment which would then be transported downstream. The construction of embankments on the floodplain of the watercourse in this location may also increase the supply of sediment. Downstream, sediment deposition would lead to reductions in morphological quality by smothering the gravel-bed. In addition, clearing trees and shrubs may lead to bank instability which could also increase fine sediment supply with detrimental effects on channel morphology. The extensive nature of the works would, if unmitigated, lead to a high magnitude potential impact on Swine Burn, resulting in an impact of Moderate/Substantial significance.

9.4.26 Tributary of Swine Burn – construction of a new outfall may lead to a release of sediment into the watercourse as this would involve disturbance to a section of river bank. Downstream, sediment deposition would lead to reductions in morphological quality. However, due to the limited extent of the works required, the potential impact of this would be of low magnitude, resulting in an impact of Negligible significance.

9.4.27 Niddry Burn – extending the existing culvert would disturb the bed and release plumes of fine sediment. Construction works would provide a high sediment supply which may enter the channel. Downstream, sediment deposition would lead to reductions in morphological quality. Construction of an outfall may lead to a release of sediment into the watercourse as this would involve disturbance to a section of river bank. Downstream, sediment deposition would lead to reductions in morphological quality. However, the limited extent of the works required and modified nature of the watercourse means the potential impact of this would be of low magnitude, resulting in an impact of Slight significance.

9.4.28 Tributary of Niddry Burn – extending the existing culvert would disturb the bed and release plumes of fine sediment. Construction works would provide a high sediment supply which may enter the channel. Downstream, sediment deposition would lead to reductions in morphological quality. However, due to the limited extent of the works required and the small size of the watercourse, which would limit the dispersal of sediment, the potential impact of this would be of low magnitude, resulting in an impact of Negligible significance.

9.4.29 River Almond – construction of the outfall structure may lead to a release of sediment into the watercourse. An increase in sediment supply through earthworks and vehicle access and runoff would have a detrimental impact on channel morphology. The channel has a medium morphological quality and smothering of the bed with fine sediment may lead to a reduction in morphological diversity. However, the highly localised nature of the potential impact would limit the impact of this to be of a low magnitude, resulting in an impact of Slight significance.

9.4.30 Ferry Burn – construction of an outfall may lead to a release of sediment into the watercourse as this would involve disturbance to a section of river bank. Downstream, sediment deposition would lead to reductions in morphological quality. However, due to the limited extent of the works required, the potential impact of this would be of negligible magnitude, resulting in an impact of Negligible significance.

9.4.31 Dolphington Burn – road drainage would be routed into the existing drainage system and utilise existing treatment systems (SUDS). This would result in a negligible magnitude, resulting in an impact of Negligible significance.

<u>Water Quality</u>

9.4.32 St. Margaret's Marsh – potential impacts associated with construction of the proposed scheme include the potential for sediment runoff and accidental spillages as a result of works within and adjacent to the marsh. The realigned B981 would run through the former landfill and the SUDS infringe on the boundary of the SSSI; construction works associated with this could result in disturbance of potentially contaminated sediments or leaching of contaminants from soils with the potential to remobilise contaminants into the surface waters of St. Margaret's Marsh. Refer to Chapter 8 (Geology, Contaminated Land and Groundwater) for further details on contaminated land and associated impacts on groundwaters during the construction phase at St. Margaret's Marsh.

9.4.33 Groundwater is anticipated to be intercepted in the cuttings for the B981 realignment and along the Mainline from ch7950–ch8430. Groundwater samples taken along the proposed scheme in this area indicate fair regional background groundwater quality. Refer to Chapter 8 (Geology, Contaminated Land and Groundwater) for further information on locations of cuttings, groundwater quality and assessment of the impacts on groundwater in this area. The only available surface waterbody for discharge of dewatering of groundwater in this area, if required, during construction is the Firth of Forth and potential impacts are therefore considered in the section below for the Firth of Forth.

9.4.34 In addition, the site compound to be located to the north of the Rosyth Link Road could be used to store all fuels, chemicals, materials and plant machinery required for the construction works to the north of the Main Crossing. Any pollution or accidental spillage incidents could adversely affect the water quality of St. Margaret's Marsh and ultimately enter the Firth of Forth.

9.4.35 In the absence of mitigation, the construction works could have a high impact magnitude due to low dilution availability on the marsh, resulting in an impact of Substantial significance on the surface water quality of St. Margaret's Marsh SSSI.

9.4.36 Linn Mill Burn – There are no direct construction works associated with Linn Mill Burn as the proposed location of the outfall is within the tidal mouth of the watercourse (location shown on Figure 9.3). However construction works are proposed in the catchment of Linn Mill Burn and there is a potential for sediment runoff and accidental spillages reaching the watercourse. The watercourse has a low dilution capacity of 0.014m^3/s. The construction works could have a negligible impact magnitude resulting in an impact of Negligible significance on the water quality of this watercourse.

9.4.37 Swine Burn – Potential impacts associated with construction of the proposed scheme could result in the potential for high sediment and pollutant release to the watercourse. In addition, the site compound to be located to the north of the 'M9 Eastbound to M9 Spur Northbound Link (ch2055 M9 to ch490 M9 Spur), is in close proximity to the watercourse realignment, and would be used to store fuels, chemicals, materials and plant machinery required for the construction works. Any pollution or accidental spillage incidents could adversely affect the water quality of Swine Burn. The watercourse has a low/medium dilution capacity of 0.044m^3/s, which could partially ameliorate any increases in turbidity and pollutants in the water column.

9.4.38 Groundwater is expected to be intercepted in the cutting for construction of the Swine Burn realignment. Groundwater samples taken along the proposed scheme in this area indicate generally poor regional background groundwater quality with the presence of total petroleum hydrocarbons (TPHs), polycyclic aromatic hydrocarbons (PAHs), metals and ammoniacal nitrogen. The highest groundwater discharge flows are expected during the first stages of construction and the potential discharge of dewatering of groundwater in this area during construction could impact on the surface water quality of Swine Burn. Refer to Chapter 8 (Geology, Contaminated Land and Groundwater).

9.4.39 The construction works could have a high impact magnitude resulting in an impact of Moderate/Substantial significance on the water quality of this watercourse.

9.4.40 Tributary of Swine Burn – Potential impacts associated with construction of the proposed scheme could result in the potential for sediment and pollutant release to the watercourse due to close proximity of works to the watercourse. The tributary has a very low dilution capacity of 0.006m^3/s. The construction works could have a low impact magnitude resulting in an impact of Negligible significance on the water quality of this watercourse.

9.4.41 Niddry Burn – Potential impacts associated with the construction of the proposed scheme could result in sediment and pollutant release into the water column due to close proximity of works to the watercourse. The watercourse has a medium dilution capacity of 0.134m^3/s, which could partially ameliorate any increases in turbidity and pollutants in the water column. The construction works could have a medium impact magnitude resulting in an impact of Moderate/Substantial significance on the water quality of this watercourse.

9.4.42 Tributary of Niddry Burn – Potential impacts associated with construction of the proposed scheme could result in sediment and pollutant release into the water column due to close proximity of works to the watercourse. The tributary has a very low dilution capacity of 0.006m^3/s. The construction works could have a medium impact magnitude resulting in an impact of Slight significance on the water quality of this watercourse.

9.4.43 River Almond – Potential impacts associated with construction of the proposed scheme could result in sediment and pollutant release into the water column due to close proximity of works to the watercourse. The River Almond has a relatively high dilution capacity of 2.45m^3/s, which could substantially ameliorate any increases in turbidity and pollutants in the water column. The construction works could have a medium impact magnitude resulting in an impact of Moderate/Substantial significance on the water quality of this watercourse.

9.4.44 Ferry Burn – Potential impacts associated with construction of the proposed scheme could result in sediment and pollutant release into the water column due to close proximity of works to the watercourse. The watercourse has a dilution capacity of 0.008m^3/s. The construction works could have a medium impact magnitude resulting in an impact of Slight significance on the water quality of this watercourse.

9.4.45 Dolphington Burn – There are no construction works proposed for Dolphington Burn. However construction works are proposed in the catchment of Dolphington Burn and there is a potential for sediment runoff and accidental spillages reaching the watercourse. Potential impacts associated with construction of the proposed scheme could result in sediment and pollutant release into the water column due to close proximity of works to the watercourse. The watercourse has a very low dilution capacity of 0.004m^3/s. The construction works could have a low impact magnitude resulting in an impact of Negligible significance on the water quality of this watercourse.

Specific Construction Impacts – Firth of Forth

9.4.46 The assessment of construction impacts on the Firth of Forth was generally carried out qualitatively, with the exception of the sediment plume modelling assessment. This was undertaken to quantify the potential concentrations of suspended solids within the Firth of Forth as a result of dredging works associated with installation of the in-channel piers of the Main Crossing. Refer to Appendix A9.1 (Hydrodynamic Modelling) for a detailed assessment of these impacts. As mentioned in paragraph 9.4.15, an outfall is proposed in the tidal mouth of Linn Mill Burn; the impacts associated with construction of this outfall form part of the Firth of Forth impact assessment below.

<u>Construction activities</u>

9.4.47 Table 9.11 provides a summary of key construction works proposed on or near the Firth of Forth in the vicinity of the Main Crossing location. The assessment below provides a qualitative assessment of the potential impact of these activities on the Firth of Forth and as summarised in Table 9.20. In addition, the potential impacts indicated by the sediment plume modelling assessment associated with the dredging works required for the in-channel piers are summarised below; refer to Appendix A9.1 (Hydrodynamic Modelling) for details.

Table 9.11: Construction activities on the Firth of Forth

Waterbody	Construction Activities
Firth of Forth	• Temporary access roads and platforms for construction of the Main Crossing and approach viaducts (access roads to Main Crossing on both shores are to be retained for maintenance during operation). • Main Crossing and approach viaduct construction. Works include earthworks, temporary access jetties and land and sea-based plant. • Construction and installation of the in-channel piers and towers. Works include dredging and sediment removal, piling, and excavation of part of Beamer Rock. • Construction of site compounds and construction-related activities to be undertaken within the compounds. • Construction of two new land-based outfalls; one on either side of the Firth of Forth draining temporary and permanent road infrastructure and the Main Crossing approach viaducts (north side – Run Q; south side (to tidal mouth of Linn Mill Burn) – Runs M and P). • Relocation of a Scottish Water sewage outfall situated near Port Edgar.

Hydrology and Flood Risk

9.4.48 Temporary increases in impermeable areas would result in temporary runoff increases into receiving waterbodies which discharge into the Firth of Forth. Temporary construction works within the Firth of Forth would cause displacement of flood waters. However, the magnitude of impact from the construction works would be negligible due to the relative size of the Firth of Forth and therefore potential impacts would be of Negligible significance. This understanding has been confirmed through consultation with SEPA in February 2009.

Coastal/Estuarine Geomorphology

9.4.49 There would be localised and temporary changes in bed and shoreline morphology associated with the temporary works for the Main Crossing construction. These works include dredging for, and construction of, the Main Crossing piers and approach piers (refer to construction methods in Chapter 4: The Proposed Scheme). 3-D modelling of the change in hydrodynamic conditions during temporary construction activities in comparison to baseline conditions (Appendix A9.1), has demonstrated that, over a simulated period of the spring tide in the Firth of Forth, tidal bottom current velocities show only slight increases and decreases (on average ± 0.05m/s) over very limited spatial and temporal scales. It was considered that these changes (in terms of their spatial and temporal extent during the tidal cycle) are not considered to be large enough to significantly increase the potential for scour, erosion, transport and deposition (i.e. morphological change) and that the temporary works would therefore have a negligible impact magnitude resulting in an impact of Negligible significance on the coastal/estuarine geomorphology of the Firth of Forth.

9.4.50 There is likely to be release of sediment into the water column during dredging for, and construction of, the Main Crossing piers and approach piers thus temporarily increasing suspended sediment concentrations above normal background levels (refer to Appendix A9.1). However, the magnitude of impact relating to construction works would be negligible across the Firth of Forth as a whole due to their relatively limited spatial and temporal extent in comparison to the size of the waterbody. The significance of impact would therefore be Negligible.

9.4.51 There would also be potential for disturbance to the morphology of the intertidal shoreline at the mouth of Linn Mill Burn and at the outfall from the St. Margaret's Marsh SUDS basin due to outfall construction. In the context of the Firth of Forth, this localised construction would only have a negligible impact magnitude resulting in an impact of Negligible significance on the coastal/estuarine geomorphology of the waterbody.

9.4.52 A Scottish Water treated sewage outfall near Port Edgar on the southern side of the Firth of Forth would need to be re-located to accommodate the proposed Main Crossing. This would result in localised disturbance of the subtidal bed and shoreline during relocation. There would be potential for localised scour and erosion and subsequent disturbance to the morphology at this location. Discussions are currently ongoing to agree the exact relocation of the sewage outfall, however, it can be assumed that an appropriate location would be agreed in consultation with Scottish Water and SEPA. This localised disturbance would result in a negligible impact magnitude resulting in an impact of Negligible significance on coastal/estuarine geomorphology.

Water Quality

9.4.53 Potential impacts to the water quality of the Firth of Forth during the construction phase may arise from the following:

- release of suspended solids into the water column;
- re-suspension of sediments could release contaminants and nutrients into the water column; and
- spillage of polluting material such as oils and chemicals, concrete and sewage.

9.4.54 These impacts could result from direct pollution during installation of the in-channel piers and associated dredging works, and indirect pollution due to runoff during construction of approach roads and temporary access roads to the Main Crossing, and site compounds.

9.4.55 During construction of the Main Crossing, dredging or piling works could disturb riverbed sediments and cause a plume of material to be dispersed within the Firth of Forth. A number of 'pockets' would be dredged to facilitate provision of foundations for the Main Crossing. The potential impacts were investigated by numerical modelling of the dispersion of suspended sediment releases during construction of piers and towers under neap and spring tidal conditions. Modelling was carried out for each dredge pocket to simulate a duration of three days during a period of neap tides and three days during a period of spring tides. Selected points 150m north, south, east and west of the sediment release points were selected to provide outputs of predicted concentrations over time. Background concentrations within the Firth of Forth at the location of the proposed Main Crossing were modelled as between 10 and 25 mg/l based on SEPA monitoring and based on a baseline sampling survey undertaken by Jacobs Arup during two days in March 2009. The methodology and results are detailed in Appendix A9.1 (Hydrodynamic Modelling) and summarised below.

9.4.56 During dredging near the northern shore and on neap tides, sediment plumes are predicted to extend approximately 0.5-1km upstream and 1km downstream with concentrations at the edge of the plumes approaching background levels. The peak suspended sediment concentrations occur close to the centres of the sediment release points. The peaks in predicted suspended sediment concentration in the plume at the selected points 150m from the sediment release points are less than 100mg/l. For greater that 95% of the tidal cycles modelled, predicted concentrations 150m from the sediment release points are below 50mg/l.

9.4.57 During dredging near the northern shore on spring tides, the sediment plumes are predicted to extend approximately 1.5km upstream and 1km downstream with concentrations at the edge of the plumes approaching background levels. During spring tides, the peaks in predicted suspended sediment concentrations in the plumes at the selected points 150m from the sediment release points are less than 100mg/l. For greater than 95% of the tidal cycles modelled, predicted concentrations 150m from the sediment release points are below 50mg/l.

9.4.58 During dredging near the southern shore on neap tides, sediment plumes are predicted to extend approximately 2km upstream and 1.5km downstream with concentrations of suspended sediment at the edge of the plume approaching background levels. The peak suspended sediment concentrations occur close to the sediment release points. The modelling predicts a few instances of short-duration peak concentrations above 700mg/l at selected points 150m from the sediment release points. Generally, the predicted peak concentrations 150m from the sediment release points are less than 700mg/l. For at least 66% of the tidal cycles modelled, predicted concentrations 150m from the sediment release points are below 100mg/l. Concentrations are generally predicted to be less than 25mg/l at the entrance to Port Edgar and less than 20mg/l within Port Edgar Marina.

9.4.59 During dredging near the southern shore on spring tides, the predicted sediment plumes extend approximately 1.5km upstream and 1.5km downstream with concentrations at the edge of the plumes approaching background levels. The modelling predicts a few instances of short-duration pear concentrations 150m from the sediment release points Generally, predicted peak concentrations 150m from the discharge points are below 800mg/l. For at least 75% of the tidal cycles modelled, predicted concentrations 150m from the sediment release points are below 100mg/l. Concentrations are generally predicted to be less than 20mg/l at the entrance to Port Edgar and less than 10mg/l within Port Edgar Marina.

9.4.60 The above model outputs described in paragraphs 9.4.56 to 9.4.59 for both neap and spring tides close to the northern and southern shores indicate an impact from dredging on the water quality of the Firth of Forth of negligible magnitude and therefore Negligible significance.

9.4.61 The effect of the increase in suspended sediment concentrations on ecology in the Firth of Forth is discussed in detail in Chapter 11 (Estuarine Ecology).

9.4.62 Soil leachate tests on sediment samples collected as part of a GI study within the vicinity of the proposed Main Crossing found leachate concentrations to exceed the relevant marine waters EQS for ammoniacal nitrogen, copper, chromium and lead (Chapter 8: Geology, Contaminated Land and Groundwater). The resuspension of such sediments during construction of the Main Crossing (e.g.

dredging and piling works) could adversely affect the water quality of the Firth of Forth. The leachate analysis was based on a one stage test with a liquid to solid ratio of 2:1. Dredging will resuspend sediments into the water column at a much higher liquid (estuarine water) to solid ratio of those used in the leachate test resulting in substantial dilution. The contact time between the sediments and the liquid will be less than that used in the leachate tests, subsequently the partitioning of contaminants from the solid to aqueous phase will be significantly reduced compared to that of the leachate test. It should also be noted that the release of such contaminants would be of a transient nature, only occurring during each dredging activity; therefore it is highly unlikely that contaminant concentrations in estuarine waters would be elevated above baseline for appreciable periods. The relevant marine waters EQS are based on an annual average concentration and therefore estuarine waters within the vicinity of the proposed Main Crossing are not expected to exceed the relevant EQS as a result of sediment resuspension. Therefore, this would result in an impact of negligible magnitude and Negligible significance. Refer to Chapter 11 (Estuarine Ecology) for more details on impacts to ecology.

9.4.63 The B981 realignment would run through the former landfill and the SUDS would encroach on the boundary of the SSSI. Construction works associated with this could result in disturbance of potentially contaminated sediments or leaching of contaminants from soils with the potential to remobilise contaminants into the surface waters of St. Margaret's Marsh and ultimately discharge into the Firth of Forth. Refer to Chapter 8 (Geology, Contaminated Land and Groundwater) for further details on potentially contaminated land at St. Margaret's Marsh.

9.4.64 There could be potential impacts associated with construction works as a result of accidental spillage of fuel and concrete to the Firth of Forth. However, due to the high dilution and dispersal capacity of the Firth of Forth, any increases in turbidity or pollutants in the water column are likely to be considerably reduced.

9.4.65 As discussed above, the Scottish Water sewage outfall near Port Edgar would need to be re-located to accommodate the proposed Main Crossing. Discussions are currently ongoing to agree the exact relocation of the sewage outfall, however, it has been considered for the purposes of this assessment that an appropriate location to provide adequate dilution/dispersion for water quality criteria will be agreed in consultation with Scottish Water and SEPA.

9.4.66 In the northern study area, the main locations that groundwater is anticipated to be intercepted are in the cuttings for the B981 realignment and along the mainline from ch7950 – ch8430. Groundwater samples taken along the proposed scheme in this area indicate fair regional background groundwater quality. In the southern study area, the main locations that groundwater is anticipated to be intercepted are in the cuttings along the Mainline from ch3025 – ch4250 and the A904 to the proposed scheme northbound merge slip. Groundwater samples taken along the proposed scheme in this area indicate generally poor regional background groundwater quality with the presence of TPHs, PAHs, metals and ammoniacal nitrogen. Refer to Chapter 8 (Geology, Contaminated Land and Groundwater) for further information on location of cuttings, groundwater quality and assessment of the impacts on groundwater in this area. The only available surface waterbody for discharge of dewatering of groundwater in these areas during construction, if required, is the Firth of Forth.

9.4.67 The highest groundwater discharge flows are anticipated during the first stages of construction and the discharge of dewatering of groundwater in this area during construction could impact on the surface water quality of the Firth of Forth. However the high dilution available in the Firth of Forth is likely to considerably reduce any potential impacts.

9.4.68 These activities and associated potential impacts in combination could have a low impact magnitude and therefore an impact of Moderate significance on the water quality of the Firth of Forth.

Generic Operational Impacts – Watercourses

Road Drainage Impacts

Hydrology and Flood Risk

9.4.69 The following aspects of road drainage may have an impact on the localised water environment along the proposed scheme route:

- Impermeable areas: impermeable areas increase the overall volume of water reaching the watercourse, as less is lost to infiltration. Road runoff may also reach the receiving watercourse earlier than pre-scheme conditions which may result in the flood response of the catchment becoming more 'flashy', increasing flood risk and stream power downstream.
- Discharge of road drainage: road drainage would drain to an outfall discharging to a receiving watercourse. Alterations to the hydrological and flood regimes of receiving watercourses may occur if there is no suitably designed attenuation of surface water runoff. Discharge of road drainage may also have an impact on the sediment regime and water quality of the receiving watercourse (refer to Water Quality and Fluvial Geomorphology sections of this chapter).
- Increased catchment: the proposed works may require the redirection of part of one watercourse catchment into another or the introduction of an outfall discharge to a watercourse. Such developments may increase local flow rates and flood risk. Alterations to flow may have implications for sedimentation patterns along the watercourse which may increase flood risk elsewhere along the watercourse through changes in channel dimensions.
- Reduced catchment: constriction or severing of established flow paths may lead to an increased flood risk; changes to sediment regime via changes to gradient and size of watercourse leading to impacts upon geomorphology and subsequently water quality. Alterations to the flow regime could also have associated impacts on the ecological status of a watercourse.
- Pre-earthworks drainage: prior to construction, it would be necessary to construct a pre-earthworks drainage system to prepare the work corridor. At this stage any small watercourses or catchment areas identified as suitable are incorporated into the pre-earthworks drainage system. The drainage system would remain in place throughout the operation of the proposed scheme and can result in permanent re-direction of discharge for affected watercourses. Catchment areas could increase or decrease depending on the outfall point of the pre-earthworks drainage system and where appropriate this is taken into account in the specific impact assessments.

Fluvial Geomorphology

9.4.70 An increase in road drainage discharging to a watercourse may lead to an increase in fine sediment supply. The actual volume of sediment generated by the operation of the proposed scheme would vary between watercourses depending on the length of road from which runoff would drain into them. Impacts on the geomorphology of watercourses could include:

- Sediment regime: an increase in transportation (turbidity) and deposition of fine sediment (sediment deposition).
- Channel morphology: a reduction of morphological, and consequently ecological, diversity due to fine sediment deposition.
- Natural fluvial processes: a reduction in dynamic processes due to channel sediment deposition. For example, the smothering of gravel surfaces, such as bars, by fine sediment can encourage vegetation colonisation increasing the stability of the feature and changing the nature of associated habitats.

9.4.71 Road drainage outfalls would be required on several waterbodies (Table 9.12). In addition to contributing sediment to the watercourse from road runoff (discussed above), the outfall structures themselves may also be vulnerable to scour from flow in the watercourse into which they discharge. The following impacts could result:

- Sediment regime: scour around outfalls would lead to local increases in sediment supply to the watercourse. The magnitude of this is likely to be limited and would be proportional to the size of the watercourse.
- Channel morphology: scour around outfalls would lead to localised changes in channel morphology.
- Natural fluvial processes: outfalls provide fixed points along river banks which can alter fluvial processes through increases in scour or changes in rates of bank erosion. In addition, where erosion around an outfall causes the structure to project into the river channel it may lead to localised alterations to flow and patterns of sediment deposition. These impacts are likely to be highly localised and proportional to the size of the watercourse.

9.4.72 An increase in discharge (flow) in the watercourse during rainfall events may occur as a result of increased surface runoff due to the low infiltration potential of the road surface. This may increase the activity of geomorphological processes within the channel. The following impacts may result:

- Sediment regime: an increase in turbidity and a greater competence to entrain and transport sediment (fine and coarse material) downstream may occur.
- Channel morphology: erosion of the channel bed and banks could increase. Morphological diversity could be reduced, or improved, depending on sediment supply.
- Natural fluvial processes: adjustment to different flow and sediment regime, for example, a flashier regime would provide more energy for erosion leading to increased lateral migration. This could be a beneficial impact where there is an improvement to morphological diversity or, alternatively, an adverse impact where an increase in fine sediment supply occurs.

Water Quality

9.4.73 Road scheme impacts on water quality are principally caused by pollutants that are transported in road runoff from a number of sources. These include vehicles (e.g. tyre rubber, brake and clutch linings, fuel, oil and coolant), highway maintenance and general road surface degradation (refer to Appendix A9.5: Water Quality for further details). There are a wide range of pollutants which may have an impact on the receiving water and its associated aquatic ecology, including:

- metals such as copper, zinc, lead, nickel and other soluble pollutants;
- suspended solids and contaminants bound to them (such as metals, phosphorous and some organic compounds);
- organic compounds such as oils and other hydrocarbons;
- biodegradable organic material such as grass cuttings; and
- rock salt and alternative de-icing agents.

9.4.74 Metal contaminants in road runoff include copper, zinc, lead and nickel. In accordance with DMRB HA 216/06 (Highways Agency et al., 2006b), dissolved copper and total zinc are used as indicators to assess the pollution levels from road runoff. Concentrations in receiving surface waters are controlled by the DSD (76/464/EEC) and the Freshwater Fisheries Directive (2006/44/EC).

9.4.75 Suspended solids can also present a pollution risk. Research has demonstrated that the fine fraction (< 63µm) of sediments is the most important source of pollution (Hamilton & Harrison, 1991). Fine sediments can adversely affect fish, invertebrates and plants by smothering them. Sediment smothering could lead to die back of water organisms and in turn increased organic loading with associated adverse impacts such as lowered levels of DO. Suspended solids may also contain polluting contaminants which adsorb and bind on to particulate matter. Indeed, typically over 50% of metal and organic contaminants associated with suspended solids are contained within the fraction finer than 63µm ((Highways Agency et al., 2006b)). In addition, an increase in suspended solid concentration and hence turbidity can reduce the potential of underwater plants to photosynthesise.

9.4.76 Contamination by oil and related compounds can have physical and chemical impacts. The most visible impact is the coating of organisms which can adversely affect respiration, photosynthesis and feeding. Additionally, biodegradation of oils in aquatic systems can lead to oxygen depletion. Many mineral oils and other hydrocarbons are toxic, persistent and bio-accumulate in the environment. For impacts to groundwater from accidental spillages during operation of the proposed scheme, refer to Chapter 8 (Geology, Contaminated land and Groundwater).

9.4.77 Diffuse sources of biodegradable organic materials include debris and grass cuttings. These materials can contain high levels of nutrients (nitrogen and phosphorus) and organic matter. They undergo rapid microbiological degradation, consuming oxygen present within the water (measured as BOD), leading to oxygen sags. The rapid oxygen sag that occurs as biodegradable material is broken down within a waterbody can lead to fish and invertebrate fatalities. In the short-term, the material may smother the river bottom, also leading to the death of aquatic species.

9.4.78 De-icing salt, used during the winter months, can cause localised impacts on the environment, as increased chloride levels in the environment may have impacts on fish and freshwater invertebrates.

9.4.79 Routine runoff and accidental spillage assessment results for watercourses receiving road drainage are presented in Tables 9.14 and 9.15, respectively.

<u>Watercourse Crossing Impacts</u>

Hydrology and Flood Risk

9.4.80 Road schemes have the potential to affect downstream flow regimes during operation, particularly as a result of installation of culverts and bridges.

9.4.81 Watercourse crossings can have an impact on flow dynamics within a watercourse by affecting the channel dimensions, roughness and gradient at the crossing location. Flood levels can increase upstream of a new crossing if the crossing structure restricts flood flow. Flood flow may be restricted to passage through the culvert after installation of the culvert, thus backing up the flow. Alternatively, flood levels may be decreased upstream of a new crossing if it is sized at greater capacity than the crossing structure that it replaced. Blockage or constriction caused by structures may lead to localised flood risk, potential for increased sediment release and changes to erosion/depositional patterns indirectly affecting the geomorphological and ecological status of a watercourse.

9.4.82 Culverts can be appropriately designed to reduce impact on hydrological processes.

Fluvial Geomorphology

9.4.83 Culverting watercourses could have a range of impacts:

- Sediment regime: the artificial culvert bed can enhance sediment transfer at high flows. Under normal flows however, sediment could accumulate within the culvert particularly where the culvert has a low gradient. Where culverts are designed to convey flood events with high return periods they may have a greater width than the natural channel. This is likely to reduce stream powers leading to sediment deposition within the culvert, reducing capacity. This may increase both flood risk and lead to sediment starvation downstream. Where culverting increases channel gradient, scour of the bed and banks at culvert outlets often occurs leading to an increase in the supply of sediment to the watercourse.

- Channel morphology: the morphological diversity within the culvert is reduced due to artificial bed and banks. Interruption of morphological continuity segments the watercourse.
- Natural fluvial processes: culverts would constrain the channel preventing lateral and vertical adjustment.

Water Quality

9.4.84 As noted above, culverts could potentially change the riverbed morphological diversity and sediment regime of a watercourse and this may have an associated impact on water quality by releasing previously 'locked' contaminants into the water column.

9.4.85 Culverts may also have an impact on water quality due to oxygen sags caused by the lack of light and rapid microbiological degradation of biodegradable matter. Structures that are relatively wide and/or short in length would tend to allow better light penetration and therefore have a lower impact on water quality.

<u>Watercourse Realignment Impacts</u>

Hydrology and Flood Risk

9.4.86 Watercourse realignments can have an impact on flood flow if the constructed channel is of different size and/or gradient than the original channel. Larger channel cross-sections (including the adjacent floodplains) and steeper gradients would lead to a reduction in flood levels. Small channel cross-sections (including the adjacent floodplains) and flatter gradients would lead to an increase in flood levels.

9.4.87 In addition, if a watercourse is realigned outside of the existing floodplain area, the floodplain storage capacity may be altered due to changes in channel bank heights and topographical features adjacent to the realigned channel. A reduction in floodplain storage capacity along the engineered section of the channel may result in increased flood risk elsewhere.

Fluvial Geomorphology

9.4.88 Watercourse realignments could result in the following impacts:

- Sediment regime: a major change in sediment regime may occur. A new course may result in a change in sediment supply, rate of sediment transfer downstream and depositional zones. Changes in boundary materials through realignment into materials more prone to erosion are likely to increase the volume of sediment supplied to the channel. Increases in channel gradient as a result of realignment would result in an increase in stream power leading to greater erosion rates reducing channel stability and promoting sediment downstream. A reduction in channel gradient however, would be likely to lead to increased deposition within the channel, leading to adverse impacts on morphological diversity.
- Channel morphology: disruption to the channel bed may be short lived and realignment may lead to an improvement in channel morphology. In poor quality streams, realignment provides an opportunity to restore/rehabilitate the watercourse.
- Natural fluvial processes: as described above, realignments can alter the nature of fluvial processes operating within a reach. An increase in erosion and/or deposition can have feedback effects that can lead to a reduction in channel stability, increasing lateral migration for example. An increase in the rate of channel processes could lead to an increase in morphological quality. However, sediment transfer downstream results in adverse consequences.

Specific Operational Impacts – Watercourses

9.4.89 The proposed scheme has been considered in the context of the general discussion of potential operational impacts above. The following components of the proposals could affect specific watercourses as described below and as summarised in Table 9.20. The impacts associated with road drainage, draining to the outfall in the tidal mouth of Linn Mill Burn, have been incorporated into the Firth of Forth impact assessment.

Road Drainage and Outfalls

9.4.90 At present the surface water runoff from the existing road network discharges into watercourses via a highway drainage system. As detailed in the baseline assessment, information available on the existing drainage system indicates that a proportion of existing drainage either outfalls directly to a watercourse with no treatment or undergoes partial treatment before discharge (Table 9.6).

9.4.91 The proposed scheme is primarily an online upgrade of the existing road network with the exception of the new offline section for Queensferry Junction. Details of the existing drainage network on roads to be upgraded are indicated in Table 9.6.

9.4.92 With the proposed scheme drainage design, six new outfalls are proposed to discharge to five watercourses, as summarised in Table 9.12 below. Road drainage lengths and new drainage areas to be drained to each watercourse are also detailed. Locations of outfalls and drainage run extents are shown on Figure 9.3.

Table 9.12: Proposed Scheme Drainage Network

Road Name	Watercourse	Drainage Run	Outfall Location (NGR)	Road Drainage Length (m)	Approximate Road Drainage Area (m^2)
Section of existing M9 eastbound. New section of taper for M9 eastbound to M9 spur northbound link.	Swine Burn	Run A	NT 1106 7472	300	3,870
Existing M9 spur. Section of new M9 eastbound to M9 spur northbound link.		Run E	NT 1144 7464	1,440	33,228
Section of existing M9 westbound. New section of taper for M9 spur southbound to M9 westbound link.	Tributary of Swine Burn	Run B	NT 1071 7471	320	6,592
Section of existing M9. Section of new M9 eastbound to M9 spur northbound link. M9 westbound to M9 spur northbound link. M9 spur westbound to M9 westbound link. M9 spur southbound to M9 eastbound link.	Niddry Burn	Run C	NT 1175 7406	2,760	44,196
Section of existing M9.	River Almond	Run D	NT 1209 7354	680	25,718
Section of new A90.	Ferry Burn	Run J	NT 1260 7745	1,340	39,798

9.4.93 In addition to new outfalls, connection to existing drainage systems is proposed at a number of locations, primarily for the realignment of existing side roads (refer to Table 1.6 in Appendix A9.5: Water Quality).

Hydrology and Flood Risk

9.4.94 Table 9.13 presents the estimated percentage increase in the 50% AEP (1 in 2-year return period) river flows due to the additional discharge from each outfall. As can be seen, the predicted increases in flows tend to be less than 4% from current flow levels, with the majority of the increases being less than 0.5%. Therefore, the impact of the additional discharge into the receiving watercourses is considered to be of negligible magnitude and Negligible significance for all watercourses except for Ferry Burn, Tributary of Swine Burn and Linn Mill Burn where impacts on these watercourses are considered to be of low magnitude. Consequently, potential impacts on Ferry Burn and Linn Mill Burn would be of Slight significance and the impact on the Tributary of Swine Burn would be of Negligible significance.

Table 9.13: Comparison of Outfall Discharge Rates and River Flows

Drainage Run	Proposed Watercourse for Outfall Discharge	Pre-development Discharge Rate (l/s)	50% AEP River Flow (m^3/s)	50% AEP River Flow (l/s)	% inc. in 50% AEP River Flow from Outfall
M9 Junction 1A					
A	Swine Burn	1.9	3.6	3640	0.05
B	Tributary of Swine Burn	3.2	0.3	300	1.08
C	Niddry Burn	24.6	8.3	8340	0.30
D	River Almond	12.6	124.0	124,000	0.01
E	Swine Burn	21.9	3.6	3640	0.60
Queensferry Junction					
GA + GB	Existing Drainage Network	22.2	n/a	n/a	n/a
HA	Existing Drainage Network	2.5	n/a	n/a	n/a
HB	Existing Drainage Network	0.5	n/a	n/a	n/a
J	Ferry Burn	23.7	0.6	600	3.95
K	Existing Drainage Network	1.5	n/a	n/a	n/a
L	Existing Drainage Network	0.8	n/a	n/a	n/a
M	Firth of Forth (tidal mouth of Linn Mill Burn)	63.9	n/a	n/a	n/a
MA	Existing Drainage Network	5.0	n/a	n/a	n/a
N	Existing Drainage Network	2.2	n/a	n/a	n/a
P	Firth of Forth (tidal mouth of Linn Mill Burn)	16.6	0.9	900	1.84
Ferrytoll Junction					
Q	Firth of Forth	88.2	n/a	n/a	n/a
R	Existing Drainage Network	6.1	n/a	n/a	n/a
S	Existing Drainage Network	2.0	n/a	n/a	n/a
T	Existing Drainage Network	7.3	n/a	n/a	n/a
U	Existing Drainage Network	1.3	n/a	n/a	n/a

9.4.95 The drainage system of the roadway is designed for the 100% AEP (1 in 1-year return period) flows and then checked for surcharge against the 20% AEP (1 in 5-year return period) flows. In addition, a 20% allowance for climate change is included in the design flows. Under high return period events, surplus water would be conveyed along the roadway towards low points and may spill onto adjacent land. As such, the land receiving the excess roadway drainage may experience temporary flooding conditions during such extreme events. This is a risk particularly where the road lies above current or planned developments where it is positioned on a bridge or embanked section of carriageway.

9.4.96 Based upon existing OS mapping and planned development along the proposed scheme, as provided by Edinburgh City Council (March, 2008), two areas which contain existing/proposed development have been identified at risk of flooding from high return period drainage events which exceed the capacity of the roadway system. These residential areas are: (i) area adjacent to the southern viaduct abutment (the section of the carriageway receiving flow from the viaduct and the section of motorway south of the viaduct), (ii) areas east and southeast of M9 Spur.

9.4.97 As a preliminary assessment, the potential volumes of excess runoff at these locations were estimated using the MicroDrainage hydraulic software package to assess the capacity of the drainage systems for the proposed scheme for the 1% AEP (1 in 100-year return period) +20% event. This assessment provided the following findings:

- The land adjacent to the proposed motorway at the location of the abutment of the viaduct may receive substantial flood water during the 1% AEP (1 in 100-year return period) +20% flood event. This flood water may impact existing and/or proposed development located between the viaduct abutment and Society Road (both on the east and west sides of the proposed carriageway). In this case, if drainage along Society Road is not able to convey all flows toward Linn Mill Burn, this flow also has the potential to progress north of Society Road and impact other development north of Society Road. The impacts associated with this flood risk are therefore considered to be of low magnitude and Slight significance as some development may be at risk of flooding for the 1% AEP (1 in 100-year return period) +20% flood event.
- The lands directly east of the M9 Spur south of the railway line and north of the B9080 are expected to receive slight flow during the 1% AEP (1 in 100-year return period) +20% flood event from the carriageway. This increase in runoff may impact the proposed/existing developments directly adjacent to the carriageway, but the risk to the property is considered of low magnitude and Slight significance due to the small volume of excess runoff assessed for the 1% AEP (1 in 100-year return period) +20% flood event and the low potential impact to development.

9.4.98 At all locations the potential impact is increased surface water runoff to the developments as a result of the construction and operation of the proposed road.

Fluvial Geomorphology

9.4.99 Untreated road drainage can deliver fine sediment directly into watercourses. In addition, sediment release as a result of scour around outfalls may lead to an increase in sediment supply. Higher rates of scour are more likely in larger watercourses with associated higher discharges, such as the River Almond. This may also trigger an increase in the rate of bank erosion.

9.4.100 Sediment deposition downstream of the outfall could lead to smothering of the bed and reductions in channel morphological diversity. However, the quantity of sediment supplied to the channel from road drainage is likely to be relatively low and concentrated into periods of high rainfall, when river flows would be high. This would increase dilution of sediment and increase dispersal and therefore reduce the potential impact of increased sediment supply to a low magnitude. The significance of this impact is dependent on the sensitivity of the watercourses (Table 9.7) but would range from Negligible to Slight. In addition, scour would be restricted to a relatively small area around the outfall structure and is unlikely to generate large volumes of sediment.

9.4.101 The operational impact of watercourses impacted by road drainage outfalls is therefore likely to be of a low magnitude, which would result in Negligible significance for the Tributary of Swine Burn and an impact of Slight significance for Swine Burn, Niddry Burn and the River Almond. The impact on Ferry Burn would be of negligible magnitude and Negligible significance. However, this assessment does not include the cumulative impacts of other activities proposed at watercourses, e.g. crossings over Swine Burn (see below and Table 9.21).

Water Quality

9.4.102 To assess the potential impacts of the proposed scheme, the water quality assessment is initially based on untreated road runoff without any form of treatment or mitigation measures. Refer to Appendix A9.5 (Water Quality) for methodology and calculation spreadsheets. This assessment has been undertaken to determine the potential impact of road drainage on the water quality of watercourses, as prescribed in the DMRB HA 216/06 and to inform subsequent requirements for mitigation to protect the water environment (Section 9.5: Mitigation). This assessment therefore represents a worst case assessment of the potential impacts of road runoff with no treatment or spillage reduction measures. (For the sections of online upgrades, the assessment has been undertaken for the full length of road draining to the proposed outfall and not just the area of new road.)

9.4.103 One drainage run (Outfall Q) is proposed to drain the approach road infrastructure and Main Crossing viaduct (north of low water mark) to the north of the Firth of Forth. This road drainage is proposed to outfall to the Firth of Forth and is therefore considered in the section below specific to the Firth of Forth (Table 9.14). Six outfalls are required to the south of the Firth of Forth and would outfall to five watercourses which eventually flow into the Firth of Forth (Table 9.10). The proposed road drainage layout is shown on Figure 9.3.

9.4.104 For watercourses proposed to receive new road drainage discharges, the calculations and resulting percentage increases in dissolved copper and total zinc concentrations over baseline, in design year 2032, are summarised in Table 9.14.

Table 9.14: Estimated Potential Impact of Zinc and Copper in Road Runoff in Design Year 2032

Waterbody (Drainage Run) and Sensitivity	Metal	EQS Annual Ave. (µg/l)	Upstream Conc. (µg/l)	Estimated Downstream Conc. (µg/l)	Potential Impact (unmitigated)	
					Magnitude	Significance
Swine Burn – M9 (Run A) (Medium)	Copper	10	5	6	Negligible	Negligible
	Zinc	75	38	40		
Swine Burn – M9 Spur and Interchange Link (Run E) (Medium)	Copper	10	5	18 *	High	Moderate/ Substantial
	Zinc	75	38	90 *		
Tributary of Swine Burn (Run B) (Low)	Copper	10	5	11 *	Medium	Slight
	Zinc	75	38	65		
Niddry Burn (Run C) (High)	Copper	10	5	11 *	Medium	Moderate/ Substantial
	Zinc	75	38	62		
River Almond (Run D) (High)	Copper	10	5	5	Negligible	Negligible
	Zinc	75	38	39		
Ferry Burn (Run J) (Low)	Copper	10	5	65 *	High	Moderate
	Zinc	75	38	281 *		

* Exceeds Annual Average EQS

9.4.105 The assessment indicates that during routine operation of the proposed scheme without mitigation, the resultant concentrations of dissolved copper and total zinc could be as follows:

- Annual average EQS is exceeded for both indicator metals in one of the outfalls to Swine Burn (Run E) and Ferry Burn (Run J). The unmitigated impact of road drainage to these watercourses is considered to be of high magnitude and therefore of Moderate/Substantial and Moderate significance, respectively.
- Annual average EQS is exceeded for one of the indicator metals in the Tributary of Swine Burn (Run B) and Niddry Burn (Run C). The unmitigated impact of road drainage to these watercourses is considered to be of medium magnitude and therefore of Slight and Moderate/Substantial significance, respectively.

- Annual average EQS is met for both indicator metals in the other outfall to Swine Burn (Run A) and the River Almond (Run D). This is due to the small area of road drainage to Swine Burn from Run A and the higher dilution and dispersal capacity afforded by the River Almond. The unmitigated impact of road drainage to these watercourses is considered to be of negligible magnitude and therefore of Negligible significance, respectively.

9.4.106 The spillage risk assessment, for those watercourses proposed to receive new road drainage discharges, is summarised in Table 9.15. Refer to Appendix A9.5 (Water Quality) for methodology and calculation spreadsheets.

Table 9.15: Summary of Spillage Risk Assessment in Design Year 2032 (No Mitigation)

Waterbody (Drainage Run and Sensitivity)	Threshold of Acceptability (1:X years)	Spillage Risk (% AEP and Return Period 1:X years)	Within Acceptable Limits?	Potential Impact (unmitigated)	
				Magnitude	Significance
Swine Burn – M9 (Run A) (Medium)	1:100	0.0026 37,906	Yes	Negligible	Negligible
Swine Burn – M9 Spur and Interchange Link (Run E) (Medium)	1:100	0.0135 7,392	Yes	Negligible	Negligible
Tributary of Swine Burn (Run B) (Low)	1:100	0.0023 44,234	Yes	Negligible	Negligible
Niddry Burn (Run C) (High)	1:200	0.0410 2,438	Yes	Negligible	Negligible
River Almond (Run D) (High)	1:200	0.0238 4,195	Yes	Negligible	Negligible
Ferry Burn (Run J) (Low)	1:100	0.0310 3,226	Yes	Negligible	Negligible

9.4.107 The assessment indicates that the risk of accidental spillage would result in an impact of negligible magnitude (i.e. considerably lower spillage rates than the threshold of acceptability) and therefore produce impacts of Negligible significance for all waterbodies.

<u>Watercourse Crossings and Embankment Widening</u>

9.4.108 Construction of the proposed scheme involves four watercourse crossings, impacting on the following three watercourses (in addition to the proposed Main Crossing over the Firth of Forth):

- Swine Burn – one new depressed invert box culvert (ch245 Interchange Link) under the 'M9 Eastbound to M9 Spur Northbound Link' (ch2055 M9 to ch490 M9 Spur) (approximately 50m) and one culvert extension of approximately 20m to the existing 144m double-barrel concrete culvert upstream of the M9 Spur (ch730 M9 Spur).
- Niddry Burn – one culvert extension of approximately 14m (7m on each side of the carriageway) to the existing 81.6m culvert under the M9 (ch1120 M9).
- Tributary of Niddry Burn – one culvert extension of approximately 10m (5m on each side of the carriageway) to the existing 52m pipe culvert under the M9 (ch880).

Hydrology and Flood Risk

9.4.109 A new crossing is proposed along Swine Burn for the slip road off the M9 to the M9 Spur. This culvert has been sized through the hydraulic modelling exercise based on DMRB (Highways Agency et al., 1993) and CIRIA 168 (CIRIA, 1997a) guidance (refer to Appendix A9.3). As such, this culvert has been sized to allow passage of the 0.5% AEP (1 in 200-year return period) flood flows and includes 0.3m freeboard capacity. In addition, the culvert has been sized with adequate capacity to allow for mammal ledge construction based on most recent DMRB guidance. A wide culvert has been adopted to provide a smooth transition from the floodplain to the culvert, reduce impact of backing up water levels upstream of the culvert, and reduce potential blockage within the culvert.

9.4.110 Although the proposed culvert is wide, its installation would back up flood levels by restricting flow through the opening of the culvert for flood events larger than the 0.5% AEP (1 in 200-year return period) event. In addition, it provides a risk of blockage at the inlet. The installation of this new crossing is expected to slightly increase water levels upstream as well as increase the risk of localised flooding in the event of blockage at the inlet.

9.4.111 To reduce the flood risk associated with hydraulic restriction provided by the new crossing, a number of measures have been implemented within the proposed scheme design as assessed: (i) selection of a wide culvert to reduce the backup effect upstream, (ii) provision of a wide floodplain channel upstream of the proposed culvert to provide adequate compensatory flood storage to reduce flood depths upstream.

9.4.112 To reduce the flood risk associated with the encroachment on the Swine Burn floodplain by the embankments of the proposed new culvert and the extended culvert and reduction in grade of the channel, the width of the floodplain channel of the realignment has been established in the proposed scheme design as assessed, to provide adequate flood compensatory storage to prevent increases in flood depths immediately adjacent to the proposed works.

9.4.113 The potential culvert extensions along Swine Burn, Niddry Burn and the Tributary of Niddry Burn, would include extension of the existing culverts, conserving their conveyance capacity. Although culvert extensions are expected to have minimal impact on conveyance capacity of the culverts, localised flood risk may be increased if road works are placed within the floodplain of the watercourse. As the culvert extensions are between 10m-20m, the impact of culvert extension on flood risk on the upstream extent and proposed location of the crossing for the different watercourses is of negligible magnitude for Swine Burn (due to the provision of adequate compensatory storage within the upstream channel realignment), medium magnitude for Niddry Burn and low magnitude for the Tributary of Niddry Burn.

9.4.114 It should be noted that the impact of the crossing construction and extensions are expected to have negligible impacts on the River Almond as the modelling results have indicated that the existing culverts under the M9 along the Swine Burn, the Niddry Burn and the Tributary of Niddry Burn control flow downstream based on flood modelling results.

9.4.115 The proposed scheme includes 5m of embankment widening within the floodplain of the River Almond. This may slightly impact on flood risk locally but impacts would only be of negligible magnitude and therefore Negligible significance within the River Almond.

Fluvial Geomorphology

9.4.116 The extension of an existing culvert and the provision of a new culvert along Swine Burn would lead to localised reductions in the morphological diversity of the river channel at this location and potentially also interruptions to sediment transport. However, as the watercourse is already modified by straightening, this will have a potential impact of low magnitude and Slight significance.

9.4.117 The proposed increase in the length of the culverts at Niddry Burn and the Tributary of Niddry Burn would lead to a local reduction in morphological diversity. However, the relatively short length of these modifications would limit the impact of this to a low impact magnitude and therefore a Slight significance for Niddry Burn and a Negligible significance for the Tributary of Niddry Burn.

Water Quality

9.4.118 The culvert extension proposed at Swine Burn could further reduce light within the existing culvert structure and negatively impact on water quality. However due to the short extension proposed, this is anticipated to result in an impact of negligible magnitude and therefore a Negligible significance on the water quality of Swine Burn.

9.4.119 The new culvert (approximately 50m in length) may impact on water quality due to lack of light, and could increase suspended solids within the watercourse due to localised scour at the culvert entrance. This could have a negligible impact magnitude and therefore an impact of Negligible significance on the water quality of Swine Burn.

<u>Watercourse Realignments</u>

9.4.120 Realignment of the Swine Burn channel is proposed over a distance of 451m between the Overtoun Bridge and the M9 Spur culvert extension. This channel realignment would include a 10m wide floodplain channel and a 2.5m wide low flow channel (total width = 12.5m). The 2.5m wide low flow channel (1.5m at bed level, 2.5m at top of bank level, and 0.5m depth) has been proposed to mirror the existing Swine Burn channel and generally convey the 50% AEP (1 in 2-year return period) flow and would meander within the floodplain channel. The 10m floodplain channel has been proposed to provide adequate flood capacity and prevent increases in flood risk upstream and downstream of the realignment as well as provide space for low-flow channel sinuosity.

9.4.121 A proposed route and design of realignment has been developed; however, additional details to refine the low flow channel alignment and assess if scour protection measures would be required based on geomorphological advice will be undertaken during the CAR application process.

Hydrology and Flood Risk

9.4.122 The proposed realignment channel would have a more gentle slope than the existing channel, and would cross the new proposed crossing before discharging into the extension of the M9 Spur culvert. As such, the floodplain channel would be constructed to an adequate width to include sufficient flood storage to prevent increases in flood depths upstream of the proposed crossing (which can be attributed water level backup from the new crossing and more gentle slope) and downstream of the proposed crossing (which can be attributed to encroachment of the floodplain due to extension of the existing M9 Spur culvert. The proposed realignment of Swine Burn would have an impact of low magnitude and Slight significance.

Fluvial Geomorphology

9.4.123 A 451m realignment of Swine Burn is proposed. The channel realignment would, where practicable, maintain existing channel dimensions (width and depth) and the overall length and gradient. Any existing flood storage areas within the realigned area would also be replaced to maintain the capacity of the watercourse, prevent an increase in flood risk and sustain connectivity to downstream areas.

9.4.124 An iterative input to the realignment design has been undertaken during the EIA. The realignment, shown on Figure 9.5, would have a two-stage channel form comprising:

- sinuous low flow channel (1.5m wide at bed, 2.5m wide at bank top and 0.5m deep) to match the upstream channel;
- 10m floodplain (width to vary between 7m and 3m on either side) to provide flood flow attenuation and separate the low flow channel from the side slopes to limit the potential for erosion of these slopes;
- on bends in the low flow channel a minimum of 3m of floodplain will be provided between the bank top and the side slope;
- 1 in 3 side slopes; and
- cobble/gravel bed with appropriately sited pools and riffles.

9.4.125 The outline design proposed will enable some improvements to channel morphology, as compared to the existing straightened channel, to be provided. However, both immediately upstream of the new culvert and in the section between the new culvert and the existing culvert, the toe of the right side slope of the new alignment would form the right bank of the channel (no floodplain is provided). The toe of the side slope in this location could therefore be vulnerable to erosion, especially during flood events. If not mitigated, erosion at the toe of the slope may trigger instability of the lower side slope due to over-steepening.

9.4.126 The channel realignment would have a potential impact on Swine Burn of low magnitude and Slight significance.

Water Quality

9.4.127 Similar to culverting, realignments could potentially change the riverbed morphology and sediment regime of the watercourse, which may have an associated impact on water quality. This is considered to have a negligible impact magnitude and therefore an impact of Negligible significance on the water quality of Swine Burn.

Catchment Severance

Hydrology and Flood Risk

9.4.128 The proposed scheme is not expected to result in any significant catchment severance to watercourses. The impact assessment shows that Linn Mill Burn catchment is likely to be decreased by 1%, which is considered to have an impact of negligible magnitude and therefore Negligible significance.

9.4.129 The catchment area of St. Margaret's Marsh will be affected by the realignment of the B981 road. The assessment shows that the catchment area will be reduced by approximately 20% and the surface water runoff to the marsh will be reduced by approximately 23%. This will have an impact of medium magnitude and therefore Moderate significance.

Cuttings

9.4.130 The main locations where groundwater is anticipated to be intercepted are:

- ch7950 to ch8430 along the mainline (Ferrytoll Junction);
- B981 realignment (Ferrytoll Junction);
- ch3025 to ch4250 along the mainline (Queensferry Junction);
- A904 to proposed scheme northbound merge slip road (Queensferry Junction); and
- Swine Burn realignment (M9 Junction 1A).

Hydrology and Flood Risk

9.4.131 There is a risk of localised flooding from surface runoff from areas naturally draining towards the direction of the cuttings. A desk-top assessment identified some small areas (<0.2 km^2) draining towards the location of these cuttings; therefore the potential risk of surface runoff flooding is considered to be of low magnitude and Slight significance.

9.4.132 Based on available GI information, the location of these artesian wells does not appear to be in close proximity to the proposed development. The locations of artesian wells along the proposed alignment are presented in Section 8.3 of Chapter 8 (Geology, Contaminated Land and Groundwater). The potential of flooding from the presence of artesian wells in or near the location of the cuttings is considered to be of negligible magnitude and Negligible significance.

Water Quality

9.4.133 The highest groundwater flows are anticipated during the first stages of construction and as construction progresses, groundwater seepage would decrease as a new equilibrium establishes. Groundwater discharge during the operational phase is expected to be minimal in comparison with highways runoff and dilution in the receiving waterbodies.

9.4.134 As indicated in the construction impacts section (paragraphs 9.4.33, 9.4.38 and 9.4.66), groundwater samples taken along the proposed scheme indicate fair regional background groundwater quality in the area of Ferrytoll and Queensferry Junction cuttings and generally poor regional background groundwater quality with the presence of TPHs, PAHs, metals and ammoniacal nitrogen in the area of the M9 Junction 1A cutting. Refer to Chapter 8 (Geology, Contaminated Land and Groundwater) for further information on location of cuttings, groundwater quality and assessment of the impacts on groundwater in this area.

9.4.135 The potential discharge of any groundwater is considered to be of negligible magnitude resulting in an impact of Negligible significance on the water quality of the potential receiving waterbodies; Swine Burn and the Firth of Forth.

Catchment Urbanisation

Hydrology and Flood Risk

9.4.136 Hardstanding (including roads and access tracks) can increase surface runoff and therefore peak flows. In the context of the Flood Estimation Handbook (FEH) the parameter that would be affected is URBEXT; a fractional index of urbanisation. FEHv2 classes catchments with URBEXT < 0.030 as essentially rural. In the pre-development situation, all catchments except for the River Almond are classified as essentially rural. Table 9.16 shows the change in the URBEXT in each of the catchments affected. As it can be seen on the Table 9.16 below, after development the catchments remain essentially rural i.e. URBEXT < 0.030.

Table 9.16: Changes in Urbanisation

Catchment	Pre- development $URBEXT_{2000}$	FEH Catchment Classification	Post- development $URBEXT_{2000}$	FEH Catchment Classification
Swine Burn	0.015	Essentially rural	0.018	Essentially rural
Tributary of Swine Burn	0.000	Essentially rural	0.009	Essentially rural
Niddry Burn	0.011	Essentially rural	0.012	Essentially rural
Tributary of Niddry Burn	0.023	Essentially rural	0.024	Essentially rural
River Almond	0.060	Moderately urbanised	0.060	Moderately urbanised
Ferry Burn	0.001	Essentially rural	0.023	Essentially rural
Linn Mill Burn	0.007	Essentially rural	0.007	Essentially rural
Dolphington Burn	0.004	Essentially rural	0.004	Essentially rural

9.4.137 In addition, changes in peak flows due to the increase in hardstanding were assessed. The results of this assessment are considered conservative as they do not consider attenuation or temporary detention provided by the SUDS features, or adjacent land. It was determined that an increase of less than 1% in both the 50% AEP (1 in 2-year return period) and the 0.5% AEP (1 in 200-year return period) events occurred for most of the catchments (refer to Table 9.13 above and Table 1.3 of Appendix A9.3). For these watercourses, it is considered to result in a potential impact of negligible magnitude and Negligible significance. The assessed increases in peak flows are, however, higher for Ferry Burn and the Tributary of Niddry Burn. In both cases, it has been estimated that 3% increases in the 0.5% AEP (1 in 200 year return period) flows are expected. For Ferry Burn and the Tributary of Niddry Burn, urbanisation is expected to have a potential impact of low magnitude and therefore Slight significance for Ferry Burn and Negligible significance for the Tributary of Niddry Burn.

Specific Operational Impacts – Firth of Forth

9.4.138 The following components of the proposals could specifically affect the Firth of Forth as described below and as summarised in Table 9.20.

9.4.139 With the proposed scheme road drainage design, three new outfalls are proposed to discharge to the Firth of Forth, as summarised in Table 9.17 below. Road drainage lengths and areas to outfall to the estuary are also detailed. Locations of outfalls and drainage runs are shown on Figure 9.3.

9.4.140 The road drainage design principles for dealing with runoff discharging to the Firth of Forth include the following, as agreed with SEPA during consultation in January and March 2009 where appropriate:

- Road network to the north of the Firth of Forth low water mark including Ferry Toll Junction, A90 and north approach viaduct (i.e. Main Crossing over north shore intertidal areas) will outfall to the Firth of Forth.
- Over the subtidal part of the Firth of Forth (main channel), road drainage to discharge through outfalls at regular spacings on both sides of the deck of the Main Crossing. Indicative spacings of 15m have been assumed in the assessment.
- Road network to the south of Firth of Forth low water mark including A90, sections of Queensferry Junction and south approach viaduct (i.e. Main Crossing over south shore intertidal areas) will outfall to the Firth of Forth at the tidal mouth of Linn Mill Burn.

Table 9.17: Proposed Scheme Road Drainage Network

Location within Firth of Forth	Road Drainage Number	Outfall Location (NGR)	Road Drainage Length (m)	Approximate Road Drainage Area (m^2)
North section	Run Q	NT 1224 8125	7,850	113,032
Main Crossing over main channel	n/a	Outfalls at regular spacings	1,880	51,700
South section (tidal mouth of Linn Mill Burn)	Runs M and P	NT 1144 7873	5,180	84,934

Hydrology and Flood Risk

9.4.141 Potential operational impacts of the proposed scheme on the Firth of Forth would be associated with runoff from the increase in impermeable areas from the proposed scheme and the installation of support structures within the Firth of Forth for the Main Crossing. The impacts of these measures would be of negligible magnitude and Negligible significance (given minimal encroachment on the floodplains and the Firth of Forth and the relative size of the Firth of Forth to the proposed pier structures). This assessment has been confirmed through communications with SEPA in February 2009.

Coastal/Estuarine Geomorphology

9.4.142 There would potentially be localised changes to the bed and shoreline morphology of the Firth of Forth due to increased scour and erosion as a result of changes in tidal flow velocities associated with the Main Crossing piers and approach piers. However, 3-D modelling of the change in hydrodynamic conditions during operation of the Main Crossing in comparison to baseline conditions (Appendix A9.1) has demonstrated that, over a simulated period of the spring tide in the Firth of Forth, tidal bottom current velocities show only negligible changes (± 0.05m/s) within the locality of the Main Crossing piers and approach piers. This indicates that scour and erosion would not be significantly increased. Therefore the bridge structures are considered to have an impact of negligible impact magnitude and Negligible significance on the geomorphology of the Firth of Forth.

9.4.143 There would be potential for localised scour and erosion and subsequent disturbance to the morphology of the shoreline of the Firth of Forth due to the presence of the new outfall structures at the tidal mouth of Linn Mill Burn and St. Margaret's Marsh that are proposed to discharge to the Firth of Forth. In the absence of mitigation, the discharge from the outfalls, under high flow conditions, would potentially cause localised scour. However, in the context of the Firth of Forth this localised scour would only have a negligible impact magnitude and a Negligible significance on the coastal/estuarine geomorphology of the waterbody.

9.4.144 The Scottish Water sewage outfall on the southern side of the Firth of Forth would need to be re-located to accommodate the proposed Main Crossing corridor. This would result in localised disturbance of the subtidal bed and shoreline. There would be potential for localised scour and erosion and subsequent disturbance to the morphology at this location. Discussions are currently ongoing to agree the exact relocation of the sewage outfall; however, it can be assumed that an appropriate location would be agreed in consultation with Scottish Water and SEPA. This localised disturbance would result in a negligible impact magnitude and therefore an impact of Negligible significance on coastal/estuarine geomorphology.

Water Quality

9.4.145 For long span bridges crossing waterways, it is typical to drain surface water runoff directly through the deck to outfall from a high level to the waterbody below. Examples of this type of drainage system on crossings in the UK include the existing Forth Road Bridge and the Second Severn Crossing. To design a system with piped drainage to the ends of a bridge or to towers on either side of main spans soon becomes unfeasible, due to the large pipe diameters required to carry drainage water significant distances, and the complex pipe jointing arrangements needed to accommodate the movements which the bridge structure undergoes on a regular basis due to traffic, thermal and wind loading.

9.4.146 The Main Crossing drainage design has been developed through an iterative process requiring detailed discussions between structural and drainage engineers and environmental specialists. Consultation has also been undertaken with SEPA regarding the potential for treatment of discharges to the Firth of Forth.

9.4.147 The Main Crossing length of approximately 1900m over the main Firth of Forth channel is proposed to discharge via through-deck drainage, similar to the existing drainage arrangements over the main channel from the existing Forth Road Bridge.

9.4.148 It is proposed that due to the ecological sensitivity of the intertidal areas, drainage from the Main Crossing over the intertidal areas on the north and south shores will be taken back to land-based SUDS prior to outfall to the Firth of Forth. This is an improvement on the existing drainage arrangement for the existing Forth Road Bridge where there is currently through-deck drainage over the intertidal areas.

9.4.149 When the proposed scheme is operational, traffic will transfer to the Main Crossing and the existing Forth Road Bridge will only take small traffic flows comprising public transport vehicles (estimated 274 vehicles per day in 2032 based on the traffic model).

9.4.150 DMRB HA 216/06 (Highways Agency et al., 2006b) does not provide a method for calculating the potential impacts of routine road runoff to estuarine or coastal waters as it is recognised that such bodies of water normally provide much greater available dilution and dispersion than inland rivers, and experience more complex flow and mixing patterns not easily replicated by simple calculations.

9.4.151 Tidal movements are the dominant flows in the estuary. In the vicinity of the proposed Main Crossing, the current speeds in the six hours before and after high water range from 0.15m/s to

1.13m/s during a spring tide and from 0.10m/s to 0.70m/s during a neap tide. During slack water periods (i.e. the period during which there are no appreciable tidal current flows), the current speed can be considered to be zero. The tidal flux through the estuary (crossing a north-south line drawn between Rosyth and South Queensferry) is estimated by the proposed scheme hydrodynamic model to be about 20,000m^3/s during the high water of spring tide, and a much reduced tidal flux of 4,000m^3/s in a neap tide.

9.4.152 The volume of routine road runoff from the road network and Main Crossing that discharges to the Firth of Forth, via through-deck drainage, is extremely low in comparison to the tidal flux in the Firth of Forth available to dilute and disperse routine runoff.

9.4.153 As a result of the large available dilution and dispersion, routine road runoff to the Firth of Forth is therefore considered to have an impact of negligible magnitude and Negligible significance on the overall water quality in the Firth of Forth in the vicinity of the proposed scheme.

9.4.154 However, an assessment has been undertaken to consider the potential very localised impacts in the immediate area where the runoff will mix with the ambient water beneath the Main Crossing. This assessment has limited the area of available dilution to the immediate surface layers of the Firth of Forth and surface current speeds in the location of the Main Crossing. For each drainage outfall (assuming outfalls spaced at 15m intervals on each side of the Main Crossing), the local impacts to the Firth of Forth have been assessed by assuming a mixing zone with a diameter of 15m and a depth of 0.5m in the surface layers is available to dilute the discharged runoff. Various current speeds to represent a range of tidal scenarios have been selected to assess the potential levels of dissolved copper and dissolved zinc in the mixing zones. (Refer to Appendix A9.5 (Water Quality) for methodology and calculation spreadsheets.) This assessment therefore uses onerous conditions to assess the potential localised impacts of road runoff prior to mixing in the wider Firth of Forth.

9.4.155 For the discharge to the Firth of Forth, from the Main Crossing through-deck drainage, the calculations and resulting predicted localised dissolved copper and dissolved zinc concentrations, in design year 2032, are summarised in Table 9.18 below.

Table 9.18: Estimated Potential Localised Impact of Zinc and Copper in Routine Road Runoff to Firth of Forth in Design Year 2032 from Main Crossing Through-Deck Drainage

Metal (Dissolved)	EQS Annual Average (µg/l)	Background Conc. (µg/l)	Current Speed (m/s)	Conc. in Mixing Zone with 15m outfall spacing (µg/l)	Potential Impact (unmitigated)	
					Magnitude	Significance
Copper	5	1.2	0.1	2.2	Negligible	Negligible
Zinc	40	3.1		5.2	Negligible	Negligible
Copper	5	1.2	0.3	1.6	Negligible	Negligible
Zinc	40	3.1		4.0	Negligible	Negligible
Copper	5	1.2	0.5	1.5	Negligible	Negligible
Zinc	40	3.1		3.7	Negligible	Negligible

9.4.156 The assessment predicts that in a 15m mixing zone immediately beneath each through-deck drainage discharge, the levels of copper and zinc would increase from background but the EQS would not be exceeded. Outside the 15m mixing zones the concentrations of zinc and copper decrease with distance away from the discharge point.

9.4.157 It is considered that due to the very high dilution and dispersal capacity of the Firth of Forth and the intermittent nature of routine road runoff, localised impacts would be of negligible magnitude and Negligible significance.

9.4.158 The spillage risk assessment for the drainage runs discharging to the Firth of Forth is summarised in Table 9.19 below. Refer to Appendix A9.5 (Water Quality) for methodology and calculation sheets.

Table 9.19: Summary of Spillage Risk Assessment to Firth of Forth in Design Year 2032 (No Mitigation)

<table>
<tr><th rowspan="2">Waterbody (Drainage Run and Sensitivity)</th><th rowspan="2">Threshold of Acceptability (1:X years)</th><th rowspan="2">Spillage Risk (% AEP and Return Period 1:X years)</th><th rowspan="2">Within Acceptable Limits?</th><th colspan="2">Potential Impact (unmitigated)</th></tr>
<tr><th>Magnitude</th><th>Significance</th></tr>
<tr><td rowspan="2">North section (Run Q) (high)</td><td rowspan="6">1:200</td><td>0.1870</td><td rowspan="2">Yes</td><td rowspan="2">Negligible</td><td rowspan="2">Negligible</td></tr>
<tr><td>535</td></tr>
<tr><td rowspan="2">Main Crossing over estuary channel (high)</td><td>0.0351</td><td rowspan="2">Yes</td><td rowspan="2">Negligible</td><td rowspan="2">Negligible</td></tr>
<tr><td>2,853</td></tr>
<tr><td rowspan="2">South section (Runs M and P) (high)</td><td>0.4677</td><td rowspan="2">Yes</td><td rowspan="2">Negligible</td><td rowspan="2">Negligible</td></tr>
<tr><td>214</td></tr>
</table>

9.4.159 The assessment indicates that the risk of accidental spillage from the North section outfall to the Firth of Forth (Run Q) and over the main estuary channel from the Main Crossing would result in an impact of negligible magnitude (i.e. considerably lower spillage rates than the threshold of acceptability) and Negligible significance.

9.4.160 The risk of spillage to the Firth of Forth from the South section outfall (Runs M and P) would be within the threshold of acceptability, i.e. <0.5% AEP (1 in 200-year return period) event. This would result in an impact of negligible magnitude and therefore Negligible significance.

Summary of Potential Impacts on Waterbodies

9.4.161 Table 9.20 provides a summary of the potential impacts to the Firth of Forth and each of the waterbodies, during both the construction and operational phases of the proposed scheme.

Table 9.20: Summary of Potential Impacts on Waterbodies

Water Feature	Sensitivity	Source of Impact	Impact Description Summary	Potential Impact (unmitigated)	
				Magnitude	Significance
St. Margaret's Marsh	Hydrology/Flood Risk: Medium Water Quality: High	General construction works and road operation in catchment	<u>Construction</u> • Hydrology/Flood Risk: Temporary alteration of the hydrological regime into St. Margaret's Marsh. • Water Quality: Potential release of suspended solids and risk of accidental spillage of pollutants due to construction works and close proximity of site compound. Potential mobilisation and release of potential contaminants from St. Margaret's Marsh landfill during construction.	Hydrology/Flood Risk: Medium Water Quality: High	Hydrology/Flood Risk: Moderate Water Quality: Substantial
			<u>Operation</u> • Hydrology/Flood Risk: Expected changes in hydrological regime into the marsh. The proposed scheme includes the realignment of the B981 through the SSSI. • Water Quality: No impact from road drainage (discharged to Firth of Forth).	Hydrology/Flood Risk: Medium Water Quality: n/a	Hydrology/Flood Risk: Moderate Water Quality: n/a
Linn Mill Burn	Hydrology/Flood Risk: Medium Water Quality: Low	General construction works and road operation in catchment	<u>Construction</u> • Hydrology/Flood Risk: Outfall installation and Society Road widening to be located in tidal section of Linn Mill Burn are not expected to impact flood risk along Linn Mill Burn. Temporary increase in hardstanding areas resulting in temporary increases in runoff into Linn Mill Burn. • Water Quality: No direct construction works associated with Linn Mill Burn. Potential sediment release and risk of accidental spillage of pollutants during construction works in catchment.	Hydrology/Flood Risk: Low Water Quality: Negligible	Hydrology/Flood Risk: Slight Water Quality: Negligible
			<u>Operation</u> • Hydrology/Flood Risk: Increase in hardstanding areas resulting in increases in runoff into Linn Mill Burn. The lands directly north of the viaduct abutment and south of Society Road south of the proposed crossing are expected to receive substantial flow during the 1% AEP (1 in 100-year return period) +20% flood event from the carriageway. • Water Quality: Scoped out of assessment as road drainage would outfall to tidal mouth of Linn Mill Burn and therefore would impact only on Firth of Forth.	Hydrology/Flood Risk: Low Water Quality: n/a	Hydrology/Flood Risk: Slight Water Quality: n/a
Swine Burn	Hydrology/Flood Risk: Medium Fluvial Geomorphology: Medium Water Quality: Medium	General construction works and road operation in catchment **Crossing** 1 new culvert ch245 (Interchange Link) (approximately 50m) 1 culvert extension ch730 (M9 Spur)	<u>Construction</u> • Hydrology/Flood Risk: Temporary construction structures placed within flood risk zones or for flow diversion of Swine Burn may temporarily increase flood risk locally and be susceptible to flood damage. Temporary increase in hardstanding areas resulting in temporary increases in runoff into Swine Burn. • Fluvial Geomorphology: Proposals, including the requirement for in-channel works, could substantially increase the supply of sediment downstream which may lead to smothering of the channel bed and a reduction in channel morphology. • Water Quality: Potential sediment release and risk of accidental spillage of pollutants due to construction works in or adjacent to the watercourse and close proximity of site compound to watercourse.	Hydrology/Flood Risk: Medium Geomorphology: High Water Quality: High	Hydrology/Flood Risk: Moderate Geomorphology: Moderate/ Substantial Water Quality: Moderate/ Substantial

Water Feature	Sensitivity	Source of Impact	Impact Description Summary	Potential Impact (unmitigated)	
				Magnitude	**Significance**
		(total 164m) **Realignment** Upstream of new culvert ch2165 – ch1840 (M9) (451m) **Road Outfall** 2 outfalls: • Run A ch2200 – ch2500 (new drainage area: 0.39ha) • Run E ch0 – ch780 (new drainage area: 3.32ha)	<u>Operation</u> • Hydrology/Flood Risk: Installation of new crossing expected to increase flood risk locally upstream of M9 Spur crossing (as the existing M9 Spur crossing appears to control flows downstream). Culvert extension and embankment widening would increase flood risk upstream as it would encroach onto floodplain. Increase of permanent hardstanding area and new outfall location would increase peak flows and change the spatial distribution of flows along reach of Swine Burn. As part of the realignment design provision has been made to accommodate change in gradient by providing a wider floodplain. • Fluvial Geomorphology: Channel realignment may trigger erosion and deposition and cause a reduction in morphological diversity. Culvert works may cause interruptions to sediment transport and sediment supplied from untreated road drainage may lead to some limited smothering of the channel bed. New outfalls may be subject to scour. • Water Quality: Length of new culvert and culvert extension likely to negligible impact upon water quality due to lack of light. Failure of copper and zinc EQS in DMRB routine runoff assessment. Spillage risk within acceptable limits.	Hydrology/Flood Risk: Low Geomorphology: Low Water Quality: High	Hydrology/Flood Risk: Slight Geomorphology: Slight Water Quality: Moderate/ Substantial
Tributary of Swine Burn	Hydrology /Flood Risk: Low Fluvial Geomorphology: Low Water Quality: Low	General construction works and road operation in catchment **Road Outfall** 1 outfall: • Run B ch2180 – ch2500 (new drainage area: 0.66ha)	<u>Construction</u> • Hydrology/Flood Risk: Temporary construction works for SUDS system within catchment may slightly increase peak flow rates into the watercourse. Temporary increase in hardstanding areas resulting in temporary increases in runoff into Tributary of Swine Burn. • Fluvial Geomorphology: Outfall construction could lead to release of sediment and deposition downstream which may cause a reduction in morphological diversity. • Water Quality: Potential sediment release and risk of accidental spillage of pollutants due to construction works in or adjacent to watercourse	Hydrology/Flood Risk: Low Geomorphology: Low Water Quality: Low	Hydrology/Flood Risk: Negligible Geomorphology: Negligible Water Quality: Negligible
			<u>Operation</u> • Hydrology/Flood Risk: Construction of SUDS feature and new outfall to discharge into the tributary expected to increase peak flows and change spatial distribution of flows within reach near outfall location. Increase in hardstanding areas resulting in increases in runoff to Tributary of Swine Burn. • Fluvial Geomorphology: Sediment supplied from untreated road drainage may lead to some limited smothering of the channel bed. New outfall may be subject to scour and may encourage channel erosion or deposition. • Water Quality: Failure of copper EQS in DMRB routine runoff assessment. Accidental spillage risk within acceptable limits.	Hydrology/Flood Risk: Low Geomorphology: Low Water Quality: Medium	Hydrology/Flood Risk: Negligible Geomorphology: Negligible Water Quality: Slight
Niddry Burn	Hydrology/Flood Risk: Medium Fluvial Geomorphology:	General construction works and road operation in catchment	<u>Construction</u> • Hydrology/Flood Risk: Temporary construction structures placed within flood risk zone or for flow diversion of Niddry Burn may temporarily increase flood risk locally and be susceptible to flood damage. Temporary increase in hardstanding areas resulting in temporary increases in runoff into Niddry Burn.	Hydrology/Flood Risk: Medium Geomorphology: Low	Hydrology/Flood Risk: Moderate Geomorphology: Slight

<table>
<tr><th rowspan="2">Water Feature</th><th rowspan="2">Sensitivity</th><th rowspan="2">Source of Impact</th><th rowspan="2">Impact Description Summary</th><th colspan="2">Potential Impact (unmitigated)</th></tr>
<tr><th>Magnitude</th><th>Significance</th></tr>
<tr><td rowspan="2"></td><td rowspan="2">Medium

Water Quality: High</td><td rowspan="2">Crossing
1 culvert extension ch1120 (M9) (total 95.6m)
Road Outfall
1 outfall:
• Run C ch1290 – ch2200 (new drainage area: 4.42ha)</td><td>• Fluvial Geomorphology: Construction works could increase the supply of sediment downstream which may lead to smothering of the channel bed and a reduction in channel morphology.
• Water Quality: Potential sediment release and risk of accidental spillage of pollutants due to construction works in or adjacent to watercourse.</td><td>Water Quality: Medium</td><td>Water Quality: Moderate/ Substantial</td></tr>
<tr><td><u>Operation</u>
• Hydrology/Flood Risk: Potential culvert extension and embankment widening would increase flood risk upstream due to floodplain encroachment. Increase of hardstanding area and new outfall location expected to increase peak flows and change the spatial distribution of flows along reach of Niddry Burn. Increase in hardstanding areas resulting in increased runoff to Niddry Burn.
• Fluvial Geomorphology: Proposals may trigger erosion and deposition and cause a localised reduction in morphological diversity. Sediment supplied from untreated road drainage may lead to some limited smothering of the channel bed. New outfall may be subject to scour.
• Water Quality: Length of culvert extension likely to have negligible impact upon water quality due to lack of light. Failure of copper EQS in DMRB routine runoff assessment. Accidental spillage risk within acceptable limits.</td><td>Hydrology/Flood Risk: Medium

Geomorphology: Low

Water Quality: Medium</td><td>Hydrology/Flood Risk: Moderate

Geomorphology: Slight

Water Quality: Moderate/ Substantial</td></tr>
<tr><td rowspan="2">Tributary of Niddry Burn</td><td rowspan="2">Hydrology/Flood Risk: Low

Fluvial Geomorphology: Low

Water Quality: Low</td><td rowspan="2">General construction works and road operation in catchment

Crossing
1 culvert extension ch880 (M9) (total 62m)</td><td><u>Construction</u>
• Hydrology/Flood Risk: Potential culvert extension and embankment widening would increase flood risk upstream as it would encroach onto floodplain. Temporary increase in hardstanding areas resulting in temporary increases in runoff into Tributary of Niddry Burn.
• Fluvial Geomorphology: Construction works could increase the supply of sediment downstream which may lead to smothering of the channel bed and a reduction in channel morphology.
• Water Quality: Potential sediment release and risk of accidental spillage of pollutants due to construction works in or adjacent to watercourse.</td><td>Hydrology/Flood Risk: Low

Geomorphology: Low

Water Quality: Medium</td><td>Hydrology/Flood Risk: Negligible
Geomorphology: Negligible

Water Quality: Slight</td></tr>
<tr><td><u>Operation</u>
• Hydrology/Flood Risk: Widening of roadway at crossing location expected to increase flood risk locally. Permanent increase in hardstanding areas resulting in increases in runoff into Tributary of Niddry Burn.
• Fluvial Geomorphology: Culvert extension may cause a localised reduction in morphological diversity.
• Water Quality: Length of culvert extension likely to have negligible impact upon water quality due to lack of light.</td><td>Hydrology/Flood Risk: Low

Geomorphology: Low

Water Quality: Negligible</td><td>Hydrology/Flood Risk: Negligible

Geomorphology: Negligible

Water Quality: Negligible</td></tr>
<tr><td>River Almond</td><td>Hydrology/Flood Risk: High</td><td>General construction works and road operation in catchment</td><td><u>Construction</u>
• Hydrology/Flood Risk: Temporary increase in hardstanding areas resulting in temporary increases in runoff into receiving waterbodies which discharge into the River Almond. Temporary displacement of flood waters due to construction works placed within the River Almond</td><td>Hydrology/Flood Risk: Low</td><td>Hydrology/Flood Risk: Slight</td></tr>
</table>

Water Feature	Sensitivity	Source of Impact	Impact Description Summary	Potential Impact (unmitigated)	
				Magnitude	Significance
	Fluvial Geomorphology: Medium Water Quality: High	**Road Outfall** 1 outfall: • Run D ch690 – ch1290 (new drainage area: 2.57ha)	floodplain. • Fluvial Geomorphology: Outfall construction could lead to release of sediment and deposition downstream which may cause a reduction in morphological diversity. • Water Quality: Potential sediment release and risk of accidental spillage of pollutants due to construction works in or adjacent to watercourse.	Geomorphology: Negligible Water Quality: Medium	Geomorphology: Negligible Water Quality: Moderate/ Substantial
			Operation • Hydrology/Flood Risk: Changes to peak flows and hydrological regimes of waterbodies with discharge into River Almond are not expected to impact on the River Almond as these are considered local disturbances. New outfall may slightly impact on spatial distribution of flows in reach of River Almond. Roadway widening within the River Almond floodplain may slightly impact on flood risk locally, but only negligible impacts within the River Almond. • Fluvial Geomorphology: Sediment supplied from untreated road drainage may lead to some limited smothering of the channel bed. New outfall may be subject to scour and may encourage channel erosion or deposition. • Water Quality: Negligible impact from routine runoff due to marginal increase over baseline for copper and zinc concentrations, and well within EQS for both pollutants. Accidental spillage within acceptable limits.	Hydrology/Flood Risk: Negligible Geomorphology: Low Water Quality: Negligible	Hydrology/Flood Risk: Negligible Geomorphology: Slight Water Quality: Negligible
Ferry Burn	Hydrology/Flood Risk: Medium Fluvial Geomorphology: Low Water Quality: Low	General construction works and road operation in catchment **Road Outfall** 1 outfall: • Run J ch1810 – ch2980 (new drainage area: 3.98ha)	Construction • Hydrology/Flood Risk: Temporary increase in hardstanding areas resulting in temporary increases in runoff into Ferry Burn. • Fluvial Geomorphology: Outfall construction could lead to release of sediment and deposition downstream which may cause a reduction in morphological diversity. • Water Quality: Potential sediment release and risk of accidental spillage of pollutants due to construction works in or adjacent to watercourse.	Hydrology/Flood Risk: Low Geomorphology: Low Water Quality: Medium	Hydrology/Flood Risk: Slight Geomorphology: Negligible Water Quality: Slight
			Operation • Hydrology/Flood Risk: Increase in hardstanding areas resulting in increases in runoff into Ferry Burn. • Fluvial Geomorphology: Sediment supplied from untreated road drainage may lead to some limited smothering of the channel bed. New outfall may be subject to scour and may encourage channel erosion or deposition. • Water Quality: Failure of copper and zinc EQS in DMRB routine runoff assessment. Spillage risk within acceptable limits.	Hydrology/Flood Risk: Low Geomorphology: Negligible Water Quality: High	Hydrology/Flood Risk: Slight Geomorphology: Negligible Water Quality: Moderate

<table>
<tr><th rowspan="2">Water Feature</th><th rowspan="2">Sensitivity</th><th rowspan="2">Source of Impact</th><th rowspan="2">Impact Description Summary</th><th colspan="2">Potential Impact (unmitigated)</th></tr>
<tr><th>Magnitude</th><th>Significance</th></tr>
<tr><td rowspan="2">Dolphington Burn</td><td rowspan="2">Hydrology/Flood Risk: Medium

Fluvial Geomorphology: Low

Water Quality: Low</td><td rowspan="2">General construction works and road operation in catchment</td><td><u>Construction</u>
• Hydrology/Flood Risk: Temporary construction works within catchment would have negligible impacts on peak flow rates into the watercourse.
• Fluvial Geomorphology: Road drainage would be routed into the existing drainage system and utilise existing treatment systems (SUDS).
• Water Quality: Potential sediment release and risk of accidental spillage of pollutants due to construction works adjacent to watercourse.</td><td>Hydrology/Flood Risk: Negligible

Geomorphology: Negligible
Water Quality: Low</td><td>Hydrology/Flood Risk: Negligible

Geomorphology: Negligible

Water Quality: Negligible</td></tr>
<tr><td><u>Operation</u>
• Hydrology/Flood Risk: Increase in hardstanding areas resulting in increases in runoff into Dolphington for high return period events.
• Fluvial Geomorphology: Road drainage would be routed into the existing drainage system and utilise existing treatment systems (SUDS).
• Water Quality: Road drainage would be routed into the existing drainage system and utilise existing treatment systems (SUDS).</td><td>Hydrology/Flood Risk: Negligible

Geomorphology: Negligible

Water Quality: Negligible</td><td>Hydrology/Flood Risk: Negligible

Geomorphology: Negligible

Water Quality: Negligible</td></tr>
<tr><td rowspan="2">Firth of Forth</td><td rowspan="2">Hydrology/Flood Risk: High

Coastal Geomorphology: High

Water Quality: High</td><td rowspan="2">General construction works and road operation in catchment

Crossing
1 bridge – Main Crossing

Road Outfall
3 outfalls:
• North (Run Q) ch6800-8750 (total drainage: 11.3ha)
• Main Crossing ch4920-6800 (new drainage area: 5.17ha)
• South (Runs M and P) ch2980-4920 (new drainage area: 8.72ha)</td><td><u>Construction</u>
• Hydrology and Flood Risk: Temporary increase in runoff into receiving waterbodies which discharge into Firth of Forth and temporary displacement of flood waters due to construction works placed within the Firth of Forth.
• Coastal/Estuarine Geomorphology: Temporary and localised morphological change including scour and erosion of subtidal bed and shoreline, and transport and deposition of suspended sediment, due to construction activities within the Firth of Forth but of limited spatial and temporal extent.
• Water Quality: Potential impacts as a result of release of suspended solids and other pollutants and risk of accidental spillage pollutants. High dilution and dispersal capacity of Firth of Forth would reduce spatial and temporal increase in turbidity and pollutants in water column.</td><td>Hydrology/Flood Risk: Negligible

Geomorphology: Negligible

Water Quality: Low</td><td>Hydrology/Flood Risk: Negligible

Geomorphology: Negligible

Water Quality: Moderate</td></tr>
<tr><td><u>Operation</u>
• Hydrology and Flood Risk: Increase in permanent hardstanding areas within the Firth of Forth catchment area and installation of Main Crossing support structures within the Firth of Forth. Potential spillage from viaduct onto properties located under viaduct for high return period events (greater than the drainage capacity of the drainage system) may present a flood risk.
• Coastal/Estuarine Geomorphology: Localised morphological change including scour and erosion of subtidal bed and shoreline due to new runoff outfalls and relocation of Scottish Water treated sewage outfall.
• Water Quality: Potential impacts from routine runoff and accidental spillage from Main Crossing and approach road runoff. High dilution and dispersal capacity of Firth of Forth would reduce any increase in pollutants in water column.</td><td>Hydrology/Flood Risk: Negligible

Geomorphology: Negligible

Water Quality: Negligible</td><td>Hydrology/Flood Risk: Negligible

Geomorphology: Negligible

Water Quality: Negligible</td></tr>
</table>

9.5 Mitigation

Introduction

9.5.1 The objectives of the mitigation measures outlined in this section are to avoid/prevent, reduce or offset the potential impacts described in Section 9.4.

9.5.2 Mitigation includes those measures to convey surface water runoff from the road to receiving waterbodies to avoid or reduce detrimental effects on water quality, water quantity, associated ecosystems and the underlying groundwater (also refer to Chapter 8: Geology, Contaminated Land and Groundwater). It also includes measures to reduce impacts on geomorphological features that may arise from the installation of culverts and realignments, as well as those to be implemented to avoid impacts during the construction phase.

9.5.3 It should be noted that in addition to the measures proposed in this section, there has been significant incorporated mitigation in the form of iterative input to the design process. Examples include the proposed realignment of Swine Burn, and the decision to drain the viaduct sections of the Main Crossing to avoid direct through the deck outfall to the intertidal areas. This iterative approach has required various reviews and design workshops in which environmental team members have informed the design process by discussing proposed engineering options, their associated potential environmental impacts, and recommending measures that limit the impacts on the water environment.

9.5.4 Mitigation proposals for the proposed scheme are detailed on the following figures:

- Drainage design and SUDS on Figure 9.3 (Surface Water Mitigation).
- Landscape and ecological mitigation on Figure 12.4 (Landscape Mitigation).

Guiding Principles

9.5.5 Mitigation is proposed to address adverse impacts where practicable, in particular all impacts assessed as being of Moderate significance or greater. There is no requirement to mitigate impacts assessed as being of Negligible or Slight significance, however where practicable, mitigation will be achieved through the implementation of generic mitigation measures, as discussed below.

9.5.6 The implications of the WFD 2000/60/EC have also been taken into account in the formulation of mitigation, i.e. measures aimed to achieve and preserve ‘good’ ecological status of all watercourses by 2015 (paragraph 9.2.6).

Approach to Mitigation

9.5.7 Mitigation measures typically comprise solutions aimed at the source of the impact. The risk of causing deterioration in status of each waterbody can be reduced by aiming to ‘design out’ risks. This was taken into account during the selection of a preferred route and road alignment during the DMRB Stage 2 assessment, for example to avoid important/sensitive water features where possible. In addition as mentioned above, environmental mitigation has informed design through an iterative, cross-discipline process involving design engineers, geomorphologists, hydrologists, ecologists and water quality specialists.

9.5.8 Consultation with SEPA and SNH has been undertaken at key design stages throughout the EIA process to seek guidance on appropriate levels of mitigation for impacts of road drainage and engineering activities on waterbodies. Relevant fisheries boards have also been contacted. Further information on the consultation process is provided in Chapter 6 (Scoping and Consultation).

9.5.9 Table 9.21 provides a summary of the mitigation that will be adhered to during the construction phase. The mitigation measures proposed to address specific potential impacts to waterbodies are summarised in Table 9.25.

<u>Controlled Activities Regulations 2005 (CAR)</u>

9.5.10 Engineering work and construction activities in or near most watercourses or waterbodies, as well as road outfalls draining over 1km of road, will require a licence under the terms of CAR (refer to paragraph 9.2.8 and mitigation item W17). A CAR application will be made to SEPA for the higher risk activities which will include detailed information on the following:

- The proposed activity, its design and the reasons for the chosen design, as well as alternatives considered and reasons for rejection. The solution taken forward will be the best practical environmental option, taking into account environmental, engineering, economic, and health and safety considerations.
- Details of the potential impacts to the water environment, including baseline environmental information and relevant environmental assessments.
- Details of the mitigation included in the design, aimed at reducing the potential impacts.
- A detailed construction methodology for all engineering activities.

9.5.11 Discussions on CAR authorisation and applications have been undertaken with SEPA and will continue during detailed design and mitigation refinement through the CAR application process. Scheme design and any subsequent mitigation has been developed with regular consultation with SEPA.

Generic Construction Mitigation

9.5.12 The Contractor will be required to comply with the mitigation requirements outlined in the paragraphs below. In addition, a Code of Construction Practice (CoCP) has been produced, defining requirements to be adhered to during the construction of the proposed scheme and associated works (Appendix A19.1: Code of Construction Practice). With regards to the Water Environment, this is required to avoid breach of EQS for surface waters and groundwater, and to avoid any increase in flood risk to properties.

9.5.13 Measures to avoid, reduce or control pollution of surface water and groundwater will incorporate SEPA requirements and CIRIA guidelines for pollution control, including relevant Pollution Prevention Guidelines (PPGs) detailed below (mitigation item W1):

- PPG01 General Guide to the Prevention of Pollution;
- PPG02 Above Ground Oil Storage Tanks;
- PPG03 Use and Design of Oil Separators in Surface Water Drainage Systems;
- PPG04 Treatment and Disposal of Sewage where No Foul Sewer is Available;
- PPG05 Works and Maintenance In or Near Water;
- PPG06 Working at Construction and Demolition Sites;
- PPG07 Refuelling Facilities;
- PPG08 Safe Storage and Disposal of Used Oils;
- PPG10 Highways Depots;
- PPG13 Vehicle Washing and Cleaning;
- PPG14 Marinas and Craft;
- PPG18 Managing Fire Water and Major Spillages;

- PPG20 Dewatering Underground Ducts and Chambers;
- PPG21 Pollution Incident Response Planning;
- PPG22 Dealing with Spillages on Highways;
- PPG26 Storage and Handing of Drums and Intermediate Bulk Containers;
- CIRIA (1997b). Report 142 Control of Pollution from Highway Drainage Discharges;
- CIRIA (1997a).Report 168 Culvert Design Guide;
- CIRIA (2004). C609 Sustainable Drainage Systems;
- CIRIA (2006a). C648 Control of Water Pollution from Linear Construction Projects;
- CIRIA (2006b). C649 Control of Water Pollution from Linear Construction Projects, Site Guide;
- CIRIA (2007). C697 The SUDS Manual; and
- DEFRA (2006).Code of Practice for Using Plant Protection Products.

9.5.14 To reduce potential increases in flows into the receiving watercourses during construction, the period of exposure of bare areas and uncontrolled runoff from newly paved areas will be limited as far as practicable (mitigation item W4).

9.5.15 During temporary construction works, consideration will be given to flood impacts. Plant and material will be stored in safe areas above the 0.5% AEP (1 in 200 year return period) floodplain, where practicable, and the aim will be for temporary construction works to be resistant to flood impacts in order to prevent movement or damage during potential flooding events (mitigation item W5).

<u>Working In-stream and Adjacent to Watercourses</u>

9.5.16 The Contractor will be required to prepare a method statement for in-stream working for approval by SEPA prior to these specific works (mitigation item W6). The method statement will include measures to:

- protect fish;
- deal with flowing water appropriately e.g. temporary diversions, over-pumping;
- reduce the risk of mobilisation of sediments to an acceptable level by employing reasonably practicable measures;
- protect banks where they are particularly vulnerable to erosion;
- undertake diversion of flow back into a channel in a manner that reduces the risk of erosion, with temporary bank stabilisation incorporated if necessary;
- avoid unnecessary in-stream working; and
- compliance with Engineering in the Water Environment Good Practice Guide: Temporary Construction Methods (SEPA, 2009c).

<u>Working In or Near the Marine Environment</u>

9.5.17 The Contractor will implement reasonable measures to reduce the risk of pollution to the marine environment (mitigation item W20) including:

- compliance with PPG14;
- compliance with the requirements of the Food and Environmental Protection Act FEPA licence(s); and

- compliance with all other relevant marine consents such as Coast Protection Act 1949 (CPA) (Office of Public Sector Information, 1949).

9.5.18 The Contractor will apply for the necessary consents required for any dredging activities and will comply with the mitigation measures as set out in the consents (mitigation item W23). A method statement for the dredging will be included in the FEPA licence application for submission to Marine Scotland, for prior approval before commencement of the dredging. This will include details of any monitoring (such as turbidity monitoring) considered necessary. The Contractor will liaise with Forth Ports to request information on any proposed dredging within the Firth of Forth during the programmed dredging period for the proposed scheme. The Contractor will be required within the constraints of the proposed scheme construction programme to make reasonable efforts to avoid carrying out proposed scheme dredging at the same time as other dredging within 3km of the Main Crossing (mitigation item W24).

9.5.19 The coastal modelling (Appendix A9.1) assumes that the dredge pockets would be dredged one at a time. If the Contractor proposes to use more than one dredging vessel to dredge two or more pockets on or near the same shore at the same time, he would be required to demonstrate to SEPA, SNH and Marine Scotland that there would be no additional impacts that could result in an overall significant impact from the dredging activities (mitigation item W25). It is anticipated that the excavation of soft muds in the intertidal area to prepare for the laying of the temporary earth bund on the southern shore could be carried out by land-based excavator. It is anticipated that such land-based excavation would not cause significant mobilisation of sediments into the water column. Consequently, it would be acceptable for the Contractor to carry out such land-based excavation simultaneously with one dredging vessel undertaking dredging of one of the dredge pockets.

9.5.20 The dredged material will be disposed of at an appropriate site authorised to receive such material and in accordance with requirements of Marine Scotland and the FEPA licence conditions for the disposal site (mitigation item W27).

9.5.21 The Scottish Water sewage outfall on the southern side of the shore will be relocated in a manner to reduce disturbance to the subtidal bed and shoreline and relocated to a position to provide adequate dilution and dispersion of effluent in accordance with Scottish Water and SEPA's requirements (mitigation item W44).

<u>Runoff from the Working Area</u>

9.5.22 During construction of the roadway and associated works, temporary drainage systems will alleviate localised flood risk and prevent obstruction of surface runoff pathways. Temporary SUDS systems or equivalent to reduce the potential for contaminated runoff to watercourses and the Firth of Forth will be used (mitigation items W3/W7). This will be achieved through the use of geotextile matting, ditches, or other methods detailed in CIRIA C648 (CIRIA, 2006a) and C697 (CIRIA 2007). A number of these temporary SUDS will be incorporated into the operational drainage network when the road is completed, but additional site-specific SUDS may be required during construction and will be removed once construction is complete.

<u>Sedimentation and Earthworks</u>

9.5.23 General Binding Rule (GBR) 10 of CAR (Scottish Executive, 2005) requires construction sites to be served by a sustainable drainage system, or equivalent, equipped to avoid pollution of the water environment. During construction of the site, temporary SUDS systems or equivalent to reduce the potential for contaminated runoff to watercourses will be implemented (mitigation item W8).

9.5.24 In addition, appropriate control measures for construction site runoff and sedimentation will include (covered by mitigation item W1):

- cleaning of roads to reduce mud and dust deposits;

- limit exposed bare areas and uncontrolled runoff from newly paved areas to that which is required (mitigation item W4);
- covering of soil stockpiles;
- use of silt fences where appropriate;
- early covering/seeding/planting of exposed surfaces where practicable;
- where appropriate, provision of peripheral cut-off ditches or drainage system to intercept runoff from outside the working area such that it does not encroach on the working area;
- lay suitable surfacing materials in site compound and on main access routes; and
- regular proactive visual inspection of the sedimentation measures and receiving watercourses.

9.5.25 If flocculants are considered necessary to aid settlement of fine suspended solids such as clay particles, the chemicals used must first be approved by SEPA (mitigation item W9).

9.5.26 Where required, CAR authorisation will be obtained from SEPA and oil interceptor(s) will be provided for vehicle parking areas, if required by SEPA (mitigation item W10).

9.5.27 The Contractor will be required to comply with the relevant sections of BS6031:1981 Code of Practice for Earthworks with respect to protection of water quality and control of site drainage including washings, dewatering, abstractions and surface water (mitigation item W1).

9.5.28 Where the Contractor considers the use of alternative materials for use as fill, e.g. in embankments, agreement with SEPA will be required prior to use of such material (mitigation item W11).

Watercourse Crossings

9.5.29 The extension of culverts will require in-channel works. In order to reduce the potential for sediment release it is recommended that works are conducted during low flow. The length of channel disturbed will be restricted to that required (mitigation item W16).

Outfalls

9.5.30 Effective mitigation for impacts associated with outfalls (mitigation item W12) will be based on the following principles:

- Construction of outfalls will not be conducted during periods of high flow in order to reduce the risk of scour and erosion around the outfall structures or to the disturbed river bank.
- Construction of outfalls in tidal areas will be appropriately programmed and include appropriate erosion protection measures around the works to reduce the risk of scour and erosion during high tides.
- Where practicable, provide sediment fences to prevent sediment being washed into the watercourses.
- Where practicable, avoid excavating into the watercourse and limit the extent of disturbance.

Oil and Fuels

9.5.31 Best practice measures associated with storage of oils and fuel will be followed (mitigation item W14). Effective mitigation for impacts associated with storage of oil and fuels will be based on the following measures:

- Above ground fuel and oil storage tanks will be required to comply with the Water Environment (Oil Storage) (Scotland) Regulations 2006 and SEPA PPG02: Above Ground Oil Storage Tanks. Accordingly, there will be an impermeable floor under any oil storage tanks and impermeable bund around the tank. The secondary containment system will provide storage of at least 110% of the tank's maximum capacity. If more than one tank is present, the bunded area will be sufficient to store 110% of the biggest tank capacity or 25% of the capacity of all the tanks, whichever is greater.

- Stationary plant will be fitted with drip trays to retain any leakage of oil or fuel. The trays will be emptied at appropriate intervals to prevent overflow.
- Construction plant and vehicles will be properly maintained. Any maintenance to construction plant carried out on site will be carried out in designated areas on an impermeable surface well away from any watercourse or drainage, unless vehicles have broken down necessitating maintenance at the point of breakdown.
- Stationary oil storage tanks will be located above the 0.5% AEP (1 in 200-year return period) flood level.
- Fuel or oil tanks, or refuelling will not be undertaken within 10m of a waterbody or 50m of a spring, well or borehole.
- It is recommended that lighting, alarm and/or CCTV systems are considered for the refuelling site compound to reduce the likelihood of accidental spillages due to vandalism.
- An oil interceptor will be provided for drainage from the refuelling area and will comply with PPG03. It will be fitted with a shut-off valve to allow containment of spillage.
- Spillage kits will be stored at key locations on site (refer to Pollution Incident Control Plan) and in particular at refuelling areas. If feasible, spillage kits will also be kept with mobile bowsers. Alternatively, spillage kits will be kept near where mobile bowsers are used.
- If underground oil storage tanks are considered necessary the sitting of these will be in compliance with SEPA's Code of Practice for Installers, Owners and Operators of Underground Storage Tanks.

<u>Chemical Storage, Handling and Use</u>

9.5.32 Effective mitigation for impacts associated with storage, handling and use of chemicals will be based on the following measures:

- PPG26 will be followed (mitigation item W1). Chemicals stored in drums will, as far as practicable, be stored within a secondary containment system. Containers without secondary containment will not be placed within 10m of a watercourse or waterbody or within 50m of a spring, well or borehole.
- Chemical stores will be located above the 0.5% AEP (1 in 200-year return period) flood level (mitigation item W5).

<u>Controls for Use of Concrete, Cement and Grout</u>

9.5.33 Concrete mixing and washing areas (mitigation item W1) will:

- be located more than 10m from watercourses and waterbodies (mitigation item W22);
- have settlement and re-circulation systems for water reuse;
- have a contained area for washing out and cleaning of concrete batching plant or ready mix lorries; and
- collect wash waters and where necessary, discharge to foul sewer (with the sewerage provider's permission), or contain wash water for authorised disposal off-site.

9.5.34 Wash water from concrete and cement works will not be discharged to the water environment.

Sewage Disposal

9.5.35 Sewage from site facilities will be disposed of appropriately either to:

- foul sewer with the permission of Scottish Water; or
- appropriate treatment and discharge agreed with Building Control and SEPA in advance of construction in accordance with PPG04: Treatment and Disposal of Sewage where No Foul Sewer is Available, and CAR (mitigation items W1/W22).

Service Diversions and Excavation/Ground Penetration near Services

9.5.36 Service diversions, protection of utilities, excavations and ground penetration will be carried out according to good practice. Potential services will be identified using information from the service provider and through survey where necessary. Measures will be taken to prevent damage to services and to avoid pollution during service diversions, excavation and ground penetration (mitigation item W13).

9.5.37 A service pipeline is located near to South Queensferry in the vicinity of the proposed scheme. Detailed plans are available and will be referred to during construction in order to preserve the pipe.

Management of Potentially Contaminated Land

9.5.38 Where works are proposed within areas of potentially contaminated land or where potentially contaminated groundwater is present, appropriate risk management measures will be implemented to reduce the risk of pollution to an acceptably low level.

9.5.39 Recommendations included in Chapter 8 (Geology, Contaminated Land and Groundwater) and associated documentation will be implemented. Where necessary the following will be undertaken:

- risk assessments; and
- further intrusive contaminated land investigation, reporting and recommendations.

Programme of Works

9.5.40 The impact of the proposed scheme can be reduced through timely implementation of certain aspects of the construction works. A programme will be developed to facilitate the practicable implementation of mitigation measures at the stage where their application will be most effective. Appropriate timing of the implementation of mitigation measures is critical (mitigation item W15).

9.5.41 Detention basins to be included in the proposed scheme will be scheduled for construction early in the programme, to allow settlement and treatment of any pollutants contained in site runoff and to control the rate of flow before water is discharged into a receiving watercourse (mitigation item W3). Additional temporary settlement ponds may also be required during construction, particularly in the vicinity of sensitive waterbodies.

9.5.42 In-channel works and works within the floodplain, i.e. construction activities or presence of personnel or construction plant within the 0.5% AEP (1 in 200-year return period) floodplain, will be avoided during periods of high flow and increased flood risk for health and safety reasons. In-channel works will avoid spawning periods in salmonid watercourses, i.e. Niddry Burn and the River Almond (between October and May). More detailed information on this can be found in Chapter 10 (Terrestrial and Freshwater Ecology) along with specific figures on work timings for particular species (mitigation item W16).

9.5.43 Prior to commencing construction, a detailed method statement for the layout and management of each part of the working area subject to a CAR Licence will be agreed with SEPA and provided to the Competent Authority and SEPA for approval a minimum of two weeks prior to start of construction (mitigation item W6)). The method statement will identify, where appropriate, the location of drainage ditches, settlement ponds and sediment fences throughout the site to reduce the impact of turbid runoff whilst maintaining efficient operation of the site. This will involve a combined site visit and consultation between Environmental Clerk of Works, design engineer, construction site manager, and representatives of the Competent Authority, SEPA or SNH (mitigation items W2/W17). Where practicable, mitigation methods will be in situ prior to the start of any construction work.

Monitoring and Inspection during Construction

9.5.44 The Contractor will be required to monitor water quality prior to and during construction assessing chemical and biological parameters as required by SEPA. Parameters, frequency of sampling and limits will be agreed with SEPA in advance of construction (mitigation item W18).

9.5.45 Daily inspections will be carried out by the Environmental Clerk of Works (mitigation items W2/W19) to identify:

- any pollution risks that are unacceptably high;
- spillages and leakages;
- non-compliance with the CoCP; and
- any suspected incidences of pollution.

9.5.46 The Environmental Clerk of Works will recommend appropriate actions where risks are unacceptably high, where there is non-compliance with the CoCP, where spillages and leakages are unacceptable or where there are any suspected pollution incidences. Where necessary, the Pollution Incident Response Procedure will be implemented (mitigation item W19).

Table 9.21: Summary of Generic Mitigation Measures during Construction

Source of Impact	Mitigation
Flood Risk	• To reduce potential increases in runoff into the receiving watercourses during construction, the period of exposure of bare areas and uncontrolled runoff from newly paved areas will be limited as far as practicable (mitigation item W4). • During temporary construction works, plant and material will be stored in safe areas outside the flood risk area, where practicable, and the aim will be for temporary construction works to be resistant to flood impacts in order to prevent movement or damage during potential flooding events (mitigation item W5). • During construction of a new roadway and associated works, temporary drainage systems will alleviate localised flood risk and prevent obstruction of surface runoff pathways (mitigation item W7).
In-channel works in watercourses	• Preparation of method statement for approval by SEPA (mitigation item W6). • Compliance with PPGs including PPG01, PPG05 and PPG06 (mitigation item W1). • Compliance with Water Environment (Controlled Activities) (Scotland) Regulations 2005 authorisation requirements (Scottish Executive, 2005) (mitigation items W8/W17).
In-channel works in Firth of Forth	• Compliance with PPG14, FEPA licence requirements and other relevant marine consents (mitigation item W20).
Runoff from working area	• Temporary drainage systems to alleviate localised flood risk; temporary (and permanent) SUDS systems (or equivalent) to reduce potential for contaminated runoff to waterbodies (mitigation item W7). • Adherence to CIRIA C648 (CIRIA, 2006a) and C697 (CIRIA 2007) (mitigation item W1). • Other runoff and erosion control measures to include: provision of wheel washes more than 10m from watercourses and appropriate disposal of dirty water; cleaning of roads; limit exposed bare areas; covering of stockpiles; use of silt fences (where appropriate); early covering/planting of exposed surfaces; provision of peripheral cut-off ditches to intercept runoff from entering working area; regular inspection and monitoring of receiving watercourses (mitigation items W21/W22). • Any flocculants to be approved in advance by SEPA (mitigation item W9). • Temporary discharge consents to be obtained from SEPA, where required (mitigation item W10). • Compliance with relevant sections of BS6031 (mitigation item W1).

Source of Impact	Mitigation
Watercourse crossings	• Works to be conducted in low flow conditions (mitigation item W16). • Compliance with Water Environment (Controlled Activities) (Scotland) Regulations 2005 authorisation requirements (Scottish Executive, 2005) (mitigation item W17).
Outfall construction	• Construction will not be conducted during periods of high flow and/or high tide (mitigation item W16). • Sediment fences will be used to prevent sediment being washed into watercourse (mitigation item W12). • Excavation into the river banks to be avoided, where practicable (mitigation item W12). • Compliance with Water Environment (Controlled Activities) (Scotland) Regulations 2005 authorisation requirements (Scottish Executive, 2005) (mitigation item W17).
Refuelling	• Compliance with the Water Environment (Oil Storage) (Scotland) Regulations 2006 (Scottish Executive 2006) (mitigation item W14). • Compliance with PPG02 (mitigation item W1). • Bunded areas of sufficient storage capacity (at least 110% of maximum tank capacity) with impervious walls and floor lining for the storage of fuel, oil and chemicals (mitigation item W14). • Appropriate measures, including site security, to avoid spillages (mitigation item W14). • Compliance with the Pollution Incident Control Plan (mitigation item W19).
Oil/fuel leaks and spillages	• Stationary plant will be fitted with drip trays and emptied regularly; plant machinery to be properly maintained (mitigation item W19). • Spillage kits will be stored at key locations on site (mitigation item W19).
Chemical storage, handling and use	• Compliance with PPG26 (mitigation item W1). Appropriate storage and containment of chemicals; stores to be located above the 0.5% AEP (1 in 200-year return period) flood level (mitigation item W5).
Concrete, cement and grout	• Concrete mixing and washing areas will be located more than 10m from waterbodies (mitigation item W22). • Wash water will not be discharged to the water environment and will be disposed of appropriately (mitigation item W1).
Sewage disposal	• Compliance with PPG04 (mitigation item W1). • Sewage to be disposed of appropriately (mitigation item W1).
Service diversions and excavation/ ground penetration	• Adherence to best practice (mitigation item W1).
Contaminated land and sediment	• In areas where ground contains elevated concentrations of contaminants, appropriate measures will be implemented to reduce risk of surface water pollution to an acceptably low level (refer to Chapter 8: Geology, Contaminated Land and Groundwater).

Specific Construction Mitigation – Watercourses

9.5.47 Where impacts have been assessed as of Moderate significance or greater (refer to Table 9.20), site-specific mitigation has been considered in addition to the generic construction mitigation measures described above. Where impacts have been assessed as Slight or Negligible significance, no specific mitigation has been proposed as the generic mitigation will be sufficient (Linn Mill Burn, Tributary of Swine Burn, Tributary of Niddry Burn, Ferry Burn and Dolphington Burn).

St. Margaret's Marsh

Hydrology and Flood Risk

9.5.48 To mitigate for the change in hydrological regime during the installation of the roadway through the marsh area, connectivity through the roadway between the upper and lower portions of the marsh area will be conserved (by way of cross-drainage piping or permeable infill materials). Runoff from the roadway construction and exposed ground surfaces will be diverted into a SUDS (or equivalent) system, and discharged into the Firth of Forth (mitigation item W29).

Water Quality

9.5.49 Further assessment of the groundwater regime at St. Margaret's Marsh prior to construction is proposed within Chapter 8 (Geology, Contaminated Land and Groundwater). This will include installation of additional groundwater sampling wells and additional groundwater and soils analysis. These investigations will inform any additional mitigation measures required during construction to protect the water quality of St. Margaret's Marsh and the Firth of Forth (mitigation items W28/G24).

9.5.50 A soils reuse assessment will be undertaken prior to reuse of soils excavated from the St. Margaret's Marsh area to identify any risks posed to the water quality of St. Margaret's Marsh (mitigation item G16).

9.5.51 During the construction of the proposed scheme, the following specific mitigation measures, in addition to the general best practice construction mitigation stated above, will be required for St. Margaret's Marsh:

- storage of chemical, fuel or oil tanks, or refuelling will located more than 10m from St. Margaret's Marsh SSSI boundary (mitigation item W21);
- concrete mixing and washing areas will be located more than 10m from St. Margaret's Marsh SSSI boundary (mitigation item W22); and
- an Environmental Clerk of Works will be present on site to supervise the implementation of appropriate environmental safeguards during construction (mitigation item W2).

<u>Swine Burn</u>

Hydrology and Flood Risk

9.5.52 Mitigation required to reduce potential impacts to the hydrology and flood risk of Swine Burn as a result of construction activities and associated works will be developed and implemented in line with the generic mitigation detailed above.

Fluvial Geomorphology

9.5.53 The construction of the new culvert will require extensive in-channel works. During culvert installation, flow will be diverted around the channel works, either in a lined open channel or through a pipe. This will allow channel works to be conducted in dry conditions reducing the risk of sediment release during construction. The diversion channel will be of similar size and gradient to the existing channel. Flow will only be re-routed into the new culvert once channel works are completed, and, if practicable, during low flow conditions. The length of channel disturbed will be restricted to that required (mitigation item W16).

9.5.54 Bare channel banks created during installation of the new culvert will be covered by geotextile matting following completion to limit the potential for erosion. Geotextile matting will limit the potential for fluvial scour, geotechnical failure and rainfall-induced runoff erosion of the exposed banks. The geotextile matting will be seeded to promote vegetation colonisation and to encourage rapid stabilisation (mitigation item W17).

9.5.55 The realignment will be constructed and completed offline. It is essential that no flow is routed through the realignment during construction. The channel works will be complete, including the new culvert prior to the re-routing of water. The new channel will be constructed by moving progressively upstream to reduce the risk of flow switching into the new channel during high flow events, prior to completion (mitigation item W17).

9.5.56 Effective mitigation for impacts associated with channel realignment will be based on the following principles (covered by mitigation item W17):

- To limit the potential for bank erosion, the new banks of the realignment will be appropriately graded to take account of geomorphological and ecological considerations.
- Covering newly formed banks along the new alignment with geotextile matting (where deemed necessary by a qualified geomorphologist) will also reduce the potential for erosion by physically holding the newly exposed bank sediments together. This will limit the potential for fluvial erosion and runoff-induced erosion on the exposed banks during rainfall. The geotextile matting will be seeded to promote vegetation colonisation to encourage rapid stabilisation of this new section of watercourse.
- Bed sediments will not be transferred from the existing channel as this will necessitate a temporary realignment during sediment transfer. Bed sediments will not be taken from the existing channel as transferring river bed sediment may release fine sediments and pollutants stored beneath the bed armour (coarse sediments forming the top layer of the bed sediments). Bed sediments will be appropriately sized (and shaped) gravels derived from a local source. The use of gravel-sized sediments will provide voids within the channel which will act as a sediment sink to fine material allowing a reduction in sediment transfer downstream where any localised readjustment (erosion) occurs following the re-routing of flow.
- It is likely that when flow is routed through the new channel alignment, there will be a period of adjustment during which some sediment release can be expected. The new channel will be monitored regularly and where signs of instability are observed, such as erosion or incision, appropriate remediation measures will be undertaken.
- Sediment control measures will be placed at the downstream end of the realignment to intercept sediment released during the connection of the new alignment.
- Site activity in the vicinity of the realignment will be carefully managed to reduce the risk of accidental spillage into the watercourse. All pumps will have drip trays to avoid accidents and be set away from the watercourse. The drip trays will be emptied and oils disposed of appropriately at sufficiently frequent intervals to avoid overflow. Where required, site road crossings will consist of a piped section sufficiently long to provide a road together with strips of ground either side to provide a barrier between the road and open channel sections.
- Works will be carried out during periods of low flow conditions (e.g. summer months) to reduce the risk of flood events disrupting the construction site or filling the incomplete realignment with water.

Water Quality

9.5.57 Mitigation required to reduce potential impacts to the water quality of Swine Burn as a result of construction activities and associated works will be in line with the generic mitigation and specific fluvial geomorphology mitigation detailed above.

9.5.58 With regards to cuttings intercepting groundwater, additional groundwater sampling has been included in the design of post-ES GI to complement knowledge of groundwater quality along the Swine Burn realignment cutting. In addition, post-ES permeability tests have been scheduled to enable an estimate of the volumes of groundwater that will be dewatered during the first part of the construction phase. This information will be provided to the Contractor (refer to Chapter 8: Geology, Contaminated Land and Groundwater).

<u>Niddry Burn</u>

9.5.59 Mitigation required to reduce potential impacts to the hydrology/flood risk, fluvial geomorphology and water quality of Niddry Burn as a result of construction activities and associated works will be in line with the generic mitigation detailed above (with particular reference to construction of culvert extensions and outfalls).

River Almond

9.5.60 No specific mitigation for hydrology/flood risk or fluvial geomorphology is required for the River Almond as the impacts during the construction stage would be of either Slight or Negligible significance.

9.5.61 Mitigation required to reduce potential impacts to the water quality of the River Almond as a result of construction activities and associated works will be in line with the generic mitigation detailed above (with particular reference to construction of outfalls).

Specific Construction Mitigation – Firth of Forth

Hydrology and Flood Risk

9.5.62 No specific mitigation for hydrology/flood risk or coastal/estuarine geomorphology is required for the Firth of Forth as the impacts during the construction stage would be of Negligible significance.

Water Quality

9.5.63 During the construction of the proposed scheme, the following specific mitigation measures, in addition to the general best practice construction mitigation stated above, will be required for the Firth of Forth:

- temporary treatment ponds will be constructed to reduce the runoff pollution from the approach road construction (mitigation item W3);
- storage of chemical, fuel or oil tanks, or refuelling will located more than 10m from St. Margaret's Marsh SSSI boundary (mitigation item W21);
- concrete mixing and washing areas will be located more than 10m from St. Margaret's Marsh SSSI boundary (mitigation item W22);
- enclosed spraying when waterproofing or using other sprayed chemicals, preventing chemicals from entering the estuary (mitigation item W26); and
- an Environmental Clerk of Works will be present on site during construction, to supervise the implementation of appropriate environmental safeguards (mitigation item W2).

9.5.64 With regards to cuttings intercepting groundwater, additional groundwater sampling has been included in the design of post-ES GI to complement knowledge of groundwater quality along the mainline cuttings ch3025-4250 and ch7950-8430 and the B981 realignment cutting. In addition, post-ES permeability tests have been scheduled to enable an estimate of the volumes of groundwater that will be dewatered during the first part of the construction phase. This information will be provided to the Contractor (refer to Chapter 8: Geology, Contaminated Land and Groundwater).

Generic Operational Mitigation

Drainage

9.5.65 The drainage system of the proposed scheme is being designed in accordance with the following guidance:

- Control of Pollution from Highway Drainage Discharges, Report 142 (CIRIA 1997).
- Sustainable Drainage Systems, CIRIA C609 (CIRIA 2004).
- The SUDS Manual, CIRIA C697 (CIRIA (2007).

- DMRB HA103/06: Vegetated Drainage Systems for Highway Runoff (Highways Agency et al., 2006c).
- DMRB HA119/06: Grassed Surface Water Channels for Highway Runoff (Highways Agency et al., 2006d).

9.5.66 Where it has been identified as necessary for road drainage to discharge to receiving waterbodies, mitigation will be designed to limit the volume of discharge and the risk to water quality. Where required, authorisation for the road drainage discharge under the Water Environment (Controlled Activities) (Scotland) Regulations 2005 (Scottish Executive, 2005) will be obtained from SEPA. For each outfall, a range of SUDS solutions will be incorporated to attenuate the road runoff to pre-development rates, reduce the polluting load carried within this runoff to acceptable levels and significantly reduce the risk of any accidental spillages.

9.5.67 In accordance with DMRB HA 216/06 guidance (Highways Agency et al., 2006b), no spillage containment mitigation is required. However, the implementation of SUDS (as required for new and upgraded road sections), would reduce the risk of pollution from a spillage event. In addition, for existing sections of road to be upgraded, which currently have limited or no treatment levels (Table 9.6), spillage risk is anticipated to reduce with the implementation of SUDS.

9.5.68 All proposed, SUDS detention basins and swales will be designed with an impermeable liner to reduce risk of pollution to groundwater (refer to Chapter 8: Geology, Contaminated Land and Groundwater). In addition, proposed drainage systems along the chainages specified in Chapter 8 (Geology, Contaminated Land and Groundwater) will be contained or lined (mitigation item G19).

9.5.69 For each outfall, a 'treatment train' to maximise pollutant removal will be proposed which comprises a series of mitigation measures such as filter drains, swales and detention basins. The drainage runs, SUDS detention basins, swales and outfall locations are shown on Figure 9.3. For new sections of road and roads to be upgraded, the treatment train will consist of three levels of SUDS (mitigation item W28), where practicable, in accordance with CIRIA (2007) and as discussed with SEPA during the consultation process (refer to Chapter 6: Consultation and Scoping). A description and intended function of each treatment system being considered is described below. The potential indicative pollution removal efficiency and design robustness of the different SUDS techniques to meet the required hydraulic and water quality design criteria, are presented in Table 9.22. In addition, the last column provides the optimum indicative pollutant reduction efficiencies by which certain SUDS measures could be expected to reduce the risk of an accidental spillage, in line with DMRB HA 216/06 guidance (Highways Agency et al., 2006b).

Table 9.22: Treatment Systems Efficiency and Design Robustness of SUDS

SUDS Treatment System	Pollutant Removal Efficiency				Hydraulic Design for Flow and Attenuation	Spillage Risk Reduction (%)
	Total Suspended Solids	Hydrocarbons	Heavy Metals	Dissolved Pollutants		
Filter Drains	Moderate-High	Moderate	Moderate-High	Moderate-High	High	40%
Swale (dry)	Moderate-High	Moderate-High	High	None-Low	High	40%
Sand Filter	High	Moderate-High	Moderate-High	None-Low	Low-Moderate	No data
Detention Basin (dry)	Moderate-High	Moderate	Moderate-High	None-Low	High	50%

Sources: CIRIA (2004); CIRIA (2007); Highways Agency et al.(2006b)

9.5.70 The hydraulic and water quality performance potential of each SUDS technique has informed the drainage design based on their primary functions and capabilities. SUDS have been selected to include different stages of the 'treatment train' (pre-treatment, conveyance, source, site or regional controls). The primary functions and the water quality treatment processes for each SUDS technique included within the proposed scheme design is listed in Table 9.23.

Table 9.23: Primary Functions and Capabilities of SUDS Techniques included within the Proposed Scheme

SUDS Treatment System	Component	Primary functions and capabilities
Filter Drains	Management Train Suitability	Conveyance, Source Control
	Water Quantity	Conveyance, Detention
	Water Quality	Filtration, Adsorption, Biodegradation, Volatilisation
Swale (dry)	Management Train Suitability	Conveyance, Source Control, Site Control
	Water Quantity	Conveyance, Detention
	Water Quality	Sedimentation, Filtration, Adsorption, Biodegradation
Sand Filter	Management Train Suitability	Pre-treatment, Site Control
	Water Quantity	Detention
	Water Quality	Filtration, Adsorption, Biodegradation, Volatilisation, Precipitation
Detention Basin (dry)	Management Train Suitability	Site Control, Regional Control
	Water Quantity	Detention
	Water Quality	Sedimentation, Biodegradation

Source: CIRIA (2007)

Filter Drains and Catchpits

9.5.71 Filter drains usually consist of a perforated pipe laid in a trench backfilled with gravel and usually placed along the road verge. Filter drains can be used to convey highway drainage to the discharge point and also filter out pollutants such as suspended solids, hydrocarbons and heavy metals. They are indicatively reported to remove between 50%-85% of total suspended solids, 30%-70% of hydrocarbons and 50-80% of heavy metals (CIRIA, 2004).

9.5.72 Piped carrier drains may be required at certain locations to transfer surface water beneath the main carriageway, and from the filter drains to designated outfall points. Such pipes convey surface water but generally are not designed to attenuate flows.

9.5.73 Catchpits consist of a small chamber with a sediment collection sump. These are pre-treatment measures designed to trap sediments and other debris, retain a proportion of the suspended solids present in the runoff and settle out hydrocarbons and metals (associated with sediments). Pre-treatment devices are intended to prevent clogging and reduce the need for maintenance of downstream SUDS treatment. Catchpits are located at regular spacings along filter drains and at the junctions of carrier drains.

Detention Basins

9.5.74 These are ‘end-of-line’ treatment systems, providing biological treatment and some reduction of dissolved contaminants and nutrients. They are constructed to collect road runoff prior to discharge to the receiving water environment. Detention basins are indicatively reported to remove between 65-90% of total suspended solids, 30-60% of hydrocarbons and 40-90% of heavy metals (CIRIA, 2004).

9.5.75 Detention basins have been included in the SUDS design instead of treatment ponds, as requested by SEPA in October 2008. Detention basins are considered to be more effective at removing pollutants such as hydrocarbons as they allow sunlight to breakdown the particles at a faster rate.

9.5.76 The required storage volume to treat road drainage (the treatment volume) is calculated based on the guidance contained in CIRIA (2007), CIRIA (2004) and guidance on best design practice for pollutant removal given in 'Treatment of Highway Runoff Using Constructed Wetlands' (Environment Agency, 1998b). The detention basin to treat and attenuate road drainage from the north section (including Ferry Toll Junction), is constrained by St. Margaret's Marsh SSSI and is therefore designed to attenuate and treat Vt (the volume generated by the mean annual flood), as agreed with SEPA in January 2009. All other basins have been designed to attenuate up to a 0.5% AEP (1 in 200-year return period) flow which is equivalent to at least 4Vt. In addition, discharges from the basins to inland watercourses is restricted to pre-development flow rates which were calculated at the 50% AEP (1 in 2-year return period) flow.

Swales and Filter Strips

9.5.77 Swales are vegetated surface features that drain water evenly off impermeable areas. The swale channel is broad and shallow and covered by grass or other suitable vegetation to slow down flows and trap pollutants. Swales can also be designed for a combination of conveyance, infiltration, detention and treatment of runoff (Table 9.23). They are typically located next to highways but can also be constructed in landscaped areas within car parks and elsewhere.

9.5.78 Swales are indicatively reported to remove between 70-90% of total suspended solids and hydrocarbons, and 80-90% of heavy metals (CIRIA, 2004). They are generally effective at removing pollutants through filtration and sedimentation for frequent small storm events (CIRIA, 2004). For larger, less frequent storms of between a 50% AEP and 10% AEP (1 in 2-year and 1 in 10-year return periods, respectively), they can act as a storage and conveyance mechanism. For larger storms with an AEP of less than 10% (return periods greater than 1 in 10 years), providing storage in swales may become impractical as catchment size increases and they are often used in conjunction with other techniques.

9.5.79 Swales are often integrated into the surrounding land use, for example public open space or road verges. Local wild grass and flower species can be introduced for visual interest and to provide a wildlife habitat. Care will be taken in the choice of vegetation as tussocks create local eddies, increasing the potential for erosion on slopes. Shrubs and trees can be planted but in this case the vegetated area will need to be wider and have a gentler slope (CIRIA, 2004).

9.5.80 Filter strips are similar to swales but instead of being a wide shallow channel, they are gently sloping areas of ground.

Sand Filters

9.5.81 Sand filters are single or multi-chambered structures designed to treat surface water drainage through filtration using a sand bed as the primary filter medium. Temporary storage of runoff can be achieved by ponding above the filter layer. They are particularly effective where high levels of pollutant removal are required. Sand filters are indicatively reported to remove between 80%-90% of total suspended solids, and 50%-80% of hydrocarbons and heavy metals (CIRIA, 2004).

Outfall Structures

9.5.82 Each outfall will be correctly positioned to limit the potential for scour around the culvert. The location and design of the outfall will be such that there would be no significant alteration to flow patterns which may lead to turbulence and/or excessive deflection of flow towards the bed or banks of the channel. The outfall will not project out into the channel and will not be located where flow converges with river banks causing higher shear stresses or where active bank erosion is occurring.

9.5.83 Details of best practice are identified in CIRIA (2007), DMRB HA107/04; Design of Culvert and Outfall Details (Highways Agency et al., 2004) and SEPA SG-28 Good Practice Guide: Intakes and Outfalls (SEPA, 2008d) (mitigation item W1).

Maintenance of Road Drainage Network

9.5.84 To avoid failure or sub-optimal operation of the road drainage network, maintenance of its components will be necessary (mitigation items W45/W46). Regular inspection to inform on maintenance frequency requirements will be required, with the minimum recommended maintenance as follows:

- maintenance of filter drains include inspection and weed control, removal of sediment and vegetation build up, replacement of clogged filter material typically at least once every 10 years;
- maintenance of filtration devices include inspections, grass cutting and site rubbish removal, annual reinstatement of eroded areas or damaged vegetation and removal of sediment;
- regular maintenance of detention basins and treatment ponds to enable efficient operation and the settlement of solids and removal of pollutants (such as hydrocarbons);
- regular maintenance of receiving watercourses and culverts to reduce the risk of blockages and associated flood risk;
- if herbicides are used, those recommended by SEPA for use near watercourses are to be applied in line with manufacturer's instructions to reduce pollution of watercourses; and
- provision of scour protection at the drainage discharge outfall to protect the banks and bed of the receiving watercourse and to limit erosion.

<u>Culvert Extensions</u>

9.5.85 During the design of the new culvert crossing at Swine Burn and the three proposed culvert extensions, workshops have been held with engineers, ecologists and geomorphologists, as well as SEPA representatives at key design stages to facilitate incorporation of appropriate mitigation measures.

9.5.86 Based on SEPA guidance, it is proposed that existing culverts be extended without limiting their existing hydraulic capacity. The extensions may lead to building within the existing floodplain. Mitigation for infill within the floodplain will be provided through compensatory storage (mitigation item W31).

9.5.87 Culvert extensions must have the same form as the existing culvert to ensure that there is no change in form (widening, narrowing and separation) which could interrupt sediment transport.

<u>Compensatory Storage</u>

9.5.88 Where the proposed scheme encroaches on the floodplain of watercourses, adequate compensatory storage will be provided for the Tributary of Niddry Burn, Niddry Burn, Swine Burn and the River Almond (mitigation item W31). Refer to Appendix A9.3 for details of compensatory storage calculations.

Specific Operational Mitigation – Watercourses

9.5.89 Site-specific mitigation during the operation of the proposed scheme is outlined below.

9.5.90 On the existing approach road infrastructure associated with the existing Forth Road Bridge, a proportion of road runoff drains from the road surface into perforated pipes, before discharging to watercourses (Table 9.6). Perforated pipes (similar to filter drains) provide a limited degree of filtration and treatment. As highlighted above, for new sections of road and roads to be upgraded within the proposed scheme, the treatment train will generally consist of three levels of SUDS, where practicable, in accordance with CIRIA (2007) and as discussed with SEPA during the consultation process. Therefore the proposed scheme will improve on this existing situation, taking most of road drainage from upgraded and new road sections into SUDS (Table 9.24).

9.5.91 Table 9.24 summarises the level of SUDS proposed before outfall to each waterbody in order to prevent deterioration of water quality, to provide sufficient attenuation of flows and to be in line with consultation with SEPA throughout the EIA process (also refer to Figure 9.3).

Table 9.24: SUDS Measures

Waterbody	Drainage Number and Road Drainage Length	Outfall Location	Proposed Levels of SUDS
Firth of Forth (north section)	Run Q 7,850m	NT 1224 8125	3-4 SUDS treatment levels: • filter drains on mainline and road infrastructure associated with Ferry Toll Junction, not approach viaduct; • detention basin to treat first flush (Vt); and • swale (and sand filter bed).
Firth of Forth (Main Crossing)	n/a 1,880m	Outfalls at regular spacings (15m indicatively)	No SUDS treatment. Drainage over inter-tidal areas on north and south shores taken back to land-based SUDS.
Firth of Forth (south section)	Run M and P 5,180m	NT 1144 7874	1-3 SUDS treatment levels: • filter drains on mainline and road infrastructure associated with Queensferry Junction, not approach viaduct; • swale (at certain locations where road is in cutting and runoff drains to the inside bend of the road); and • detention basin.
Swine Burn	Run A 300m	NT 1106 7472	1 SUDS treatment level: • filter drains (small carriageway widening in this location and will allow for an improvement over existing situation).
	Run E 1440m	NT 1144 7464	2 SUDS treatment levels: • filter drains; and • detention basin.
Tributary of Swine Burn	Run B 320m	NT 1071 7471	2 SUDS treatment levels: • filter drains; and • detention basin.
Niddry Burn	Run C 2,760m	NT 1175 7406	2-3 SUDS treatment levels: • filter strips (at the M9 Junction 1A loop); • filter drains; and • detention basin.
River Almond	Run D 680m	NT 1209 7354	3 SUDS treatment levels: • filter drains; • swale; and • detention basin.
Ferry Burn	Run J 1340m	NT 1260 7745	3 SUDS treatment levels: • filter drains; • swale; and • detention basin.

St. Margaret's Marsh

Hydrology and Flood Risk

9.5.92 Mitigation is required to reduce the impact to the hydrology and flood risk of St. Margaret's Marsh as a result of the operation of the SUDS pond and the realigned B981 through the northern portion of the marsh. To mitigate against catchment severance following the completion of the B981 roadway, cross drainage will be provided underneath this road to hydrologically link the upstream and downstream portions of the marsh area (mitigation item W29). In addition, areas of scrub woodland will be provided to compensate for areas of the marsh taken up by the road. It has been estimated that if all mitigation is in place, this will result in a decrease of 7% to the surface water flow of the marsh.

9.5.93 The post-ES GI will provide additional background information on the hydrogeology of St. Margaret's Marsh, including information on groundwater quality, following which significance of impact on St. Margaret's Marsh will be confirmed.

9.5.94 Based on these data, a groundwater monitoring network will be put in place within St. Margaret's Marsh (mitigation item W29). There remains some uncertainty on baseline information relating to St. Margaret's Marsh groundwater bodies and their interactions. Chapter 8 (Geology, Contaminated Land and Groundwater) provides further information with regard to the additional GI undertaken and the monitoring proposed.

Water Quality

9.5.95 No specific mitigation for water quality is required for St. Margaret's Marsh as the impacts during the operational stage would be of Negligible significance. It is proposed that road drainage from the new B981 will be taken to SUDS before discharging to the Firth of Forth.

Linn Mill Burn

Hydrology and Flood Risk

9.5.96 Mitigation required to reduce the impact to flood risk and hydrology of Linn Mill Burn will be in line with the generic mitigation detailed above for new outfall and SUDS features implementation. The outfall from this SUDS pond will be installed downstream of Society Road in the tidal mouth of the watercourse and is therefore not expected to impact flood risk within the Linn Mill Burn.

9.5.97 To mitigate against an increase in flood risk from the carriageway drainage onto lands adjacent to the viaduct abutments for flood events rarer than the 1% AEP (1 in 100-year return period) with an allowance for an additional 20% increase for climate change, excess runoff will be directed toward areas of detention, and/or conveyed toward the Firth of Forth without impacting areas of high risk (mitigation item W30). Regular inspection/maintenance of the drainage system conveying flood flows to low risk areas will be undertaken regularly to prevent blockage.

Water Quality

9.5.98 No specific mitigation for water quality is required for Linn Mill Burn as the impacts during the operational stage would be of Negligible significance.

Swine Burn

Hydrology and Flood Risk

9.5.99 Mitigation required to reduce the impact to flood risk and hydrology of Swine Burn will be in line with the generic mitigation detailed above for new outfall and SUDS features implementation.

9.5.100 The design of the Swine Burn realignment has taken account of the encroachment on the floodplain by the embankments of the proposed new culvert and the culvert extension (refer to paragraph 9.4.112 in Section 9.4).

9.5.101 To reduce potential flood risk associated with culvert blockage of the new proposed culvert and the extended culvert, a regular inspection and debris removal maintenance programme will be implemented (mitigation item W45).

9.5.102 To mitigate against an increase in flood risk from the carriageway drainage onto lands adjacent to the section of the motorway south of the railway line and north of the B9080 roadway (for high return period events), excess runoff will be directed toward areas of detention or areas of less flood risk, and/or conveyed toward the Swine Burn without impacting areas of high risk, if deemed practicable (mitigation item W32).

Fluvial Geomorphology

9.5.103 The new culvert on Swine Burn will be a depressed invert box culvert (mitigation item W33). The culvert invert will be set below streambed level to allow 300mm of natural substrate to be used within the culvert and provide limited in-stream morphological diversity. Substrate in the culvert is likely to be new material of a similar size to that of the original channel in order to reduce the risk of sediment washing out at times of high flow. The design of the culvert will be in accordance with guidance from the Scottish Executive on culverts and migratory fish (SEERAD, 2000).

9.5.104 To enable a 0.5% AEP (1 in 200-year return period) flow capacity without interrupting sediment transport, the culvert will have a two-stage cross-sectional form (mitigation item W33). This will involve the provision of a low flow channel and bench to act as a floodplain. This will reduce the risk of interception of sediment transport leading to siltation and will prevent low flows becoming too diffuse.

9.5.105 A regular maintenance regime will be implemented in order manage debris in and around the culvert. This work will include the removal of debris and dead vegetation from the culvert as this may increase sediment deposition (mitigation item W33).

9.5.106 The culvert design will follow SEPA policy and the guidelines set out in CIRIA (1997) (mitigation item W1). In addition, the culvert will be designed to facilitate fish passage following guidance from SEERAD (2000). The culvert design will also incorporate the requirements of CAR (mitigation item W17).

9.5.107 The culvert will be designed such that its gradient does not differ markedly from the pre-existing channel gradient to avoid excessive siltation or erosion. In addition, the culvert will have a mammal ledge installed to allow otter passage (mitigation item TE20) to the requirements of the DMRB (Highways Agency et al., 1999) (Chapter 10: Terrestrial Ecology).

9.5.108 To limit the potential for post-construction erosion of the floodplain, the floodplain will be encouraged to vegetate with a simple cover of grasses and tall (rank) herbs. In addition, occasional clumps of broadleaf (deciduous) trees will be planted on the floodplain. This vegetation will both replicate the existing conditions and also provide protection against surface scouring during floods (mitigation item W46).

9.5.109 To limit the potential for post-construction bank erosion, small areas of broadleaf (deciduous) trees will also be planted on the floodplain along the outside of bends in the low flow channel. These trees will be set-back from the channel margin by 2m. This will allow for a degree of bank erosion during the immediate post construction phase when vegetation is becoming established. Setting the trees back allows for bank erosion without risking removal of the trees, by erosion, before they become established (mitigation item W46).

9.5.110 Further design refinement will continue during the preparation of the CAR application for the realignment, in consultation with SEPA. This will ensure the realignment details are optimised for reduction of impacts. This will be informed by a Sediment Dynamics Assessment. It is recommended that design refinements emerging from this assessment should include:

- minor amendments to the position of the low flow channel;
- localised variations in the cross-section form of the low flow channel;
- bed sediment sizing;
- determination of the position and dimensions of pools and riffles;

- identification of requirements for bank protection; and
- refined recommendations for floodplain riparian vegetation provision.

9.5.111 A period of monitoring will be undertaken after construction to reassess the effects on sediment transport.

Water Quality

9.5.112 During operation, road drainage will be treated through SUDS before discharging to Swine Burn at two outfalls (Table 9.24) (mitigation item W32). The SUDS treatment train will consist of:

- Drainage Run A outfall: 1 level of SUDS including filter drains.
- Drainage Run E outfall: 2 levels of SUDS including filter drains and a detention basin.

9.5.113 Additional groundwater sampling is proposed post-construction within Chapter 8 (Geology, Contaminated Land and Groundwater) to complement knowledge of groundwater along the Swine Burn realignment cutting.

<u>Tributary of Swine Burn</u>

9.5.114 No specific mitigation for hydrology/flood risk, fluvial geomorphology or water quality is required for the Tributary of Swine Burn as the impacts during the operational stage would be of Negligible or Slight significance.

9.5.115 During operation, road drainage will be treated through SUDS before discharging to an outfall at the Tributary of Swine Burn (Table 9.24) (mitigation item W35). The SUDS treatment train will consist of:

- Drainage Run B outfall: 2 levels of SUDS including filter drains and a detention basin.

<u>Niddry Burn</u>

Hydrology and Flood Risk

9.5.116 For structures or embankments within the floodplain, compensatory storage will be created by landforming and this will be provided directly adjacent to the watercourse floodplain where practicable (mitigation item W31). Mitigation required to significantly reduce the impact to the hydrology and flood risk of the Niddry Burn will be in line with the generic mitigation detailed above for new outfall and SUDS features implementation.

9.5.117 To reduce potential flood risk associated with culvert blockage of the extended culvert, a regular inspection and debris removal maintenance programme will be implemented (mitigation item W45).

Fluvial Geomorphology

9.5.118 No specific mitigation for fluvial geomorphology is required for Niddry Burn as the impacts during the operational stage would be of Slight significance.

Water Quality

9.5.119 During operation, road drainage will be treated through SUDS before discharging to an outfall at Niddry Burn (Table 9.24) (mitigation item W36). The SUDS treatment train will consist of:

- Drainage Run C outfall: 2-3 levels of SUDS including filter strips (at certain locations), filter drains and a detention basin.

Tributary of Niddry Burn

9.5.120 No specific mitigation for hydrology/flood risk, fluvial geomorphology or water quality is required for the Tributary of Niddry Burn as the impacts during the operational stage would be of Negligible or Slight significance.

9.5.121 For structures or embankments within the floodplain compensatory storage has been taken into account during progression of the proposed scheme design. This will be created by landforming, and located directly adjacent to the watercourse floodplain where practicable (mitigation item W31).

9.5.122 To reduce potential flood risk associated with culvert blockage of the extended culvert, a regular inspection and debris removal maintenance programme will be implemented (mitigation item W45).

River Almond

9.5.123 No specific mitigation for hydrology/flood risk, fluvial geomorphology or water quality is required for the River Almond as the impacts during the operational stage would be of Negligible or Slight significance.

9.5.124 During operation, road drainage will be treated through SUDS before discharging to an outfall at the River Almond (Table 9.24) (mitigation item W39). The SUDS treatment train will consist of:

- Drainage Run D outfall: 3 levels of SUDS including filter drains, swale and a detention basin.

Ferry Burn

Hydrology and Flood Risk

9.5.125 Mitigation required to reduce the impact to flood risk and hydrology of Ferry Burn will be in line with the generic mitigation detailed above for new outfall and SUDS features implementation.

Fluvial Geomorphology

9.5.126 No specific mitigation for fluvial geomorphology is required for Ferry Burn as the impacts during the operational stage would be of Negligible significance.

Water Quality

9.5.127 During operation, road drainage will be treated through SUDS before discharging to Ferry Burn (Table 9.24) (mitigation item W40). The SUDS treatment train will consist of:

- Drainage Run J outfall: 3 levels of SUDS including filter drains, swale and a detention basin.

Dolphington Burn

9.5.128 Runoff is to be routed into the existing A90/M9 Spur drainage system in this location, which incorporates SUDS (mitigation item W41). No mitigation for hydrology/flood risk, fluvial geomorphology or water quality is required for Dolphington Burn as the impacts during the operational stage would be of Negligible or Slight significance.

Specific Operational Mitigation – Firth of Forth

9.5.129 No specific mitigation for hydrology/flood risk, fluvial geomorphology or water quality is required for the Firth of Forth as the impacts during the operational stage would be of Negligible significance.

9.5.130 However, to mitigate against potential flood risks associated with spilling of flood waters from the proposed viaduct onto residential development and roadways directly below, the drainage capacity of the drainage network of the viaduct will be tested and increased if practicable to direct flood runoff toward areas of lower flood risk (toward the abutment of the viaduct) (mitigation item W42).

9.5.131 The Scottish Water treated sewage outfall on the southern side of the Firth of Forth will be moved to a suitable location, with appropriate hydrodynamic conditions comparable to those that exist at its present location, so as to reduce disturbance, in consultation with Scottish Water and SEPA (mitigation item W44).

Water Quality

9.5.132 For the two land-based drainage outfalls from the approach roads and viaducts to the Firth of Forth, SUDS treatment is summarised in Table 9.24 (mitigation item W42), and has been agreed with SEPA where appropriate.

9.5.133 As discussed in Section 9.4 (Specific Operational Impacts – Firth of Forth), no SUDS mitigation is proposed for the Main Crossing through-deck drainage as road drainage would have a negligible impact magnitude and significance on the main estuary channel (Tables 9.18 and 9.19).

9.5.134 However in order to further reduce impacts from the Main Crossing, the following mitigation is proposed (mitigation items W42/W43):

- Outfalls will be located at regular spacings (indicatively 15m) along both sides of the bridge deck. This will reduce the volume of drainage discharging from a single outfall and promote greater distribution and dispersal of discharge over the Firth of Forth channel.
- Through deck drainage will include a droplet dispersal design instead of direct drop outfalls. The droplet dispersal system involves surface runoff passing through a type of shower-head and being transformed into droplets which are then dispersed across the channel. This combined with the height of the deck structure above the Firth of Forth will result in drainage dispersing over a wide area.
- As stated above, drainage over the inter-tidal areas on the north and south shores will be taken back to land-based SUDS, prior to outfall.

Summary of Mitigation Measures for each Waterbody

9.5.135 Table 9.25 summarises the mitigation proposed for the activities which may have an impact on each waterbody during the construction and operational phases of the proposed scheme.

Table 9.25: Summary of Mitigation Measures

Water Feature	Potential Impact	Mitigation Measures
St. Margaret's Marsh	Road drainage	Provision of cross-drainage connection between the upper portion and lower portion of the marsh area (mitigation item W29).
	Realignment	n/a
	Construction	Adherence to best practice. Generic mitigation measures apply.
Linn Mill Burn	Road drainage	For flood flows in excess of the carriageway drainage capacity, detention or conveyance of the flood water toward areas of less risk or directly to the Swine Burn will be provided, if practicable (mitigation item W30).
	Construction	Adherence to best practice. Generic mitigation measures apply.
Swine Burn	Road drainage	Two outfalls – correct positioning; scour protection if required (mitigation item W32). Two treatment trains (mitigation item W32)will consist of the following SUDS measures: • Drainage Run A: filter drains. • Drainage Run E: filter drains and a detention basin. For flood flows in excess of the carriageway drainage capacity, detention or conveyance of the flood water toward areas of less risk (mitigation item W32).

Water Feature	Potential Impact	Mitigation Measures
	Crossing	One new depressed invert culvert; one double-barrel culvert extension (mitigation item W33). Culvert will be designed in line with CIRIA 168 guidance and with allowance for freeboard above the 0.5% AEP (1 in 200-year return period) flood level and mammal passage (mitigation item W33). A wide culvert is proposed to reduce flood water back-up impacts and provide smoother transition from the wider floodplain channel to the culvert. Due to the width of the large opening of the proposed culvert, a trash screen is not deemed necessary; however regular inspection to ensure the culverts are free from debris is recommended (mitigation item W33).
	Realignment	2-stage channel; sinuous (mitigation item W34). Provision of an adequately sized floodplain channel within the realignment to compensate for encroachment of the floodplain by the new proposed crossing and the culvert extension (mitigation item W34).
	Construction	Adherence to best practice. Generic mitigation measures apply.
Tributary of Swine Burn	Road drainage	One treatment train (mitigation item W35) will consist of the following SUDS measures: • Drainage Run B: filter drains and a detention basin.
	Construction	Adherence to best practice. Generic mitigation measures apply.
Niddry Burn	Road drainage	One treatment train (mitigation item W36) will consist of the following SUDS measures: • Drainage Run C: filter strips (at the M9 Junction 1A loop), filter drains and a detention basin.
	Crossing	Culvert extension with same form as existing culvert (mitigation item W37).
	Structures/ embankments	Provision of compensatory storage for all encroachment works into the floodplain (mitigation item W31).
	Construction	Adherence to best practice. Generic mitigation measures apply. Provision of compensatory storage for encroachment into the floodplain. A regular inspection programme to ensure the culverts are free from debris is recommended (mitigation item W31).
Tributary of Niddry Burn	Crossing	Culvert extension with same form as existing culvert (mitigation item W38).
	Structures/ embankments	Provision of compensatory storage for all encroachment works into the floodplain (mitigation item W31).
	Construction	Adherence to best practice. Generic mitigation measures apply.
River Almond	Road drainage	One treatment train (mitigation item W39) will consist of the following SUDS measures: • Drainage Run D: filter drains, swale and a detention basin.
	Structures/ embankments	Provision of compensatory storage for all encroachment works into the floodplain (mitigation item W31).
	Construction	Adherence to best practice. Generic mitigation measures apply.
Ferry Burn	Road drainage	One treatment train (mitigation item W40)will consist of the following SUDS measures: • Drainage Run J: filter drains, swale and a detention basin.
	Construction	Adherence to best practice. Generic mitigation measures apply.
Dolphington Burn	Road drainage	Tie in with existing drainage network and SUDS (mitigation item W41).
	Construction	Adherence to best practice. Generic mitigation measures apply.
Firth of Forth	Road drainage	Two land-based treatment trains (mitigation item W42) will consist of the following SUDS measures: • Drainage Run Q (north section): filter drains (not approach viaduct), detention basin (Vt) and swale (including bed filter) • Drainage Runs M and P (south section): filter drains (not approach viaduct), detention basin and swale. Drainage over intertidal areas on both shores to be taken back to land-based SUDS systems, listed above (mitigation item W42). Drainage on Main Crossing to include droplet-dispersal system to disperse discharge and any road contaminants within. Outfalls positioned at regular spacings (15m indicatively) on either side of bridge deck (mitigation item W42).

Water Feature	Potential Impact	Mitigation Measures
		Enhancement of drainage system along the viaduct to capture flood flows from the 0.5% AEP event (1 in 200-year return period) if practicable (mitigation item W42).
	Crossing	Bridge crossing – adherence to best practice.
	Realignment	n/a
	Construction	Adherence to best practice. Generic mitigation measures apply. Development of detailed method statement in agreement with SEPA.

9.6 Residual Impacts

9.6.1 Following implementation of the mitigation outlined in Section 9.5, the potential for impacts on the water environment will be avoided/prevented, reduced or offset. Residual impacts are summarised for each waterbody in Table 9.26. Residual construction impacts are considered to be short-term and temporary. Residual operational impacts are considered to be long-term and permanent.

9.6.2 The residual impact for each technical discipline was assessed, followed by an overall residual impact significance which defaults to the highest impact remaining for each watercourse, after the implementation of the mitigation measures detailed in Section 9.5.

9.6.3 Where residual impact after implementation of generic and specific mitigation measures is assessed to be greater than Negligible magnitude, the residual impact on the receptor is described in Table 9.26.

9.6.4 Mitigation measures have been proposed which will reduce the likelihood and magnitude of the potential impacts, such that all residual impacts on the water environment are assessed as being of Slight significance or lower.

Table 9.26: Summary of Residual Impacts on Waterbodies

Water Feature	Sensitivity	Phase	Residual Impact Magnitude	Residual Impact Significance	Overall Residual Impact Significance
St. Margaret's Marsh	Hydrology/Flood Risk: Medium Water Quality: High	<u>Construction</u> Hydrology/Flood Risk: Diversion of runoff from construction areas into Firth of Forth is expected to impact the hydrological regime of surface water entering the marsh.	Hydrology and Flood Risk: Low Water Quality: Negligible	Hydrology/Flood Risk: Slight Water Quality: Negligible	Slight
		<u>Operation</u> Hydrology/Flood Risk: Diversion of runoff from hardstanding areas associated with the roadway and SUDS pond into Firth of Forth is expected to impact hydrological regime of surface water entering the marsh (an expected decrease of runoff input of 8%).	Hydrology and Flood Risk: Low Water Quality: Negligible	Hydrology/Flood Risk: Slight Water Quality: Negligible	Slight
Linn Mill Burn	Hydrology/Flood Risk: Medium Water Quality: Low	<u>Construction</u>	Hydrology and Flood Risk: Negligible Water Quality: Negligible	Hydrology/Flood Risk: Negligible Water Quality: Negligible	Negligible
		<u>Operation</u>	Hydrology and Flood Risk: Negligible Water Quality: Negligible	Hydrology/Flood Risk: Negligible Water Quality: Negligible	Negligible
Swine Burn	Hydrology/Flood Risk: Medium Fluvial Geomorphology: Medium Water Quality: Medium	<u>Construction</u> Hydrology/Flood Risk: Increase in runoff flows. Potential residual impact associated with flood risk to construction plant, construction works, local infrastructure and property. Fluvial Geomorphology: Careful construction using mitigation measures outlined would greatly reduce potential impacts associated with the works.	Hydrology and Flood Risk: Low Geomorphology: Low Water Quality: Negligible	Hydrology/Flood Risk: Slight Geomorphology: Slight Water Quality: Negligible	Slight
		<u>Operation</u> Fluvial Geomorphology: Mitigation measures will reduce the impacts associated with the new culvert. Realignment would provide an improvement to existing modified channel form.	Hydrology and Flood Risk: Negligible Geomorphology: Low Water Quality: Negligible	Hydrology/Flood Risk: Negligible Geomorphology: Slight Water Quality: Negligible	Slight
Tributary of Swine Burn	Hydrology/Flood Risk: Low Fluvial Geomorphology: Low	<u>Construction</u>	Hydrology and Flood Risk: Negligible Geomorphology: Negligible Water Quality: Negligible	Hydrology/Flood Risk: Negligible Geomorphology: Negligible Water Quality: Negligible	Negligible

Water Feature	Sensitivity	Phase	Residual Impact Magnitude	Residual Impact Significance	Overall Residual Impact Significance
	Water Quality: Low	Operation	Hydrology and Flood Risk: Negligible Geomorphology: Negligible Water Quality: Negligible	Hydrology/Flood Risk: Negligible Geomorphology: Negligible Water Quality: Negligible	Negligible
Niddry Burn	Hydrology/Flood Risk: Medium Fluvial Geomorphology: Medium Water Quality: High	Construction Hydrology/Flood Risk: Increase in runoff flows. Fluvial Geomorphology: Careful construction using mitigation measures outlined would greatly reduce potential impacts associated with the works.	Hydrology and Flood Risk: Low Geomorphology: Low Water Quality: Negligible	Hydrology/Flood Risk: Slight Geomorphology: Slight Water Quality: Negligible	Slight
		Operation Fluvial Geomorphology: Providing a culvert extension that matches the existing structure will reduce the potential impacts.	Hydrology and Flood Risk: Negligible Geomorphology: Low Water Quality: Negligible	Hydrology/Flood Risk: Negligible Geomorphology: Slight Water Quality: Negligible	Slight
Tributary of Niddry Burn	Hydrology/Flood Risk: Low Fluvial Geomorphology: Low Water Quality: Low	Construction Hydrology/Flood Risk: Slight increase in peak runoff flows.	Hydrology and Flood Risk: Low Geomorphology: Negligible Water Quality: Negligible	Hydrology/Flood Risk: Negligible Geomorphology: Negligible Water Quality: Negligible	Negligible
		Operation Fluvial Geomorphology: Providing a culvert extension that matches the existing structure will reduce the potential impacts.	Hydrology and Flood Risk: Negligible Geomorphology: Low Water Quality: Negligible	Hydrology/Flood Risk: Negligible Geomorphology: Negligible Water Quality: Negligible	Negligible
River Almond	Hydrology/Flood Risk: High Fluvial Geomorphology: Medium Water Quality: High	Construction	Hydrology and Flood Risk: Negligible Geomorphology: Negligible Water Quality: Negligible	Hydrology/Flood Risk: Negligible Geomorphology: Negligible Water Quality: Negligible	Negligible
		Operation	Hydrology and Flood Risk: Negligible Geomorphology: Negligible Water Quality: Negligible	Hydrology/Flood Risk: Negligible Geomorphology: Negligible Water Quality: Negligible	Negligible
Ferry Burn	Hydrology/Flood Risk: Medium Fluvial Geomorphology: Low Water Quality: Low	Construction Hydrology/Flood Risk: Slight increase in peak runoff flows.	Hydrology and Flood Risk: Low Geomorphology: Negligible Water Quality: Negligible	Hydrology/Flood Risk: Slight Geomorphology: Negligible Water Quality: Negligible	Slight
		Operation Hydrology/Flood Risk: Slight increase in peak flows.	Hydrology and Flood Risk: Low Geomorphology: Negligible Water Quality: Negligible	Hydrology/Flood Risk: Slight Geomorphology: Negligible Water Quality: Negligible	Slight
Dolphington Burn	Hydrology/Flood Risk: Medium	Construction	Hydrology and Flood Risk: Negligible	Hydrology/Flood Risk: Negligible	Negligible

Water Feature	Sensitivity	Phase	Residual Impact Magnitude	Residual Impact Significance	Overall Residual Impact Significance
	Fluvial Geomorphology: Low Water Quality: Low		Geomorphology: Negligible Water Quality: Negligible	Geomorphology: Negligible Water Quality: Negligible	
		Operation Hydrology/Flood Risk: Increase in peak flows and spatial distribution of flows.	Hydrology and Flood Risk: Low Geomorphology: Negligible Water Quality: Negligible	Hydrology/Flood Risk: Slight Geomorphology: Negligible Water Quality: Negligible	Slight
Firth of Forth	Hydrology/Flood Risk: High Coastal/Estuarine Geomorphology: High Water Quality: High	Construction	Hydrology and Flood Risk: Negligible Geomorphology: Negligible Water Quality: Negligible	Hydrology/Flood Risk: Negligible Geomorphology: Negligible Water Quality: Negligible	Negligible
		Operation	Hydrology and Flood Risk: Negligible Geomorphology: Negligible Water Quality: Negligible	Hydrology/Flood Risk: Negligible Geomorphology: Negligible Water Quality: Negligible	Negligible

9.7 Ongoing Design Development

Alternative Construction Compound

9.7.1 An addition to the scheme proposals is the inclusion of an alternative location for the construction compound to the west of South Queensferry. This alternative was identified in response to concerns raised by local residents during the ongoing consultation process, and it locates the compound further to the west.

9.7.2 This alternative site was identified subsequent to the completion of the assessment of potential impacts of the proposed scheme on the water environment as reported in this chapter. The alternative site is still located in the Linn Mill Burn catchment (see Table 9.10) and a separate assessment is provided in Chapter 19 (Disruption Due to Construction).

Ferry Hills Rock Cuts

9.7.3 The proposed scheme design as assessed in this chapter includes significant rock cuts to the north and south of Ferrytoll Junction. Detailed design may allow these rock cuts to be avoided or reduced. Design development indicates that there could be potential for a westward shift of the proposed scheme alignment of up to approximately 15m between approximate chainage ch7500-7800 (southwest of Jamestown) and ch8150-8500 (west of Hope Street Cemetery) to allow the rock cuts to be avoided.

9.7.4 Environmental review of this refinement indicates that this could reduce adverse impacts associated with the rock cuts without materially increasing other environmental effects. If this option were taken forward it is considered that would be no change to the significance of impacts reported in this chapter.

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