6 Geology, Soils and Groundwater

This chapter considers the potential impacts and residual effects of the proposed scheme on geology, soils, contaminated land and groundwater within the study area. Excavations, piling and other earthworks will be required as part of the construction of the proposed scheme and the impacts of these have been assessed.

Baseline conditions were established through desk-based assessment, consultation, site walkover and ground investigations. This process established that a large proportion of the land made available for temporary works and construction falls within the Firth of Forth Site of Special Scientific Interest (SSSI) which is designated for coastal geomorphology, bedrock geology and quaternary deposits, however the designated geological features fall outside the study area.

Soils of high value/importance (organic rich/peaty saltings) are present within the land made available for temporary works and construction and are likely to be impacted by excavations, piling and other earthworks during the construction of the proposed scheme. Given the nature of the works, the magnitude of impact is considered likely to be minor adverse on soils resulting in a Moderate significance of effect. Following implementation of the proposed mitigation, the significance of effect on this receptor is expected to be reduced to Slight.

Superficial geology within the study area is composed of reclaimed intertidal deposits (organic rich/peaty clays and silts associated with marine and estuarine alluvium) underlain by glacial till. Made ground deposits were also observed within the A985 embankment. As the natural superficial deposits support the development of the high value/importance soils, they are also considered to be of high value/importance, while the made ground deposits are considered to be of negligible value/importance. Given the nature of the works, the magnitude of impact on superficial deposits (including made ground) is considered to be negligible, resulting in a Slight significance of effect on natural superficial deposits and Neutral significance of effect on made ground deposits.

Bedrock geology at the site of the proposed scheme is composed of Carboniferous sedimentary rock of the Passage Group and Lower Coal Measures (negligible value/importance). The magnitude of impact is considered to be negligible, resulting in a Neutral significance of effect.

Mineral resource potential (associated with the Lower Coal Measures) within the study area is considered to be of low value/importance. The magnitude of impact is considered to be negligible, resulting in a Neutral significance of effect.

Identified areas of potential contaminated land are predominantly associated with the existing road infrastructure (A985 and A876 carriageways and the Kincardine Bridge structure). A Slight to Large significance of effect is anticipated on receptors as a result of interaction with potential contaminated land. Following implementation of mitigation, the significance of effect is expected to be reduced to Slight for all receptors.

Groundwater within the study area is considered to be of medium value/importance with no groundwater abstractions or Groundwater Dependent Terrestrial Ecosystems identified within the study area. A minor adverse magnitude of impact is anticipated on sub-surface water flows within the superficial deposits as conditions are not expected to deviate significantly from those currently present. Therefore, a Slight significance of effect during both construction and operation is anticipated. A moderate adverse magnitude of impact is anticipated on groundwater quality, with a resultant Moderate significance of effect. Residual effects are expected to reduce to Slight following the implementation of mitigation measures.

In conclusion, no significant residual effects are anticipated after the implementation of proposed mitigation measures.

6.1 Introduction

6.1.1 This chapter presents the assessment of the proposed scheme, as described in Chapter 3 (The Proposed Scheme) and shown in Figure 3.1, in relation to geology, soils, groundwater and contaminated land. This includes impacts to bedrock and superficial geology, mineral extraction, soils, contaminated land, groundwater and associated receptors such as groundwater fed private water supplies (PWS) and Groundwater Dependant Terrestrial Ecosystems (GWDTE).

6.1.2 Geological impacts can occur due to excavating or masking exposures of rocks or superficial geological deposits of scientific interest, particularly if the features of interest are not reproduced elsewhere, nationally or regionally. Impacts can also include restrictions on existing or potential future commercial exploitation of resources, and conversely previous exploitation of resources can impose constraints on the proposed scheme; for example, where land has become unstable due to mining or has been contaminated by previous land uses. It is also recognised that rock exposures can deliver environmental benefit, such as improved access to, and exposure of, new areas of geological interest.

6.1.3 During construction, there is an inherent risk of spillage or leakage of fuel or oil from storage tanks or construction plant. Without suitable mitigation measures, these pollutants could enter superficial and bedrock aquifers and cause degradation of water quality. Construction work can also lead to the dewatering of these aquifers which may cause differential settlement effects and impact sensitive receptors such as water supplies or wetlands.

6.1.4 The assessment is supported by the following figures:

- Figure 6.1: Potentially Contaminated Land; and
- Figure 6.2: Ground Investigation (GI) Borehole Locations.

6.2 Legislation, Policies and Guidance

6.2.1 The assessment takes cognisance of relevant legislation, policy, guidance and regulations including those listed in Table 6.1.

Table 6.1: Key Legislation, Policy, Guidance and Regulation

Topic	Name of Relevant Legislation, Policy, Guidance and Regulation
Legislation	The Roads (Scotland) Act (Environmental Impact Assessment) Regulations 2017 (Scottish Government 2017a); EU Water Framework Directive (2000/60/EC) (European Parliament 2000); EU Groundwater Directive (2006/118/EC) (European Parliament 2006); Water Environment Water Services (WEWS) (Scotland) Act 2003 (Scottish Government 2003); The Water Environment (Controlled Activities) (Scotland) Regulations 2011 (as amended by the Water Environment (Controlled Activities) (Scotland) Amendment Regulations 2013) (Scottish Government 2011); The Water Environment (Miscellaneous) (Scotland) Regulations 2017 (Scottish Government 2017b); Part IIA of the Environmental Protection Act 1990 (UK Government 1990); The Environment Act 1995 (UK Government 1995); The Contaminated Land (Scotland) Regulations 2000 (as amended by The Contaminated Land (Scotland) Regulations 2005) (Scottish Government 2000); and The Waste Management Licensing (Scotland) Regulations 2011 (as amended by the Waste Management Licensing (Scotland) Amendment Regulations 2016) (Scottish Government 2011).

Topic	Name of Relevant Legislation, Policy, Guidance and Regulation
Policy	The Scottish Soil Framework (Scottish Government 2009); Water Framework Directive (WFD) policy guidance 'The Future for Scotland's Waters: Guiding Principles on the Technical Requirements of the Water Framework Directive' (Scottish Environment Protection Agency (SEPA) 2002); Scottish Planning Policy (SPP), A Natural, Resilient Place, Managing Flood Risk and Drainage (Scottish Government 2014); and Planning Authority Protocol (Policy 41) Development at Risk of Flooding: Advice and Consultations (SEPA 2016).
Key Guidance and Standards	DMRB LA 104: Environmental assessment and monitoring (formerly HA 205/08, HD 48/08, IAN 125/15 and IAN 133/10), Revision 1 (Highways England, Transport Scotland, Welsh Government and The Department for Infrastructure Northern Ireland 2019), hereafter referred to as DMRB LA 104; DMRB LA 109: Geology and Soils (formerly DMRB Volume 11, Section 3, Parts 6 (Land Use) and 11 (Geology and Soils), Revision 0 (Highways England, Transport Scotland, Welsh Government and The Department for Infrastructure Northern Ireland 2019), hereafter referred to as DMRB LA 109; DMRB LA 113: Road Drainage and the Water Environment (formerly HD 45/09), Revision 1 (Highways England, Transport Scotland, Welsh Government and The Department for Infrastructure Northern Ireland 2020), hereby referred to as DMRB LA 113; Construction Code of Practise for the Sustainable Use of Soils on Construction Sites (Department for Environment, Food and Rural Affairs (Defra) 2009); The Water Environment (Controlled Activities) (Scotland) Regulations 2011 (as amended) A Practical Guide (SEPA 2019); Water Use Supporting Guidance 53: Environmental Quality Standards and Standards for Discharges to Surface Waters (WAT-SG-53), Version 7.1 (SEPA 2020a); Water Use Regulatory Method 11: Licensing Groundwater Abstractions including Dewatering (WAT-RM-11), Version 6 (SEPA 2017); Land Use Planning System Guidance Note 31: Guidance on assessing the impacts of development proposals on groundwater abstractions and groundwater dependant terrestrial ecosystems (LUPS-GU31), Version 3 (SEPA 2017); Water Use Position Statement 10-01: Assigning Groundwater Assessment Criteria for Pollutant Inputs (WAT-PS-10-01), Version 3.0 (SEPA 2014); Construction Industry Research and Information Association (CIRIA) Report C532: Control of water pollution from construction sites (CIRIA 2001a); CIRIA Report C552: Contaminated Land Risk Assessment: A guide to good practice (CIRIA, 2001b); Contaminated Land Report 11: Model procedures for the management of land contamination (CLR11) (Environment Agency (EA) 2004); Land contamination: risk management (EA 2020); British Standard Code of Practice for the investigation of potentially contaminated sites (BS 10175:2011 + A2:2017); Planning Advice Notice (PAN) 33 Development of Contaminated Land (Scottish Government2017); Environmental Protection Act 1990: Part IIA Contaminated Land Statutory Guidance: Edition 2 (Scottish Executive 2006); and Environmental Protection Act 1990: Part 2A Contaminated Land Statutory Guidance (Defra 2012).

6.3 Approach and Methods

6.3.1 This assessment has been undertaken following Design Manual for Roads and Bridge (DMRB) LA 109: Geology and Soils (Highways England, Transport Scotland, Welsh Government and Department for Infrastructure Northern Ireland 2019) and DMRB LA 113: Road Drainage and the Water Environment (Highways England, Transport Scotland, Welsh Government and Department for Infrastructure Northern

Ireland 2020). These guidance documents superseded DMRB Volume 11, Section 3, Part 11 (Geology & Soils) and DMRB Volume 11, Section 3, Part 6 (Land Use) which previously contained guidance on the assessment of geology, contaminated land and soils (including agricultural capability) and HD45/09 (Road Drainage and the Water Environment) in relation to assessment on groundwater. The guidance within DMRB LA 104: Environmental assessment and monitoring (Highways England, Transport Scotland, Welsh Government and Department for Infrastructure Northern Ireland 2019) has also influenced the approach and methods undertaken for this assessment.

6.3.2 In line with the Scoping Report (Jacobs 2018a) agricultural soils have been scoped out of the Geology, Soils and Groundwater assessment. The topic of agricultural soils was considered under the People and Communities: Communities and Private Assets topic. However, the Scoping Report assessed that due to the temporary nature of the required land-take, the fact the land is not classified as prime agricultural land and that it is not used for agricultural production, the impact was not expected to result in a significant effect. Chapter 5 (Consultation and Scoping) provides further information on the conclusions of the consultation and scoping process.

6.3.3 The Geology, Soils and Groundwater baseline will include information pertaining to the occurrence of peat and mineral resources within the study area to provide context for the Geology, Soils and Groundwater assessment. However, the assessment of effects on peat and mineral resources is presented within Chapter 13 (Material Assets and Waste).

Study Area

6.3.4 As shown in Figure 6.1, the assessment study area extends 250m from the land made available (LMA) for temporary works and construction boundary. DMRB LA 109 does not specify a study area, stating that it should be based on project specific considerations. The addition of the 250m buffer to the LMA is based on the Guidance for the Safe Development of Housing on Land Affected by Contamination (National House Building Council and Environment Agency 2008). As such, the assessment study area is a conservative, but a sensible approach in the context of the proposed scheme, taking into account the distance over which contamination can migrate.

6.3.5 In accordance with DMRB LA 113, the study area for the consideration of Groundwater Dependant Terrestrial Ecosystems (GWDTE) extended 100m from the LMA with the option to extend this boundary should the dewatering impact assessment require so.

6.3.6 The study area for groundwater abstractions extended up to a distance of 850m from the LMA for temporary works and construction boundary in accordance with the minimum study area to be applied for groundwater abstractions licensing under The Water Environment (Controlled Activities) (Scotland) Regulations 2011 (Scottish Government 2011) and based on Water Use Regulatory Method 11 (WAT-RM-11): Licensing Groundwater Abstractions including Dewatering (Version 6) (Scottish Environmental Protection Agency (SEPA) 2017).

Baseline Conditions

6.3.7 Baseline conditions cover the following aspects:

- bedrock and superficial geology;
- features of geological importance;
- mineral extraction;
- groundwater environment and associated receptors, including PWS; and
- contaminated land.

6.3.8 Baseline conditions were determined through desk-based assessment, consultation with statutory and non-statutory bodies and ground investigations.

Desk Based Assessment

6.3.9 The desk-based assessment included a review of the following information:

- British Geological Survey (BGS) data including BGS Hydrogeological Map of Scotland (1988a) and Groundwater Vulnerability Map of Scotland (BGS 1988b), the BGS Geoviewer (http://mapapps2.bgs.ac.uk/geoindex/home.html) and BGS UK Hydrogeology viewer (http://www.bgs.ac.uk/research/groundwater/datainfo/hydromaps/hydro_maps_scanviewer.html).
- Macaulay Institute for Soil Research, Soil Survey of Scotland Map, Sheet 5, Eastern Scotland (1981).
- Ordnance Survey (OS) historical maps dating back to 1867 for information on former land use, any potential contamination and physical hazards, and information on private water supplies.
- SEPA Water Classification Hub (https://www.sepa.org.uk/data-visualisation/water-classification-hub/).
- SEPA Water Environment Hub (https://www.sepa.org.uk/data-visualisation/water-environment-hub/).
- SNH Natural Spaces designation database (https://gateway.snh.gov.uk/natural-spaces/index.jsp).
- Scotland's Environment website (https://www.environment.gov.scot/).
- Scotland's Soils website (https://soils.environment.gov.scot/) providing access to both the National soil map of Scotland and the Soil map of Scotland (partial cover) which provides further detail where mapping is available.
- previous assessments:
  - A985 Kincardine Bridge Refurbishment. Geotechnical Interpretative Report (GIR) (Jacobs 2019).
  - A985 Kincardine Bridge Refurbishment. Geotechnical Design Report. (GDR) (Jacobs 2020).
  - A985 Kincardine Bridge Refurbishment Piled Viaduct Replacement Scoping Report (Jacobs 2018a).
  - A985 Kincardine Bridge Refurbishment Ground Investigation Technical Specification (Jacobs 2018b).
  - Kincardine Bridge Refurbishment Environmental Review (Transport Scotland 2009).
  - The Upper Forth Crossing at Kincardine: Environmental Statement (Scottish Executive 2003).
  - Upper Forth Crossing at Kincardine, Existing Bridge Refurbishment, Desk Study (Transport Scotland 2008).

Consultation

6.3.10 Consultation has been undertaken with a number of statutory and non-statutory bodies. These include the following:

- SEPA for information on licenced groundwater abstractions (via The Water Environment (Controlled Activities) (Scotland) Regulations 2011 (as amended)) and on former and current contaminated land use;
- Falkirk Council for information on former and current contaminated land use, groundwater fed PWS, and licensed fuel storage; and
- SNH for information on the location and extent of environmental sensitivities in the vicinity of the proposed scheme.

6.3.11 Further information on the consultation process is provided in Chapter 5 (Consultation and Scoping).

Site Walkover

6.3.12 A site walkover was conducted by Jacobs personnel on 21 March 2019 to obtain further information on baseline conditions.

Ground Investigation

6.3.13 An intrusive ground investigation (GI) designed by Jacobs on behalf of Transport Scotland was conducted by SOCOTEC between 4 July 2018 and 21 August 2018. The investigation consisted of six cable percussive boreholes, two cable percussive boreholes with rotary follow-on and nine rotary open-holes with rotary follow on boreholes.

6.3.14 An addendum GI was conducted by SOCOTEC between 26 February and 13 March 2019 to investigate the A985 embankment soils. The investigation consisted of one dynamic sampling borehole and one dynamic sampling with rotary follow on borehole using a slope climbing rig through the shoulder of the existing southern approach viaduct to Kincardine Bridge. The locations of all boreholes are provided within Figure 6.2.

6.3.15 Geoenvironmental laboratory testing was scheduled on soil samples recovered during the fieldwork and sent to the SOCOTEC geochemistry laboratory at Bretby (Burton upon Trent) for chemical analysis. The results are presented in the Factual Report (SOCOTEC 2019a) and the Addendum Factual Report (SOCOTEC 2019b). The findings from the two factual reports informed the subsequent Geotechnical Interpretative Report (GIR) (Jacobs 2019) and the Geotechnical Design Report (GDR) (Jacobs 2020).

Impact Assessment

6.3.16 The impact assessment reported in this chapter has been undertaken in accordance with the guidance provided in DMRB LA 104, 109 and 113 (Highways England *et al.* 2019; Highways England *et al.* 2020) whereby the level of significance of a potential impact on the existing baseline condition is determined by the value/importance of the receptor/attribute, combined with the magnitude of impact. The criteria outlined in Table 6.2 and Table 6.3 are based on those that have been applied to similar schemes in Scotland and are designed to comply with DMRB guidance.

6.3.17 The groundwater assessment is undertaken within the context of the Water Framework Directive (WFD) (2000/60/EC) which was transposed into Scottish law under the Water Environment and Water Framework (Scotland) Act 2003, and the Groundwater Directive (2006/118/EC). Impacts on groundwater quality and/or flow may also have direct or indirect effects on groundwater abstractions, ecological receptors with potential groundwater dependency and surface water features.

6.3.18 In compliance with DMRB LA 109 a desk study has been undertaken to identify potential sources of contamination associated with current and historical land uses, and pathways to receptors in accordance with CLR11 (EA 2004), Land contamination: risk management (EA 2020) and British Standard Code of Practise for the investigation of potentially contaminated sites (BS 10175:2011 + A2:2017).

Value/Importance

6.3.19 The value/importance of receptors/attributes is categorised on a scale of negligible to very high based on professional judgement in accordance with the criteria outlined in Table 6.2.

Table 6.2: Value/Importance Criteria

Value / Importance	Criteria	Examples
Very High	Attribute has a high importance and/or rarity on an	**Geology**
		Areas containing very rare geological features considered to be of international importance such as UNESCO World Heritage Sites, UNESCO Global Geoparks, Sites of

Value / Importance	Criteria	Examples
	international or national scale.	Special Scientific Interest (SSSI) or Geological Conservation Review (GCR) sites where citations indicate features of international importance.
		Soils
		Soils directly supporting an EU designated site.
		Groundwater
		Groundwater aquifer(s) with very high productivity or Water Framework Directive (WFD) good groundwater quality and quantity status. Exploitation of groundwater resource is extensive for public, private domestic and/or agricultural use (i.e. feeding ten or more properties) and/or industrial supply. Groundwater aquifer supports a designated/sensitive ecosystem and/or supports a surface water feature with hydrological importance to a designated/protected under EC and UK legislation sensitive ecosystem. Groundwater aquifer locally supports Groundwater Dependant Terrestrial Ecosystems (GWDTE) or wetland vegetation which is highly groundwater dependent.
		Contaminated Land
		Very high sensitivity land use such as residential or allotments. Very high value groundwater body as defined above. Very high value surface water feature as defined in Chapter 7 (Road Drainage and the Water Environment). Internationally designated ecological sites. Scheduled Monument/Listed Building.
High	Attribute has a high importance and/or rarity on local scale.	**Geology**
		Areas containing geological features considered to be rare and of national importance with little potential for replacement such as SSSI, candidate SSSI, GCR sites or geological sites which meet national designation criterion yet are not designated as such.
		Soils
		Soils directly supporting a UK designated site such as SSSI. Scottish Natural Heritage (SNH) priority peatland Class 1 (nationally important carbon-rich and peaty soils, deep peat and priority peatland habitat likely to be of high conservation value) and Class 2 (nationally important carbon-rich and peaty soils, deep peat and priority peatland habitat likely to be of potentially high conservation value and restoration potential).
		Groundwater
		Groundwater aquifer with moderate/high productivity or Water Framework Directive (WFD) good groundwater quality and quantity status. Exploitation of groundwater resource is not extensive (i.e. private, domestic and/or agricultural use feeding less than ten properties). Groundwater aquifer supports a sensitive ecosystem of regional importance and/or supports a surface water feature with hydrological importance to a sensitive ecosystem of regional importance Groundwater aquifer supports GWDTE or wetland vegetation which is moderately groundwater dependent.
		Contaminated Land
		High sensitivity land use such as public open space. Proposed scheme construction/maintenance areas. High value groundwater body as defined above. High value surface water feature as defined in Chapter 7 (Road Drainage and the Water Environment).
Medium	Attribute has a medium quality and/or rarity on a local scale	**Geology**
		Areas containing geological features of regional importance with limited potential for replacement and considered worthy of protection for their educational, research, historic or aesthetic importance, such as Local Geodiversity Sites (LGS)/ Regionally Important Geological Sites (RIGS) or geological sites which meet regional designation criterion yet are not designated as such. Presence of areas of economically important minerals of regional value.

Value / Importance	Criteria	Examples
		Soils
		Soils directly supporting a non-statutory designated site such as Local Nature Reserves or Sites of Nature Conservation Importance. Scottish Natural Heritage (SNH) priority peatland Class 3 (dominant vegetation cover is not priority peatland habitat but is associated with wet and acidic type. Occasional peatland habitats can be found. Most soils are carbon-rich and peaty soils, with some areas of deep peat).
		Groundwater
		Groundwater aquifer with low productivity or Water Framework Directive (WFD) variable groundwater quality and quantity status. No known present exploitation of groundwater as a resource and aquifer properties make potential exploitation appear unlikely. Groundwater aquifer supports a sensitive ecosystem of authority area importance and/or a surface water feature with hydrological importance to a site of authority area importance. Groundwater aquifer locally supports GWDTE or wetland vegetation which is lowly groundwater dependent.
		Contaminated Land
		Medium sensitivity land use such as commercial or industrial. Medium value groundwater body as defined above. Medium value surface water feature as defined in Chapter 7 (Road Drainage and the Water Environment).
Low	Attribute has a low quality and/or rarity on a local scale	**Geology**
		Sites and geological features of local importance not currently identified as SSSI, GCR or LGS/ RIGS but that may require protection in the future.
		Soils
		SNH priority peatland Class 5 (soil information takes precedence over vegetation data and there is no peatland habitat recorded, but all soils are carbon-rich and peaty soil and deep peat).
		Groundwater
		Groundwater aquifer with very low productivity or Water Framework Directive (WFD) poor groundwater quality and quantity status. No known past or present exploitation of groundwater as a resource. Groundwater aquifer supports a sensitive ecosystem of less than authority area importance and/or supports a surface water feature with hydrological importance to sensitive ecosystems of less than authority area importance. Groundwater aquifer locally supports areas of vegetation with no groundwater dependency.
		Contaminated Land
		Low sensitivity land use such as highways and rail. Low value groundwater body as defined above. Low value surface water feature as defined in Chapter 7 (Road Drainage and the Water Environment).
Negligible	-	**Geology**
		Geological features not currently protected and unlikely to require protection in the future (no geological exposures or little/no local interest). No exploitable minerals or geological resources.
		Soils
		Previously developed land with little potential to return to agriculture. SNH priority peatland Class 4 (areas unlikely to be associated with peatland habitats or wet and acidic type, and unlikely to include carbon-rich or peat soils), Class 0 (mineral soils where peatland habitats are not typically found), Class -1 (unknown soil types) and Class -2 (non-soil (i.e. loch, built up area, rock and scree)).
		Contaminated Land
		Undeveloped surplus land/no sensitive land use proposed

Magnitude

6.3.20 The magnitude of potential impacts was assessed on a scale of major to negligible/no change for both adverse and beneficial impacts based on the likely effect of the proposed activities, based on professional judgement in accordance with the criteria and examples provided in Table 6.3. The assessment of magnitude was influenced by the timing, scale, size and duration of changes to the baseline conditions, as well as the likelihood or probability of occurrence.

Table 6.3: Magnitude Criteria

Magnitude	Criteria	Examples
Major Adverse	Results in loss of attribute and/or quality and integrity of the attribute	**Geology**
		Partial (greater than 50%) or total loss of a geological feature/designation; detrimental change to quality or integrity or severe damage to key characteristics, features or elements; or where there would be complete severance of a site such as to affect the value of the site/resource.
		Soils
		Physical removal or permanent sealing of soil resource, peatland or agricultural land or where the value of the area would be severely affected (over 2ha loss/sealing of very high value/importance soils or over 10ha loss/sealing of high to low value/importance soils).
		Groundwater
		Major or long-term change to groundwater aquifer(s) flow, water level, quality or available yield. Groundwater resource use is irreparably impacted upon, with a major or total loss of an existing supply or supplies. Changes to water table level or quality would result in a major or total change in or loss of a groundwater dependent area, where the value of a site would be severely affected. Changes to groundwater aquifer(s) flow, water level and quality would result in major changes to groundwater base flow contributions to surface water and/ or alterations in surface water quality, resulting in a major shift away from baseline conditions such as change to WFD status. Dewatering effects create significant differential settlement effects on existing infrastructure and buildings.
		Contaminated Land
		Contamination levels encountered in excess of assessment criteria (for human health, environment and/or property) requiring substantial remediation works or treatment, or qualitative risk assessment identifies one or more high-risk relevant pollutant linkage.
Moderate Adverse	Results in effect on integrity of attribute, or loss of part of attribute	**Geology**
		Partial loss of geological feature/designation, potentially adversely affecting the integrity of the feature/designation; partial loss of and/or damage to key characteristics, features or elements such that the value of the site would be affected, but not to a major degree.
		Soils
		Permanent loss/reduction of one or more soil function(s) and restriction to current or approved future use (e.g. through degradation, compaction, erosion of soil resource) (between 1 and 2ha loss/reduction of very high value/importance soils or between 1 and 10ha loss/reduction of high to low value/importance soils).
		Groundwater
		Moderate changes to groundwater aquifer(s) flow, water level, quality or available yield. Groundwater resource use is impacted slightly, but existing supplies remain sustainable. Changes to water table level or quality would result in partial change in or loss of a groundwater dependent area, where the value of the site would be affected, but not to a major degree.

Magnitude	Criteria	Examples
		Changes to groundwater aquifer(s) flow, water level and quality would result in moderate changes to groundwater base flow contributions to surface water and/ or alterations in surface water quality, resulting in a moderate shift from baseline conditions that may be long-term or temporary. Dewatering effects create moderate differential settlement effects on existing infrastructure and buildings.
		Contaminated Land
		Contamination levels marginally above assessment criteria (for human health environment and/or property) requiring some treatment; or qualitative risk assessment identifies one or more moderate risk relevant pollutant linkage.
Minor Adverse	Results in some measurable change in quality or vulnerability of attribute	**Geology**
		Geology: minor measurable change (up to 15%) in geological feature/designation attributes, quality or vulnerability; minor loss of, or alteration to, one (maybe more) key characteristics, features or elements.
		Soils
		Temporary loss/reduction of one or more soil function(s) and restriction to current or approved future use (e.g through degradation, compaction, erosion of soil resource).
		Groundwater
		Minor changes to groundwater aquifer(s) flow, water level, quality or available yield. Changes to water table level, quality and yield result in little discernible change to existing resource use. Changes to water table level or quality would result in minor change to groundwater dependent areas, but where the value of the site would not be affected. Changes to groundwater aquifer(s) flow, water level and quality would result in minor changes to groundwater base flow contributions to surface water and/ or alterations in surface water quality, resulting in a minor shift from baseline conditions (equivalent to minor but measurable change within WFD status). Dewatering effects create minor differential settlement effects on existing infrastructure and buildings.
		Contaminated Land
		Contamination levels marginally above assessment criteria (for human health environment and/or property) and minor remediation/mitigation works required; or qualitative risk assessment identifies one or more low-risk relevant pollutant linkage.
Negligible	Results in effect on attribute but of insufficient magnitude to affect the use or integrity	**Geology**
		Very slight change from geological feature/designation baseline conditions where overall integrity of resource is not affected.
		Soils
		No discernible loss/reduction of soil function(s) that restrict current or approved future use (under 1ha loss/sealing).
		Groundwater
		No measurable impact upon an aquifer and/or groundwater receptor(s). Very slight change from groundwater baseline conditions, approximating to 'no change' conditions. Dewatering effects create no or no noticeable differential settlement effects on existing infrastructure and buildings.
		Contaminated Land
		Contamination levels below human health, environment and property assessment criteria and no remediation required; or qualitative risk assessment identifies no risk.
Minor beneficial	Results in some beneficial effect on attribute or a	**Geology**
		Improvement of existing geological features/designations such as cleaning existing rock exposures.

Magnitude	Criteria	Examples
	reduced risk of negative effect occurring	**Soils**
		Return of a minor area of land (i.e. removal of hardstanding) increasing soil function(s) and increased opportunity for future beneficial use.
		Groundwater
		Reduction of groundwater hazards to existing structures
		Contaminated Land
		Change in land use so that existing risk levels are reduced.
Moderate beneficial	Results in moderate improvement of the quality of the attribute	**Geology**
		Improved access to existing geological features/designations.
		Soils
		Return of a moderate area of land (i.e. removal of hardstanding) increasing soil function(s) and increased opportunity for future beneficial use.
		Groundwater
		Contribution to improvement in waterbody WFD classification. Support to significant improvements in damaged GWDTE.
		Contaminated Land
		Removal of existing pollutant linkages.
Major beneficial	Results in major improvement of attribute quality	**Geology**
		Creation of new geological features/designations.
		Soils
		Return of a major area of land (i.e. removal of hardstanding) increasing soil function(s) and increased opportunity for future beneficial use.
		Groundwater
		Recharge of an aquifer. Improvement in WFD classification.
		Contaminated Land
		Removal of contamination source.
No Change		No temporary or permanent loss or alteration of characteristics, features or elements; no observable impact in either direction.

Significance

6.3.21 The significance of effects was determined as a function of the value/importance of the receptor/attribute and the magnitude of the predicted impact. According to the environmental assessment methodology within DMRB LA 104, specifically for projects in Scotland, the significance of significant potential effect shall be reported including embedded mitigation measures. Any residual effects shall be reported after assessment of the effectiveness of essential mitigation measures required to reduce and, if possible, offset likely significant adverse environmental effects. The matrix for the determination of significance, provided in the DMRB LA 104 guidance, is shown in Table 6.4.

Table 6.4: Matrix for Determination of Significance

Importance	Magnitude				
	No change	**Negligible**	**Minor**	**Moderate**	**Major**
Very High	Neutral	Slight	**Moderate or Large**	**Large or Very Large**	**Very Large**
High	Neutral	Slight	Slight or **Moderate**	**Moderate or Large**	**Large or Very Large**
Medium	Neutral	Neutral or Slight	Slight	**Moderate**	**Moderate or Large**
Low	Neutral	Neutral or Slight	Neutral or Slight	Slight	Slight or **Moderate**
Negligible	Neutral	Neutral	Neutral or Slight	Neutral or Slight	Slight

6.3.22 Where Table 6.4 gives the choice between two significance, the highest significance has been selected by default.

6.3.23 Effects of **Moderate** significance and above are considered significant in the context of The Roads (Scotland) Act 1984 (Environmental Impact Assessment) (Scotland) Regulations 2017, hereafter referred to as the Roads EIA Regulations, and the level at which mitigation would be proposed. Significant effects (potential or residual) are shown in bold throughout the chapter.

Limitations to Assessment

6.3.24 The identification of potential contamination sources relies on the accuracy of historical mapping.

6.3.25 Geological and hydrogeological information obtained from the 2018/2019 GI (SOCOTEC 2019a and 2019b) have been used for this assessment. In areas where no data were available, the nearest geological and hydrogeological information was extrapolated from the wider available dataset.

6.3.26 The assessment is reliant on the accuracy of the information provided during consultation.

6.4 Baseline Conditions

Geology and Soils

Designated Geological Sites and Features of Geodiversity Interest

6.4.1 A large proportion of the site (LMA for temporary works and construction boundary) and study area falls within the Firth of Forth SSSI. The Firth of Forth SSSI covers an extensive coastal area located on the east coast of Scotland, stretching from Alloa to Crail on the north shore and to Dunbar on the south shore.

6.4.2 Bedrock features designated within the SSSI include Stratigraphy of the Lower and Upper Carboniferous (SNH 2020). The SSSI is also designated for coastal geomorphology and quaternary deposits. It is noted that the designated bedrock and geomorphological and quaternary features fall outside of the study area and therefore no impacts are anticipated on these receptors (SNH 2020).

6.4.3 Non-geological qualifying features associated with the Firth of Forth SSSI and other designated sites are described in Chapter 8 (Marine Ecology) and Chapter 9 (Terrestrial Ecology) with impacts in relation to fluvial and coastal geomorphology considered and described in Chapter 7 (Road Drainage and the Water Environment). These features are supported by the underlying soils and shallow superficial deposits.

Soils

6.4.4 The Soil Map of Scotland (partial cover) (Scottish Government 2020) identifies saltings as the primary soil type underlying the site. These are defined as 'saline alluvial soils' (intertidal deposits) derived from saltmarsh, marine and estuarine alluvial deposit parent material. Whilst no carbon-rich, deep peat or

priority peatland areas have been identified within the study area based on a review of the SNH Carbon and Peatland Map (SNH 2016), peaty alluvial soils and saltings are considered to be rare soil types in the Falkirk area and are of potential national interest (Falkirk Local Development Plan 2 (FLDP2) (Falkirk Council 2020)).

6.4.5 It is noted that the soil descriptions on the borehole logs within the 2018/2019 GI Factual report (SOCOTEC 2019a and 2019b) are engineering descriptions and hence require additional interpretation when considering soils as opposed to engineering materials. With the exception of 17BH02 and 17BH20 which were situated on the existing carriageway, materials representing saltings deposits were identified from the ground surface at all 17 remaining borehole locations in the 2018/2019 GI (SOCOTEC 2019a and 2019b). The description of the saltings deposits were variable as described below:

- A mottled brown and orange slightly sandy silty clay underlying the surface vegetation extending to approximately one metre in depth noted at three of the 17 locations (17BH01, 17BH03 and 17BH16) that are above, adjacent and below the mean high water spring mark respectively; and
- Material described as 'plastic pseudo-fibrous peat' underlying the surface vegetation extending to a maximum depth of 0.5m below ground level (bgl) noted at 14 locations below the mean high water spring mark within the saltmarsh. This includes the materials described as made ground in 17BH06 and 17BH19 (situated below the mean high water spring mark within the saltmarsh) where rare extraneous materials were noted within the matrix of a 0.5m thick surface layer described as 'plastic pseudo-fibrous peat'. It is anticipated these deposits are actually natural and not reworked and that the presence of extraneous materials is a result of these falling into the deposits under self-weight.

6.4.6 As noted above, the engineering descriptions provided in the logs for the 'peat' have been reviewed. Noting the relatively low organic matter content recorded by laboratory testing (below 20%), the location of the deposits in the saltmarsh/intertidal zone and the limited thickness (0.5m thick or under) these deposits underlying the site are considered to be indicative of the organic rich/peaty saltings rather than peat as described in the logs.

6.4.7 Given the presence of rare soils of potential national interest (organic rich/peaty saltings), soils in the site area are considered to be of high value/importance.

Made Ground

6.4.8 No made ground is recorded on the BGS Onshore Geoindex (BGS 2020) within the study area. However, it is likely that made ground is present in the vicinity of the existing A985 carriageway (including Kincardine Bridge) and A876 carriageway embankments which are likely to comprise deposits of made ground.

6.4.9 Made ground was confirmed to be present within the two locations within the A985 (southern approach to Kincardine Bridge) embankment (17BH02 and 17BH20) during the 2018/2019 GI (Jacobs 2019). The made ground was described as a black sandy clay with rootlets in the top 0.15m underlain by a black gravelly/sandy clayey fine to coarse sand/gravel with cobbles and extraneous materials including fragments of plastic, clinker, blaes and brick to depths of 3.2mbgl and 4.70mbgl.

6.4.10 As noted in paragraph 6.4.5, it is considered that deposits described as made ground in 17BH06 and 17BH19 are more likely to be organic rich/peaty saltings with extraneous materials that have fallen into them under self-weight and have been included as soils as opposed to reworked made ground materials.

6.4.11 As per the definitions in Table 6.2, made ground is considered to be of negligible value/importance.

Superficial Geology

6.4.12 Superficial geology at the site of the proposed scheme indicates that the area is underlain by reclaimed intertidal deposits comprising silt and clay and post-glacial raised beach deposits, and associated marine

and estuarine alluvium, underlain by glacial till (BGS 2020). This is supported by the 2018/2019 GI (SOCOTEC 2019a and 2019b) which encountered superficial deposits to depths of between 20.00mbgl and 28.00mbgl primarily consisting of organic rich/peaty clays and silts.

6.4.13 Superficial deposits are expected to support the development of the high value/importance soils present in the study area. As a result, shallow superficial geology present in the study area is, therefore, considered to be of high value/importance.

Bedrock Geology

6.4.14 Bedrock geology at the site of the proposed scheme is composed of Carboniferous sedimentary rock of the Passage Group and Lower Coal Measures (BGS 2020). The Passage Group is a cyclic formation which directly underlies the proposed scheme, consisting primarily of sandstones and seatearths. There is a fault to the north-east of the area required for temporary works and construction which trends north-west to south-east and is indicated to dip to the north-east. The closest coal seam is shown to subcrop to the west of the A876 South Approach Road, dipping to the southwest by an unknown amount.

6.4.15 Bedrock was encountered during the 2018/2019 GI at a minimum depth of 20mbgl (17BH18) and proven to a maximum depth of 55.20mbgl (17BH09). Bedrock encountered typically comprised interbedded sandstones and mudstones, occasionally siltstones and rarely coal.

6.4.16 As per the definitions in Table 6.2, bedrock geology present in the study area is not considered to fall under the SSSI and is considered to be of negligible value/importance.

Mineral Extraction

6.4.17 The mining status of the site is covered by a Coal Mining Report obtained from the Coal Authority and was reviewed as part of the Geotechnical Desk Study (Jacobs 2008) and Geotechnical Interpretative Report (Jacobs 2019). The report noted that the study area lies within the likely zone of influence from workings in one coal seam located at 480m depth. The seam was last worked in 2002. Any ground movement from these workings should have ceased (Jacobs 2019).

6.4.18 Although the site is located at the fringe of a Coal Authority defined Development High Risk Area, which ends at the Higgins Neuk Roundabout, there are no known mine entries in the study area or within 100m of the site (Coal Authority 2020). There is however potential for unrecorded mine workings to be located in the vicinity of the site area.

6.4.19 Given their historical presence, and the indicated superficial and bedrock geology conditions, the potential for further mineral resources to be present in the study area cannot be entirely discounted. As stated in paragraph 6.3.3, mineral resources including extraction are assessed in Chapter 13 (Material Assets and Waste).

Contaminated Land

6.4.20 The assessment of potential contamination has focused on the potential for impacts on receptors as a direct consequence of the proposed scheme encountering contamination. The assessment has been informed by the contaminated land assessment undertaken for the proposed scheme presented within the Geotechnical Interpretative Report (GIR) (Jacobs 2019) and summarised within the Geotechnical Design Report (GDR) (Jacobs 2020). A summary of the potential receptors and potential sources of contamination within the study area is provided below. A full contaminated land conceptual site model is presented in the GIR (Jacobs 2019).

Potential Receptors

6.4.21 Potential receptors that could require assessment in the context of these being present have been compiled based on the definitions provided in 'The Environmental Protection Act 1990: Part IIA Contaminated Land – Statutory Guidance: Edition 2' (Scottish Executive 2006), as well as the geological and wider baseline conditions in the study area. These therefore include the following (values have been assigned to each receptor as per the definitions in Table 6.2):

- Human health: construction and maintenance workers within the proposed scheme construction/maintenance areas (high value/importance), future end users of the proposed end land use (highways) (low value/importance).
- Water environment: groundwater within superficial deposits and underlying bedrock (medium value/importance); surface water (Forth Estuary) (very high value/importance).

Potential Sources of Contamination

6.4.22 The GIR stated that although there was no obvious evidence of made ground or contamination identified from historical maps there was potential for made ground of unknown composition to be present within the study area associated with road construction activities. A review of available data has identified five areas within the study area with the potential for made ground deposits:

- the existing A985 carriageway including Kincardine Bridge (K-C1);
- An area of spoil (K-C2), located approximately 220m to the north of the existing carriageway recorded on both the 1944 and 1950 edition historical maps (National Library of Scotland 2020);
- the A876 carriageway (K-C3);
- a former pier (ferry crossing) (K-C4), located approximately 75m to the north of Kincardine Bridge; and
- a hardcore ramp (K-C5), located to the north of Kincardine Bridge which was removed around the time of the construction of the Clackmannanshire Bridge.

6.4.23 Only three potential contaminated land sources (K-C1, K-C3 and K-C5) are located within the LMA for temporary works and construction boundary.

6.4.24 Made ground has only been proven within potential contaminated land source K-C1 (within A985 embankment soils on the southern approach to the Kincardine Bridge). One soil sample collected from the made ground (17BH02 at 1mbgl) contained concentrations of a small number of polyaromatic hydrocarbons in excess of generic assessment criteria for construction/maintenance activities and areas of public open space (Land Quality Management (LQM) / Chartered Institute of Environmental Health (CIEH) 2015). Amosite asbestos fibres were also noted in this same sample with a concentration just above the detection limit of 0.001%. This concentration of asbestos could be classed as 'trace' and not subject to the Control of Asbestos Regulations (CAR) 2012 (refer to 'Watch Point 2' of Contaminated Land: Applications in Real Environments (CL:AIRE) 2016). No bulk Asbestos Containing Materials (ACM) was found during the 2018/2019 GI, however, the potential for unforeseen contamination within the embankment soils cannot be discounted.

6.4.25 Areas of potentially contaminated land located within the study area of the proposed scheme are shown on Figure 6.1.

Groundwater

6.4.26 The groundwater body underlying the site is classified by SEPA as the Airth groundwater body, which was given an overall status of Poor in 2016 (SEPA 2020b and 2020c). Given the location of the majority of the site within the intertidal zone of the Forth Estuary, superficial groundwater is expected to be high in salinity. No groundwater quality testing was undertaken as part of the ground investigation (SOCOTEC

2019a, 2019b). This was due to both access constraints for the exploratory locations (below the high water line or adjacent to live traffic) and the connectivity with the Forth Estuary and associated saline intrusion.

6.4.27 GI conducted by Babtie in 2000 and 2002 indicated that the local water table is situated above rockhead. Water levels recorded in the boreholes typically settled at 1m to 2m below ground level (Transport Scotland 2009).

6.4.28 A summary of groundwater levels observed during groundwater monitoring as part of the 2018/2019 GI (SOCOTEC 2019a, 2019b) is presented in Table 6.5. Groundwater piezometric levels encountered during the 2018/2019 GI were consistently shallow at around 1 to 2mbgl (SOCOTEC 2019a, 2019b) in bedrock. 17BH02 is the only borehole installed in superficial deposits and recorded groundwater piezometric level fluctuating between 3 and 4mbgl. This suggests that bedrock groundwater may be slightly confined at depth.

Table 6.5: Summary of Groundwater Monitoring

Borehole No.	Installation	Stratum Monitored	Ground Level (m AOD)	Depth / Response Zone (mbgl)	Number of Monitoring Rounds	Groundwater Depth Range (mbgl)
17BH02	50mm standpipe	Bothkennar Gravel	4.93	16.00 to 19.00	5	2.88 to 4.28
17BH05	Vibrating Wire Piezometer	Weathered bedrock (SANDSTONE)	2.87	26.40 to 27.00	4	0.09 to 0.53
17BH08	Vibrating Wire Piezometer	MUDSTONE / SANDSTONE	2.81	32.00 to 34.00	4	1.42 to 1.79
17BH13	Vibrating Wire Piezometer	SANDSTONE	2.85	26.70 to 27.30	4	-0.14 to 0.30

6.4.29 There are no known groundwater abstractions or groundwater fed PWS within the vicinity of the proposed scheme.

6.4.30 An extended Phase 1 habitat survey was undertaken in June 2017 and updated in November 2019. The results of the survey are reported within Chapter 9 (Terrestrial Ecology) and shown on Figure 9.2. The survey did not identify any GWDTEs as defined by Land Use Planning System Guidance Note 31 (SEPA 2017) within the vicinity of the proposed scheme. The habitat within the study area is intertidal saltmarsh, classified within the Firth of Forth SSSI, and is therefore not likely to be groundwater fed. The intertidal saltmarsh habitat is discussed in Chapter 8 (Marine Ecology).

6.4.31 As per the definitions in Table 6.2, the groundwater body underlying the site is of medium value/importance.

6.5 Potential Impacts

Introduction

6.5.1 This section describes the assessment of potential impacts of the proposed scheme that could arise in the absence of mitigation measures beyond any embedded in the design. No specific embedded mitigation measures have been included for geology, soils and groundwater as part of the proposed scheme. Additional essential mitigation measures to reduce significant residual effects are identified and described in Section 6.6 (Mitigation).

6.5.2 Construction and operational phases have been considered together as the majority of construction effects (such as removal of excavated material) would extend through to the operational phase. Where differences in impacts are predicted between the construction and operational phases, these impacts have been assessed for each in turn.

6.5.3 The new viaduct replacement structure will require piles to be placed in the saltmarsh. It is proposed that piled platforms are also to be formed to support the temporary diversion. The concrete piles to support the new viaduct replacement structure would involve boring approximately 30m into the ground and the bedrock, requiring excavation of the ground surface. It is anticipated that excavations of approximatively 2.5m deep will be required, with a cofferdam placed around excavations to reduce groundwater ingress. The concrete piles supporting the temporary bridge structure will remain in-situ following its removal with the piles cut down to at least 1m below ground level.

Geology and Soils

6.5.4 Potential impacts in relation to non-geological interest features associated with the Firth of Forth SSSI and other designated sites are described in Chapter 8 (Marine Ecology) and Chapter 9 (Terrestrial Ecology). Impacts on soils and superficial deposits, which support these non-geological features of the SSSI, are considered below.

Soils

6.5.5 Soils of high value/importance (organic rich/peaty saltings) are present within the LMA for temporary works and construction boundary and could potentially be impacted by excavations, piling and other earthworks during the construction of the proposed scheme subject to temporary works design. A total volume of 6,738m^3 of organic rich/peaty saltings was calculated within this working area (up to the base of the existing embankment) using an interpolation of the depths of organic rich/peaty saltings encountered during the GI (SOCOTEC 2019a, 2019b). It should be noted that this volume is a total estimate of organic rich/peaty saltings present and not all will be impacted as a result of the proposed scheme.

6.5.6 Given the nature of the works, the magnitude of impact is considered likely to be minor adverse (as per the definitions in Table 6.3), therefore resulting in a Moderate significance of effect.

Made Ground

6.5.7 Made deposits (negligible value/importance) are present within the LMA for temporary works and construction boundary and are likely to be impacted by excavation, piling and other earthworks during construction of the proposed scheme. The disturbance and/or reduction in the extent of these deposits as a result of the construction activities is considered to be of negligible magnitude. As a result, the overall significance of effect is considered to be Neutral for both construction and operation.

Superficial Geology

6.5.8 Superficial deposits of high value/importance are present within the working area and are likely to be impacted by excavations, piling and other earthworks during the construction of the proposed scheme. The disturbance and/or reduction in the extent of these deposits as a result of the construction activities is considered to be of negligible magnitude because of their widespread occurrence in the region and country, and therefore minimal percentage loss. As a result, the overall significance of effect is considered to be Slight for both construction and operation.

Bedrock Geology

6.5.9 The proposed use of piling may impact on bedrock geology (negligible value/importance), resulting in a slight decrease in their extent, which is considered to be of negligible magnitude based on the

widespread distribution of these deposits. This results in a potential effect of Neutral significance during the construction and operation phases.

Contaminated Land

6.5.10 Construction of the proposed scheme may impact contaminated land via direct disturbance (including demolition and removal) of potentially contaminated land (i.e. sources that are within the LMA of the proposed scheme).

6.5.11 There is the potential for risk to human health and biodiversity, changes to water quality, due to the potential release/disturbance of any potential contaminants from soils or construction activities. Given the intrusive nature of the works and the construction of piles, new pollutant pathways may also be generated and present a risk to the water environment and groundwater at depth. The equilibrium of the saltmarsh may also be sensitive to sub-surface water contamination.

Human Health

6.5.12 Construction and maintenance workers within the proposed scheme construction/maintenance areas (high value/importance) will have direct exposure to excavated made ground/natural soils, shallow groundwater and potentially ground gas/vapour migration. The contaminated land assessment within the GIR (Jacobs 2019a) identified:

- a moderate/low risk from potential soil/groundwater contamination (including potentially localised asbestos) and a moderate risk from potential ground gas associated with made ground, natural organic rich/peaty saltings and/or underlying coal seams to construction workers; and
- a low risk from potential soil/groundwater contamination (including potentially localised asbestos); and a moderate/low risk from potential ground gas associated with made ground, natural organic rich/peaty saltings and/or underlying coal seams to maintenance workers.

6.5.13 The impact magnitude is assessed as moderate adverse during construction and minor adverse during operation. This results in a Large significance of effect during construction and a Moderate significance of effect during operation prior to essential mitigation.

6.5.14 The value/importance assigned to human future end users is indicative of the nature of the activities associated with that proposed end use, in this case the proposed end use is the A985 road (highways/rail). The transient nature of human activity and the limited exposure time associated with the proposed end use is reflected in the low value/importance assigned to future end users. The contaminated land assessment within the GIR (Jacobs 2019a) identified a low risk from potential soil/groundwater contamination (including potentially localised asbestos) and a moderate/low risk from potential ground gas associated with made ground, natural organic rich/peaty saltings and/or underlying coal seams to future end users. The impact magnitude is assessed as minor adverse during operation which results in a Slight significance of effect during operation.

Water Environment

6.5.15 The contaminated land risk assessment within the proposed scheme GIR (Jacobs 2019a) identified a low risk to the water environment receptors: groundwater within superficial deposits and bedrock (medium value/importance); and surface water (Forth Estuary) (very high value/importance) from potential soil/groundwater contamination. However, it was recognised that there was potential for the creation of new preferential pathways via piled foundations (groundwater), run off from stockpiled excavated material and road drainage networks (surface water). The impact magnitude is assessed as minor adverse during both construction and operation. This results in a Slight significance of effect for groundwater within superficial deposits and bedrock; and a Large significance of effect for the Forth Estuary (surface water) prior to essential mitigation.

Groundwater

Groundwater Flow

6.5.16 Shallow groundwater may be locally disturbed as a result of the earthworks, given that groundwater was encountered during the 2018/2019 GI works consistently across the site at a depth of around 1mbgl. With earthworks at a maximum of 2.5m expected, dewatering effects are expected to be localised and short lived.

6.5.17 Despite not being a GWDTE, the equilibrium of the saltmarsh may be sensitive to sub-surface water flow changes. Conditions during/following construction are not expected to deviate significantly from those currently present. This is due to the piled structures associated with the existing crossing (piled viaduct) already being in place and the small-scale nature of the earthworks in comparison to the scale of the Forth Estuary.

6.5.18 Bedrock groundwater is unlikely to be intercepted, however new flow pathways may be created during piling.

6.5.19 Overall, potential impacts on groundwater (medium value/importance) are considered to be minor adverse, resulting in a potential Slight significance of effect on groundwater flows.

Groundwater Quality

6.5.20 Piling works may result in the creation of preferential pathways however, it is considered unlikely that contaminants within the soils would leach from in-situ soils and migrate to the nearby groundwater receptors in sufficient concentrations and volumes likely to cause harm to the water environment given the effects of dilution, dispersion and retardation during transport (Jacobs 2019a).

6.5.21 Temporary storage of oils, fuels and chemicals will be required during the construction phase. Accidental spillage of these contaminants could result in migration through the upper unsaturated zone to the shallow aquifer, impairing groundwater quality unless appropriate measures for control are taken.

6.5.22 Overall, potential impacts on groundwater (medium value/importance) are considered to be moderate adverse magnitude, resulting in a potential Moderate significance of effect on groundwater quality.

6.5.23 Potential impacts on surface water quality of the saltmarsh are described in Chapter 7 (Road Drainage and the Water Environment).

6.6 Mitigation

6.6.1 This section identifies essential mitigation measures to avoid/prevent, reduce or offset potential significant impacts, described in Section 6.5 (Potential Impacts), taking into account best practice, legislation and guidance, during both construction and operation.

Geology and Soils

6.6.2 Potential geological effects are of Slight significance for all deposits with the exception of Soils. Therefore, mitigation measures are only considered for potential impacts on Soils.

6.6.3 Falkirk LDP2 Place and Environment Policy PE25 (Soils and Agricultural Land) (Falkirk Council 2020) requires development which is likely to disturb areas of carbon rich or rare soil to submit a soil or peat management plan which demonstrates that: the areas of highest quality or deepest peat have been avoided, any disturbance, degradation or erosion has been minimised through mitigation; and any likely release of greenhouse gas emissions caused by disturbance is offset.

6.6.4 Noting the classification of the saltings as a rare soil potentially of national importance, the Contractor shall develop a Soil Management Plan prior to construction, for implementation during construction, with cognisance of the requirements identified in relation to organic rich/peaty saltings under Falkirk Council's LDP2 Place and Environment Policy PE25 (Soils and Agricultural Land) (Falkirk Council 2020). This shall include consideration of the selection of appropriate construction methodologies to limit the areas and volume of saltings to be disturbed and/or excavated to a minimum during construction to limit the impact upon the deposits. The Soil Management Plan will adopt principles from the 'Scottish Soil Framework' (Scottish Government 2009) and other voluntary or industry regulated Codes of Practice, including 'Promoting the Sustainable Reuse of Greenfield Soils in Construction' (SEPA 2010), the 'Construction Code of Practice for the Sustainable Use of Soils on Construction Sites' (Defra 2009). In addition, whilst not directly relevant to saltings, where encountered during construction, excavation and storage, or if any off-site removal is required, the Soil Management Plan will include consideration of the guidance provided in the publication 'Development on Peatland: Guidance on the Assessment of Peat Volumes, Reuse of Excavated Peat and the Minimisation of Waste' (Scottish Renewables and SEPA 2012) where appropriate to manage any impact on these organic soils and be compliant with the Waste Management Licensing (Scotland) Regulations 2011.

6.6.5 The above will be captured in a Soil Management Plan that will be developed by the Contractor. (**Mitigation Item G1**).

Contaminated Land

6.6.6 Interaction is expected between construction of the proposed scheme and areas of potentially contaminated land. This interaction could lead to direct and indirect impacts to human health and the water environment which have been predicted to range from Slight to Moderate significance. The mitigation items described below would be implemented to negate or minimise the predicted impacts and to minimise the contact with any potentially contaminated soil or groundwater.

6.6.7 Consultation has been undertaken with the relevant local authorities and SEPA (as necessary) regarding works in relation to land affected by contamination to support the obligations set out in 'Planning Advice Note 33: Development of Contaminated Land' (Scottish Government 2017). No remediation requirement has been identified, however should unforeseen contamination be identified during construction it will be risk assessed and appropriate action will be undertaken. Should any remedial action be required, it will be carried out under the appropriate remediation licencing (**Mitigation Item G2**).

6.6.8 Prior to construction and demolition, appropriate health and safety and waste management procedures for working with potentially contaminated soils (including asbestos) and water will be established. In respect of potential risks to construction workers associated with the presence of asbestos fibres and dust, it is recommended that the Contractor should produce the necessary risk assessments for construction within potentially asbestos contaminated ground, and develop appropriate method statements and procedures to manage the potential risks in line with CL:AIRE publication 'Interpretation for Managing and Working with Asbestos in Soil and Construction and Demolition Materials', published in 2016 (CL:AIRE 2016). Waste management procedures will take account of inter alia Waste Management Licence (Scotland) Regulations 2011 (as amended by the Waste Management Licensing (Scotland) Amendment Regulations 2016) and the Health and Safety Executive (HSE) Approved Code of Practice for managing and working with asbestos (L143) (HSE 2013). These procedures will be implemented as appropriate during construction (**Mitigation Item G3**).

6.6.9 Risks to construction, demolition and maintenance staff working with/near contaminated land will be mitigated by the implementation of the above in combination with the adoption of appropriate systems of work, including personal protective equipment (PPE) as a last resort. In the event that unrecorded contamination is encountered, works should be stopped and the working procedures reassessed to confirm the working methods remain appropriate. An appropriate response procedure should be developed in the event that unexpected asbestos contamination is identified during construction works

in accordance with requirements of the Control of Asbestos Regulations (CL:AIRE 2016) and the HSE Approved Code of Practice for managing and working with asbestos (L143) (HSE 2013) (**Mitigation Item G4**).

6.6.10 A watching brief to be implemented to identify potential presence of previously unidentified contamination. Personnel appointed by the Contractor to be appropriately trained if involved in earthworks activities (**Mitigation Item G5**).

6.6.11 To prevent cross contamination and pollution from piling works undertaken in areas of land affected by contamination, the Contractor will develop a Piling Risk Assessment and adhere to appropriate guidance including the 'Piling and Penetrative Ground Improvement Methods on Land Affected by Contamination: Guidance on Pollution Prevention, National Groundwater and Contaminated Land Centre Report NC/99/77' (EA 2001) (**Mitigation Item G6)**.

6.6.12 To maximise the reuse of site-won materials on-site (and minimise the need for disposal of waste in line with the principles of the "Waste Hierarchy") whilst ensuring that no risks are posed to human health nor the water environment, a soil reuse assessment will be undertaken prior to construction. The soil reuse assessment will identify any potential risks posed to both human health and the water environment from potentially contaminated soils reused throughout the scheme (**Mitigation Item G7**).

6.6.13 If excavated soils are deemed unsuitable or not required for onsite reuse they should be initially considered for offsite reuse or recycling (in accordance with Waste Management Licensing requirements). If destined for offsite disposal they will be assessed in line with the 'Waste Classification: Guidance on the Classification and Assessment of Waste' (Technical Guidance WM3) (Natural Resources Wales, SEPA, Northern Ireland Environment Agency, Environment Agency 2018) prior to disposal to determine whether they are hazardous or non-hazardous. This will establish the most appropriate and cost-effective waste stream for the waste materials (**Mitigation Item G8**).

6.6.14 Given the presence of made ground, organic rich/peaty saltings and/or underlying coal seams within the study area, there is potential for the localised generation of methane and/or carbon dioxide which may warrant further consideration should below ground or confined space working be required. Appropriate working methods cognisant of potential ground gas risks will be required to be developed and adopted by the Contractor during below ground site construction works including excavations and piling. It is recommended that this should include as a minimum, gas monitoring undertaken prior to any entry into excavations, confined spaces or below ground structures and use of personal gas monitors and PPE (including respiratory protective equipment (RPE)) as a last resort. The implications of encountering pockets of ground gas should also be considered during piling risk assessments for the site (**Mitigation Item G9**).

Hydrogeology

Groundwater Flow

6.6.15 The potential volume of groundwater being dewatered would be considered in the context of potential groundwater abstraction CAR licences prior to works commencing. This would be done using all available GI data (**Mitigation Item G10**).

Groundwater Quality

6.6.16 Chapter 7 (Road Drainage and the Water Environment), provides details on anticipated mitigation to address potential impacts on surface waters, including adherence to SEPA Pollution Prevention Guidelines (PPGs) during construction and operation. It should be noted that SEPA are in the process of replacing the PPGs with Guidance for Pollution Prevention (GPPs) which should be adhered to, as appropriate. In respect of groundwater, these measures would also:

- mitigate against pollution by reducing the potential for pollutant release and preventing any contaminated runoff produced by the works from entering groundwater via the unsaturated zone; and
- protect groundwater receptors against impacts on water quality.

6.6.17 Storage of excavated soils and made ground will be minimised on site (spatially and in duration) and all storage areas will be appropriately lined, with adequate drainage management in place. This is to ensure that no polluted water percolates into the ground or contaminated run-off is generated (**Mitigation Item G11**).

Schedule of Environmental Commitments

6.6.18 A summary of the essential mitigation measures, to be implemented in constructing and operating the proposed scheme relevant to geology, soils and groundwater, is provided in Table 6.6. Chapter 17 (Schedule of Environmental Commitments) contains the complete schedule of measures for the proposed scheme.

Table 6.6: Schedule of Environmental Commitments - Geology, Soils and Groundwater

Mitigation Item	Party Responsible for Implementation	Timing of Measure	Description	Mitigation Purpose/Objective	Specific Consultation or Approval Required	Monitoring / Compliance
G1	Contractor	Construction	The Contractor shall develop a Soil Management Plan prior to construction, for implementation during construction, with cognisance of the requirements identified in relation to organic rich/peaty saltings under Falkirk Council's Local Development Plan 2 (LDP2) Place and Environment Policy PE25 (Soils and Agricultural Land) (Falkirk Council 2020), the 'Scottish Soil Framework' (Scottish Government 2009) and other voluntary or industry regulated Codes of Practice, including 'Promoting the Sustainable Reuse of Greenfield Soils in Construction' (SEPA 2010), the 'Construction Code of Practice for the Sustainable Use of Soils on Construction Sites' (Defra 2009). This shall include consideration of the selection of appropriate construction methodologies to limit the areas and volume of saltings to be disturbed and/or excavated to a minimum during construction to limit the impact upon the deposits. In addition, whilst not directly relevant to saltings, guidance provided in the publication 'Development on Peatland: Guidance on the Assessment of Peat Volumes, Reuse of Excavated Peat and the Minimisation of Waste' (Scottish Renewables and SEPA 2012) shall be adopted where appropriate.	To comply with relevant waste management practices under The Waste Management Licensing (Scotland) Regulations 2011 and reduce impacts on rare soils of potential national interest.	Consultation with Falkirk Council and SEPA.	Ongoing monitoring of compliance throughout works via implementation of Management Plans as specified in Employer's Requirements in the Contract documents.
G2	Transport Scotland and Contractor	Construction	Consultation has been undertaken with the relevant local authorities and SEPA (as necessary) regarding works in relation to land affected by contamination to support the obligations set out in 'Planning Advice Note 33: Development of Contaminated Land' (Scottish Government 2017) if and where relevant. No remediation requirement has been identified, however should unforeseen contamination be identified during construction, any remedial action will be carried out under the appropriate remediation licencing.	To reduce impacts from contaminated land sources.	Consultation with Falkirk Council and SEPA as required.	Consultation requirements to be included as a contract requirement as necessary.
G3	Contractor	Pre-construction and Construction	Prior to construction, appropriate health and safety and waste management procedures for working with potentially contaminated soils (including asbestos) and water will be established. In respect of potential risks to construction workers associated with the presence of asbestos fibres and dust, it is recommended that the Contractor should produce the necessary risk assessments for construction within potentially asbestos	To ensure appropriate health and safety and waste management procedures for working with potentially contaminated soils are followed.	None required	Employers Regulations and/or specification

Mitigation Item	Party Responsible for Implementation	Timing of Measure	Description	Mitigation Purpose/Objective	Specific Consultation or Approval Required	Monitoring / Compliance
			contaminated ground, and develop appropriate method statements and procedures to manage the potential risks in line with CL:AIRE publication 'Interpretation for Managing and Working with Asbestos in Soil and Construction and Demolition Materials' (CL:AIRE 2016). Waste management procedures will take account of inter alia Waste Management Licence (Scotland) Regulations 2011 (as amended by the Waste Management Licensing (Scotland) Amendment Regulations 2016) and the HSE Approved Code of Practice for managing and working with asbestos (L143) (HSE 2013). These procedures will be implemented as appropriate during construction.			
G4	Contractor	Construction and Post-construction / Operation	Risks to construction, demolition and maintenance staff working with/near contaminated land will be mitigated by the implementation of the above in combination with the adoption of appropriate systems of work, including personal protective equipment (PPE) as a last resort. In the event that unrecorded contamination is encountered, works should be stopped and the working procedures reassessed to confirm the working methods remain appropriate. An appropriate response procedure should be developed in the event that unexpected asbestos contamination is identified during construction works in accordance with requirements of the Control of Asbestos Regulations (CL:AIRE 2016) and the HSE Approved Code of Practice for managing and working with asbestos (L143) (HSE 2013).	To reduce impacts from contaminated land sources and confirm the safety of construction and maintenance staff.	None required	Employers Regulations and/or specification
G5	Contractor	Construction	A watching brief to be implemented to identify potential presence of previously unidentified contamination. Personnel appointed by the Contractor to be appropriately trained if involved in earthworks activities.	To identify potential presence of previously unidentified contamination	None required	Employers Regulations and/or specification
G6	Contractor	Construction	To prevent cross contamination and pollution from piling works undertaken in areas of land affected by contamination, the Contractor will develop a Piling Risk Assessment and adhere to appropriate guidance including the 'Piling and Penetrative Ground Improvement Methods on Land Affected by Contamination: Guidance on Pollution Prevention, National Groundwater and Contaminated Land Centre Report NC/99/77' (EA 2001)	To prevent cross contamination and pollution from piling works undertaken in areas of land affected by contamination.	None required	Employers Regulations and/or specification
G7	Contractor	Pre-construction	To maximise the reuse of site-won materials on-site (and minimise the need for disposal of waste in line with the principles of the "Waste Hierarchy") whilst ensuring that no risks are posed to	To identify any potential risks posed to human health and the water environment. In addition,	None required	Employers Regulations and/or specification

Mitigation Item	Party Responsible for Implementation	Timing of Measure	Description	Mitigation Purpose/Objective	Specific Consultation or Approval Required	Monitoring / Compliance
		and Construction	human health nor the water environment, a soil reuse assessment will be undertaken prior to construction. The soil reuse assessment will identify any potential risks posed to both human health and the water environment from potentially contaminated soils reused throughout the scheme.	this mitigation item would maximise re-use of site-won materials on-site and minimise the need for disposal of waste in line with the principles of the "Waste Hierarchy" through re-use of excavation arisings (refer to **Mitigation Item M&W3**)		
G8	Contractor	Construction	If excavated soils are deemed unsuitable or not required for onsite reuse they should be initially considered for offsite reuse or recycling (in accordance with Waste Management Licensing requirements). If destined for offsite disposal they will be assessed in line with the 'Waste Classification: Guidance on the Classification and Assessment of Waste' (Technical Guidance WM3) (Natural Resources Wales, SEPA, Northern Ireland Environment Agency, Environment Agency 2018) prior to disposal to determine whether they are hazardous or non-hazardous. This will establish the most appropriate and cost-effective waste stream for the waste materials	To determine whether disposed soils are hazardous or non-hazardous.	None required	Employers Regulations and/or specification
G9	Contractor	Pre-construction and Construction	Given the presence of made ground, organic rich/peaty saltings and underlying coal seams there is potential for the localised generation of methane and/or carbon dioxide which may warrant further consideration should below ground or confined space working be required. Appropriate working methods cognisant of potential ground gas risks will be required to be developed and adopted by the Contractor during below ground site construction works including excavations and piling. It is recommended that this should include as a minimum, gas monitoring undertaken prior to any entry into excavations, confined spaces or below ground structures and use of personal gas monitors and PPE (including RPE) as a last resort. The implications of encountering pockets of ground gas should also be considered during piling risk assessments for the proposed scheme.	To mitigate against potential impacts on human health due to ground gas.	None required	Employers Regulations and/or specification
G10	Contractor	Pre-construction and Construction	The potential volume of groundwater drainage would be considered in the context of potential groundwater abstraction CAR licences prior to works commencing. This would be done using all available GI data	Compliance with CAR licensing to protect the water environment.	Approval required from SEPA	None expected once approval granted

Mitigation Item	Party Responsible for Implementation	Timing of Measure	Description	Mitigation Purpose/Objective	Specific Consultation or Approval Required	Monitoring / Compliance
G11	Contractor	Construction	Storage of excavated soils and made ground will be minimised on site (spatially and in duration) and all storage areas will be appropriately lined, with adequate drainage management in place. This is to ensure that no polluted water percolates into the ground or contaminated run-off is generated.	To ensure that no polluted water percolates into the ground or contaminated runoff is generated.	None required	Ongoing monitoring of compliance throughout works and ensuring site is restored upon completion via contract requirements

6.7 Residual Effects

6.7.1 The implementation of mitigation measures in relation to soils should ensure that the effect on soil resources and rare soils of conservation value be reduced to Slight significance.

6.7.2 The implementation of mitigation measures in relation to contaminated land is expected to reduce potential effects to a residual effect of Slight significance.

6.7.3 The implementation of mitigation measures in relation to groundwater quality are expected to reduce potential effects to a residual effect of Slight significance on the completion of the works, with minor alterations possible due to the installation of foundations and piles.

6.7.4 On site storage and use of chemicals and fuels will be subject to control measures under SEPA Pollution Prevention Guidelines (PPGs) (to be replaced by Guidance for Pollution Prevention (GPPs)) to prevent release to the water environment, and residual effects are expected to be of Slight significance.

6.8 Assessment of Policy Compliance

6.8.1 DMRB LA 104 (Highways England *et al*. 2019) states that environmental assessment, reporting and monitoring shall meet the requirements of the national planning policy for each relevant Overseeing Organisation.

6.8.2 Appendix A4.1 (Assessment of Policy Compliance) provides a review of national and local policy documents which are of relevance to the assessment undertaken and reported in this chapter in accordance with DMRB guidance.

6.8.3 National planning policy of relevance to this assessment include Scottish Planning Policy (SPP) themes *Valuing the Natural Environment*, in addition to Falkirk Council Local Development Plan 2 (FLDP2) policies PE19 (Biodiversity and Geodiversity) and PE25 (Soils and Agricultural Land) and associated Supplementary Guidance on contaminated land and new development. A full policy compliance assessment can be found in Table 1 of Appendix A4.1 (Assessment of Policy Compliance). It is assessed that the proposed scheme adheres to the requirements of policies relevant to geology, soils and groundwater.

Summary of Policy Compliance

6.8.4 Overall, the design and assessment of the proposed scheme has had regard to and is compliant with policy objectives to minimise impacts on geology, soils and groundwater. A full policy compliance assessment can be found in Table 1 of Appendix A4.1 (Assessment of Policy Compliance).

6.9 Statement of Significance

6.9.1 All effects on geology, soils and groundwater are not predicted to be significant in the context of the Roads EIA Regulations following implementation of mitigation.

6.10 References

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