10 Geology, Soils, Contaminated Land and Groundwater

This chapter considers the potential impacts of the proposed scheme on the existing geology, soils, contaminated land and hydrogeology within the study area.

Baseline conditions were established through desk based assessment, consultation and site surveys. This process established that no designated Geological Receptors or Geological Conservation Review sites were identified within the study area; superficial deposits were primarily composed of alluvium and glaciofluvial deposits with a localised hydrogeological potential as a groundwater resource; the underlying bedrock was composed of metamorphic rocks of Dalradian age (Southern Highland Group), considered to be impermeable and generally without groundwater, except at shallow depth; and several potential sources of contamination were identified within the study area (including made ground; backfilled quarries/pits; roads and railways; small scale industrial/economic activities and a number of septic tanks). In addition, the location and type of groundwater receptors such as Private Water Supplies, ecological receptors with a potential groundwater dependency and surface water features were identified and documented

The impact assessment was designed to assess the significance from both direct (within the proposed footprint) and indirect (groundwater dewatering) effects from the proposed scheme. The impact of the proposed scheme on geology, soils and mineral resources is expected to be Neutral. Moderate to Moderate/Low significance of impact was identified for a number of contaminated land source and/or pathways. The impact on groundwater flow and/or quality is expected to be Moderate to Moderate/Large within superficial deposits and Slight within the bedrock aquifer. Potential differential settlement has not been identified as an issue on existing infrastructure and buildings. The impacts to three active groundwater fed Private Water Supplies and/or their associated infrastructure have been identified with a Slight/Moderate to Very Large significance. Neutral to Slight significance of impact was identified for surface water features from indirect groundwater dewatering. No ecological receptors with groundwater dependency have been identified within the study area.

No significant residual impacts are anticipated for the majority of receptors after the implementation of the proposed mitigation with the exception of groundwater flow within superficial aquifers. Significant residual impacts have been assessed on groundwater flow within glacial till (Moderate) and glaciofluvial/alluvium/River Terrace deposits (Moderate/Large).

10.1 Introduction

10.1.1 This chapter presents the DMRB Stage 3 assessment of the proposed scheme in relation to geology, soils, contaminated land and groundwater.

10.1.2 This includes impacts to bedrock and superficial geology, mineral extraction, soils, contaminated land, groundwater and associated receptors including private water supplies (PWS).

10.1.3 Geological impacts can occur due to excavating or masking exposures of rocks or superficial geological deposits of particular scientific interest, particularly if the features of interest are not reproduced elsewhere, nationally or regionally. Impacts can also include restrictions on existing or potential 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 some environmental benefit, such as improved access to, and exposure of, new areas of geological interest.

10.1.4 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 the aquifers and degrade water quality. Construction works can lead to dewatering and also to contamination of superficial and bedrock aquifers.

10.1.5 Similarly, during operation of the proposed scheme, runoff from the road surface may contain elevated concentrations of pollutants, such as oils, suspended solids, metals, engine coolants (e.g. ethylene glycol) and, in winter, salt which may find their way into the groundwater system. Groundwater flows can also be intercepted or altered by new cuttings and other significant changes to landform.

10.1.6 The assessment is supported by the following appendices:

- Appendix A10.1: Contaminated Land Sources;

- Appendix A10.2: Ecological Receptors with Potential Groundwater Component;
- Appendix A10.3: Infrastructure, Properties and Cultural Heritage Receptors; and
- Appendix A10.4: Surface Water Indirect Dewatering Assessment.

10.2 Approach and Methods

10.2.1 This assessment has been undertaken using the guidance contained in DMRB Volume 11 Section 3 Part 11 'Geology and Soils' (Highways Agency et al., 1993) (hereafter referred to as DMRB Geology and Soils), taking into account updated guidance on contaminated land risk assessment where appropriate (described in paragraph 10.2.17), and DMRB Volume 11 Section 3 Part 10 HD 45/09 Road Drainage and the Water Environment (The Highways Agency et al., 2009) (hereafter referred to as HD45/09).

10.2.2 Consideration of soils includes contaminated land and made ground (included in the assessment of contaminated land), and potential impacts on peat (included in assessment of superficial deposits). Agricultural soil quality is considered as part of the assessment reported in Chapter 8 (People and Communities - Community and Private Assets) with mitigation included to address the potential deterioration of soils due to disturbance (and subsequent storage/reuse) at the construction stage.

10.2.3 The overall material volume balances associated with quantities of materials to be generated in areas of excavation and required in areas of embankments during construction of the proposed scheme are assessed in Chapter 18 (Materials).

Study Area

10.2.4 The assessment covers a study area extending to a corridor of 250m from the footprint of the proposed scheme. For Groundwater Dependant Terrestrial Ecosystems (GWDTE), as agreed with SEPA, a study area extending 100m from the existing A9 was used, and extended where required, for the purpose of dewatering impact assessments. The study area for groundwater abstractions was up to a distance of 850m from the proposed scheme which corresponds to the minimum study area applied for groundwater abstractions under The Water Environment (Controlled Activities) (Scotland) Regulations 2011 and based on "Regulatory Method (WAT-RM-11) Abstraction from Groundwater V6" (SEPA, 2017).

Baseline Conditions

10.2.5 Baseline conditions cover the following aspects of ground conditions:

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

10.2.6 Baseline conditions were determined through a desk-based assessment, consultation with landowners and statutory and non-statutory bodies, targeted site surveys and ground investigations.

<u>Desk-based Assessment</u>

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

- British Geological Survey (BGS) data including BGS Superficial and Bedrock Geological Maps (BGS, 2014), BGS UK Hydrogeology viewer (BGS, 2015) and the BGS Geoviewer (http://mapapps2.bgs.ac.uk/geoindex/home.html).
- Macaulay Institute for Soil Research, Soil Survey of Scotland Map, Sheet 5, Eastern Scotland, 1981.

- UK Soil Observatory Soils map viewer (2016).
- Ordnance Survey (OS) historical maps dating back to 1856 for information on former land use, any potential contamination and physical hazards and information on private water supplies (PWS).
- Scottish Environment Protection Agency's (SEPA) interactive River Basin Management Plan (SEPA, 2014) (http://gis.sepa.org.uk/rbmp/).
- Scottish National Heritage designation database (SNH, 2014) (https://gateway.snh.gov.uk/natural-spaces/index.jsp).
- Scotland's Environment Web (Scottish Government, 2015) (http://www.environment.scotland.gov.uk).
- Previous assessments:
  - A9 Dualling Programme Strategic Environmental Assessment (SEA) Reports (Transport Scotland, 2013, 2014a, 2014b).
  - Geotechnical Preliminary Sources Study Report (PSSR). Tay Crossing to Pitlochry (Jacobs, 2013).

Consultation

10.2.8 Consultations have 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.
- Perth & Kinross Council (PKC) for information on former contaminated land use, Part IIA legislative led determinations, PWS, licensed fuel storage and any additional relevant information.
- SNH for information on the location and extent of environmental sensitivities in the vicinity of the proposed scheme and to establish any future development constraints.
- private property/landowners to identify presence of PWS and obtain information on water source location and type, water storage, treatment and intended use.

10.2.9 Further information on the consultation process is provided in Chapter 7 (Consultation and Scoping).

Site Walkover and Surveys

10.2.10 A site visit took place on 22 February 2018 to obtain further information on targeted PWS and septic tanks.

Ground Investigation

10.2.11 Two stages of GI, designed by Jacobs, have been carried out by Fugro GeoServices Ltd. The first was undertaken between August and December 2015 and is referred to as the 'Advanced GI'. The second was split into two stages; referred to as the 'Preliminary GI' and the 'Preliminary GI Supplementary Task Order (STO)'. Both ground investigations are summarised in Table 10.1.

Table 10.1: Ground investigation timeline and summary

	Stage 1	Stage 2	
GI Reference	Advanced GI	Preliminary GI	Preliminary GI STO
Date Undertaken	August – December 2015	October – December 2016	March – April 2017
Total No. of Boreholes	47	19	34
Cable Percussion	37	12	16
Rotary	2	2	6
Sonic Drilled	8	5	11
Open Hole Borehole	0	0	1

	Stage 1	Stage 2	
Boreholes available for Groundwater and/or Gas Monitoring	28	11	12
Trial Pits	0	12	35
Laboratory Testing	Completed in February 2016	Completed in February 2017	Completed in September 2017
Report Reference	A9 Dualling Southern Section Tay Crossing to Ballinluig Report on Ground Investigation without Geotechnical Evaluation	Tay Crossing to Ballinluig Report on Ground Investigation Without Geotechnical Evaluation	Tay Crossing to Ballinluig Supplementary Task Order (STO) Report on Ground Investigation Without Geotechnical Evaluation

10.2.12 Soil and groundwater samples collected during the ground investigations were sent to Derwentside Environmental Testing Services for chemical analysis.

Impact Assessment

10.2.13 Potential impacts in relation to geology, hydrogeology and contaminated land were assessed individually as per the methodologies provided below. The criteria outlined in Tables 10.2 to 10.4 and 10.6 to 10.11 are based on those that have been applied to similar schemes in Scotland and are designed to comply with DMRB guidance.

Geology/Mineral Resources

10.2.14 The sensitivity and magnitude criteria in Table 10.2 and Table 10.3 were used for bedrock and superficial geology (including soils), features of geological importance and mineral extraction. The impact significance was then determined using Table 10.4.

Table 10.2: Sensitivity criteria - geology and soils

Sensitivity	Description
High	Areas containing geological or geomorphological features considered to be of a national interest such as Sites of Special Scientific Interest (SSSI), candidate SSSI or Geological Conservation Review (GCR) sites. Presence of extensive areas of economically important minerals valuable as a national resource. Areas of peatland within designated sites such as SSSI, Special Area Conservation (SAC) or Special Protection Area (SPA) with national or European importance and/ or 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).
Medium	Areas containing geological features of designated regional importance considered worthy of protection for their educational, research, historic or aesthetic importance, such as Local Geodiversity Sites (LGS)/ Regionally Important Geological Sites (RIGS). Presence of areas of economically important minerals of regional value. 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).
Low	Sites and geological features not currently identified as SSSI, GCR or LGS/ RIGS but that may require protection in the future. Presence of mineral areas or resource of local importance only. 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).
Negligible	Geological features not currently protected and unlikely to require protection in the future. No exploitable minerals or geological resources. Presence of very low quality topsoil or soils (typically indicated by Land Capability for Agriculture Class 7). 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)).

Table 10.3: Magnitude criteria - geology and soils

Magnitude	Description
Major	Partial (greater than 50%) or total loss of a geological site or mineral deposit, or where there would be complete severance of a site such as to affect the value of the site/ resource. Major or total loss of topsoil, soils or peatland, or where the value of the area would be severely affected.
Moderate	Loss of part of a geological/geodiversity site or mineral deposit, major severance, major effects to the setting, or disturbance such that the value of the site would be affected, but not to a major degree. Partial loss of topsoil, soils or peatland, or where the value of the area would be affected, but not to a major degree.
Minor	Small effect on a geological/geodiversity site or mineral deposit (up to 15%) or a medium effect on its setting, or where there would be a minor severance or disturbance such that the value of the site would not be affected. Partial loss of topsoil, soils or peatland, or where soils will be disturbed but the value of the area would not be affected.
Negligible	Very slight change from geological, mineral and soil baseline conditions.

Table 10.4: Matrix for determination of impact significance - geology and soils

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

10.2.15 Beneficial impacts in terms of geological features may also occur, as rock exposures can help to develop understanding of local geology and/or provide a site of interest (e.g. rock cuttings later being designated as a SSSI or GCR). This is relevant to the A9 project due to presence of designated sites (Section 10.3: Baseline), and impacts and opportunities are considered by applying professional judgement with context of the assessment categories set out in Table 10.2 and Table 10.3.

10.2.16 Impacts on geology and soil of **Slight/Moderate** significance and above are considered to be potentially significant in the context of the EIA Regulations, and the level at which mitigation would be proposed.

Contaminated Land

10.2.17 In line with industry norms, the assessment focuses on the potential for impacts on receptors as a consequence of encountering contaminated land using a conceptual site model (CSM) developed for the proposed scheme. A receptor can be a person (including construction workers), the water environment, flora, fauna or buildings/structures. The CSM represents a network of relationships between potential sources within the study area and exposure of the receptors through different pathways. The potential receptors and pathways have been compiled based on the legal definitions used in Part IIA of the Environment Protection Act 1990, as provided in statutory guidance (Scottish Executive, 2006). The contaminated land sources have been identified through a desktop exercise using historical OS maps, consultation information and available GI.

10.2.18 The pollutant pathways and receptors used within the assessment are provided in Table 10.5, with individual references assigned for linkages (PP1 to PP22).

Table 10.5: Potential pollutant pathways

Pollutant Pathway	Receptor	Pathway
Construction		
PP1	Human Health (Construction)	Ingestion, inhalation and dermal contact with soils, soil dust, fibres, deep and shallow groundwater and surface water.
PP2		Migration of ground gases into shallow pits or site buildings.

Pollutant Pathway	Receptor	Pathway
PP3	Off-site Receptors (Local residents and transient traffic (foot, road and rail traffic) in the surrounding area.	Ingestion, inhalation and dermal contact with wind-blown dust/fibres created during excavation works.
PP4		Migration of ground gases into homes or workplaces through preferential pathways created during construction posing a potential asphyxiation/explosion risk.
PP5	Groundwater – Superficial Aquifers	Leaching and migration of contaminants.
PP6	Groundwater – Bedrock Aquifers	Migration of contaminants or contaminated shallow groundwater into the deeper rock aquifer.
PP7	Surface Waters	Migration of contaminated shallow groundwater through superficial deposits or made ground.
PP8		Runoff from contaminated source(s).
PP9		Migration of contaminated bedrock groundwater towards surface water receptor.
PP10		Discharge of intercepted contaminated groundwater during passive or active dewatering.
PP11	Ecological Receptors (water dependant habitats and agricultural land/livestock)	Inhalation, ingestion and direct contact with contaminated soils/water.
Operational		
PP12	Human Health (Operational)	Ingestion, inhalation and dermal contact with soils, soil dust, fibres, deep and shallow groundwater, surface water in the long term during routine maintenance activities e.g. drainage inspections.
PP13		Migration of ground gases into confined spaces e.g. service pits, accommodation buildings creating an asphyxiation/explosion risk.
PP14	Off-site Receptors	Ingestion, inhalation and dermal contact with wind-blown dust/fibres from contaminated soils reused within road features such as embankments and landscaped areas.
PP15		Migration of ground gases into homes or workplaces through preferential pathways remaining following construction thus posing a potential asphyxiation/explosion risk.
PP16	Groundwater – Superficial Aquifers	Leaching and migration of contaminants.
PP17	Groundwater – Bedrock Aquifers	Migration of contaminated shallow groundwater into the deeper rock aquifer.
PP18	Surface Waters	Migration of shallow groundwater through superficial deposits or made ground.
PP19		Runoff from contaminated source(s).
PP20		Migration of contaminated shallow groundwater through drainage channels and associated granular bedding materials or engineered structures.
PP21		Discharge of intercepted contaminated groundwater.
PP22	Ecological Receptors	Inhalation, ingestion and direct contact with contaminated soils/water.

10.2.19 For the purposes of this assessment, the CSM disregards those pathways that are incomplete and therefore cannot pose a risk to any of the identified receptors. Where a source, pathway and receptor combination exists this is referred to as a complete pollutant linkage and a generic qualitative risk assessment has been undertaken.

10.2.20 Potential impacts are discussed in terms of likelihood (Table 10.6) and magnitude/consequence (Table 10.7). The Generic Qualitative Assessment is then undertaken based on the matrix shown in Table 10.8.

10.2.21 The estimation of quantities of materials to be disposed off-site is provided in Chapter 18 (Materials).

Table 10.6: Likelihood criteria - contaminated land

Likelihood	Definition
High likelihood	There is a complete pollution linkage of an event that either appears very likely in the short-term and almost inevitable over the long-term, or there is evidence at the receptor of harm or pollution.
Likely	There is a complete pollution linkage and all the elements are present and available, which means that it is probable that an event will occur. Circumstances are such that an event is not inevitable, but possible in the short-term and likely over a long-term.
Low likelihood	There is a complete pollution linkage and the circumstances are possible under which an event could occur. However, it is by no means certain that even over a longer period such an event would take place, and is less likely in the shorter term.
Unlikely	There is a complete pollution linkage but circumstances are such that it is improbable that an event would occur even in the very long-term.

Table 10.7: Magnitude (consequence) criteria - contaminated land

Magnitude	Definition
Severe	Short-term (acute) damage to human health (significant harm). Pollution of sensitive water resources as a result of short-term exposure. Damage to a particular ecosystem as a result of acute exposure. Catastrophic damage to buildings/property/Scheduled Monument (SM).
Medium	Long-term (chronic) damage to human health (significant harm). Pollution of sensitive water resources as a result of chronic exposure. A significant change in a particular ecosystem, or organism forming part of such an ecosystem. Substantial damage to buildings/property/SM.
Mild	No appreciable impact on human health based on the potential effects on the critical human health receptor Pollution of non-sensitive water resources. Damage to ecological systems with no significant impairment. Significant damage to sensitive buildings/structures/SM and/or services
Minor	Harm (not necessarily significant), which may result in financial loss or require expenditure to resolve. Non-permanent health effects to human health. No appreciable pollution. Easily repairable effects or damage to ecological systems. Easily reparable damage to buildings/structures/SM/services.

Table 10.8: Matrix for determination of impact significance - contaminated land

Likelihood / Consequence	Unlikely	Low likelihood	Likely	High likelihood
Severe	**Moderate/Low**	**Moderate**	**High**	**Very High**
Medium	Low	**Moderate/Low**	**Moderate**	**High**
Mild	Very Low	Low	**Moderate/Low**	**Moderate**
Minor	Very Low	Very Low	Low	**Moderate/Low**

10.2.22 Impacts in terms of contaminated land exposure of **Moderate/Low** significance and above are considered to be potentially significant in the context of the EIA Regulations, and the level at which mitigation would be proposed.

Groundwater

10.2.23 The assessment of the magnitude of impact on the quality and level of groundwater is based primarily on the type of road profile (e.g. cutting, embankment or transition cutting-embankment) facing the receptor. However, where appropriate, the vulnerability of groundwater flow to sub-surface disruptions is also considered to refine the assessment of magnitude of impact. Impacts on groundwater quality and/or flow may also have direct or indirect effects onto groundwater abstractions, ecological receptors with potential groundwater dependency and surface water features. The assessment is undertaken within the context of the Water Framework Directive (WFD) (2000/60/EC) and the Groundwater Daughter Directive (2006/118/EC).

10.2.24 Potential groundwater flooding impacts are considered in Appendix A11.3 (Flood Risk Assessment) and are not discussed in this chapter.

10.2.25 Criteria for the definition of groundwater sensitivity and magnitude are reported in Tables 10.9 and Table 10.10. These consider groundwater sensitivity in the context of hydrogeological conditions, including groundwater resources and ecological receptors with potential groundwater dependency. Details on the approach applied to identify and assess impacts on GWDTEs are provided in Appendix A10.2 (Ecological Receptors with potential Groundwater Component).

10.2.26 Sensitivity criteria attributed for surface water receptors correspond to the importance criteria for aquatic habitats as shown in Table 12.9 (Chapter 12: Ecology and Nature Conservation). Definitions of 'Importance' of aquatic habitats provided in Table 12.9 are considered a good representation of the sensitivity of water features to potential groundwater dewatering impacts. Details on the approach applied to asses impacts on surface water receptors are provided in Appendix A10.4 (Surface Water Indirect Dewatering Assessment).

10.2.27 The impact significance for groundwater aspects was then determined using the matrix as shown in Table 10.11.

Table 10.9: Sensitivity criteria – groundwater

Sensitivity	Description
Very High	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. Important sites of nature conservation dependent on groundwater as per importance criteria attributed in Table 12.6: Importance Criteria for Ecological Features (Chapter 12: Ecology and Nature Conservation) or groundwater is considered likely to support wetland vegetation which is highly groundwater dependent. Surface water features with hydrological importance to designated sensitive ecosystems of national/ international importance.
High	Groundwater aquifer(s) with moderate/ high productivity or WFD good groundwater quality and quantity status. Exploitation of groundwater resource is not extensive (i.e. private domestic and/ or agricultural supply feeding less than ten properties). Local areas of nature conservation dependent on groundwater as per importance criteria attributed in Table 12.6: Importance Criteria for Ecological Features (Chapter 12: Ecology and Nature Conservation), or groundwater is considered likely to support wetland vegetation which is moderately groundwater dependent. Surface water features with hydrological importance to sensitive ecosystems of regional importance.
Medium	Groundwater aquifer(s) with low productivity or WFD variable groundwater quality and quantity status. No current known exploitation of groundwater as a resource and aquifer(s) properties make potential exploitation appear unlikely. Minor areas of nature conservation with a degree of groundwater dependency, as per importance criteria attributed in Table 12.6: Importance Criteria for Ecological Features (Chapter 12: Ecology and Nature Conservation). Surface water features with some but limited hydrologic importance to sensitive or protected ecosystems of authority area importance.
Low	Groundwater aquifer(s) with very low productivity or WFD poor groundwater quality and quantity status. No known past or present exploitation of groundwater aquifer(s) as a resource. Areas of vegetation with no groundwater dependency. Surface water features with minimal/ insignificant hydrological importance to sensitive ecosystems of less than authority area importance.

Table 10.10: Magnitude criteria – groundwater

Magnitude	Description
Major	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.

Magnitude	Description
	Dewatering effects create significant differential settlement effects on existing infrastructure and buildings.
Moderate	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. 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.
Minor	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.
Negligible	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.

Table 10.11: Matrix for determination of impact significance – groundwater

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

10.2.28 Impacts on groundwater of **Moderate** significance and above are considered to be potentially significant in the context of the EIA Regulations, and the level at which mitigation would be proposed.

Limitations to Assessment

10.2.29 The identification of potential contamination sources relies on the accuracy of historical mapping. Assessment of historical quarrying activity is based on a desk-based review of OS maps. It is possible that quarrying works could have been undertaken and the void backfilled between the recorded years of mapping, such that no map evidence exists.

10.2.30 Geological and hydrogeological information obtained from the 2015 Advanced GI 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.

10.2.31 Information on PWS depends on the accuracy provided through consultations with land owners and the local authority.

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

10.3 Baseline Conditions

Geology

Designated Geological Receptors

10.3.1 The Shingle Islands SSSI is located on four islands and adjacent riverbank areas of the River Tay and the River Tummel to the north and south of Ballinluig as shown on Figure 10.1. Three are within 850m of the proposed scheme with two of the islands located on the west bank of the River Tay (opposite

bank to the proposed scheme) between Dowally and Guay (ch3600 and ch5400) and one is situated on the east bank of the River Tummel at Richard's Island (approximately 300m southwest of ch8200). The fourth area is to the northwest of Ballinluig Junction on the opposite bank of the River Tummel from the existing A9 and over 1km northwest of the proposed scheme. Although classified as a biological SSSI, the geological characteristics of the SSSI are integral to the designated freshwater habitats (river shingle/sand) which support important insect fauna and breeding birds (the other notifiable features of the SSSI) and the geology of this site is therefore considered to support the designation of this site of national importance. The river shingle and sands form extensive and dynamic landforms in various stages of colonisation providing a unique variety of habitats which allow the assemblage of rare and local fly species and a wide range of breeding bird species.

10.3.2 As per the geological and soils criteria in Table 10.2, the Shingle Islands SSSI is considered to be of high sensitivity.

10.3.3 There are no geological SSSI or Geological Conservation Review sites within the 250m study area.

Soils

10.3.4 A review of the Macaulay Institute Soil Map of Scotland (1981), in conjunction with the UK Soil Observatory map viewer (2016) indicates that soil types throughout the study area are humus iron podzols. These are soils derived from glaciofluvial and raised beach sands and gravels with acid igneous rock parent material. Generally, humus iron podzols are nutrient deficient but can support a number of uses including arable and permanent pasture, oak and birchwood, rush pasture and sedge mires.

10.3.5 Soils present within the footprint of the proposed scheme are considered to fall under SNH priority peatland Class 0. Based on the criteria in Table 10.1, these soils are considered to be of negligible sensitivity. An assessment of the impacts of the proposed scheme on soils relating to Land Capability for Agriculture Classes is reported in Chapter 8 (People and Communities – Community and Private Assets).

Made Ground

10.3.6 Made ground deposits are expected to be associated with the existing A9 and the Highland Main Line railway, albeit not indicated on the BGS online datasets.

10.3.7 Initial GI pre-dating the existing A9, did not record the presence of any made ground, however, the Ballinluig Junction GI works undertaken in 2007 identified made ground associated with the existing A9 (Jacobs, 2013).

10.3.8 Made ground was encountered in 28 boreholes and seven trial pits during the Advanced and Preliminary GI stages, with a greatest proven thickness of 4.0m. Made ground was most commonly made up of a layer of tarmacadam, potentially buried, along with sand and gravel. This type of made ground was associated with the existing A9, existing side roads (including the former A9) or existing access tracks. Made ground was also found to consist of sand and gravel with concrete, brick, clinker, glass, pipe and slate fragments. At one location (associated with an access track), made ground was found to consist of slightly sandy, gravelly clay with other locations displaying reworked sand and gravel. The presence of made ground has been recorded in Appendix A10.1 (Contaminated Land Sources).

10.3.9 Based on the criteria in Table 10.2 for geological features and resources, made ground present in the study area is considered to be of negligible sensitivity.

Superficial Geology

10.3.10 Superficial deposits underlying the study area are primarily composed of alluvium (consisting of clay, silt, sand and gravel) and glaciofluvial deposits (consisting of gravel, sand and silt). There are also isolated areas of river terrace deposits along the existing A9 (consisting of gravel, sand, silt and clay). Glacial till is indicated to lie over the lower hillsides. Typically, the existing A9 lies to the eastern edge of the floodplain, at the limit between the alluvium/river terrace deposits and the glaciofluvial deposits.

10.3.11 The GI findings generally support the historical and published information, with the superficial deposits encountered predominantly consisting of sands and gravels in varying proportions, with areas of silt, bands of clay and occasional boulder beds. The superficial deposits were most commonly identified as glaciofluvial deposits, although river terrace deposits and alluvium were also recorded frequently in the area.

10.3.12 Peat was not encountered in any of the reviewed historical borehole logs (Jacobs, 2013), nor within the Advanced and Preliminary GI stages. In addition, peat deposits are not recorded on the BGS Onshore Geoindex, nor SNH's Carbon and Peatland 2016 Map (SNH, 2016) within the study area.

10.3.13 The average proven thickness of superficial deposits is 19.6m with a maximum proven thickness of 79.5m (ch0) and a minimum recorded thickness of 2.4m (ch500). Superficial deposit thickness was variable over short distances.

10.3.14 Based on the criteria presented in Table 10.2, superficial deposits present in the study area are considered to be of negligible sensitivity.

Bedrock Geology

10.3.15 Underlying the superficial geology is metamorphic bedrock of Dalradian age, belonging to the Southern Highland Group. This is recorded by the BGS GeoIndex as psammites and semipelites, with an area of micaceous psammite at the southern end of the section. No faults are indicated in this area.

10.3.16 Previous GIs undertaken in the 1970s and in 2007 (Jacobs, 2013) encountered bedrock within 8 borehole locations consistently described as mica schist, locally including garnets and quartz or calcite veins. The Advanced and Preliminary GI's encountered bedrock identified as the Southern Highland Group in 19 locations, consisting variably of pelite, semipelite and psammite and with quartzite underlying pelite at one location.

10.3.17 Recorded rockhead elevation generally varied from 43.9m above ordnance datum (AOD) to 105.4mAOD. One borehole, located near to the River Tay at the start of the proposed scheme, recorded a rockhead elevation of -25.15mAOD beneath a significantly thick drift deposit. Rockhead elevation tended to gently decrease from the north to the south of the proposed scheme until ch1900, when it appeared to step back up rapidly to a higher elevation.

10.3.18 Based on the criteria in Table 10.2, bedrock present in the study area is considered to be of negligible sensitivity.

Mineral Extraction

10.3.19 The study area is not affected by historical coal mining. However, it has been exploited for sand and gravel mineral extraction. One historical sand pit (referred to as TB-C4) and one historical gravel pit (referred to as TB-C10) were identified during a review of historical OS maps. These are shown in Appendix A10.1 (Contaminated Land Sources) and on Figure 10.2.

10.3.20 In addition, information from a Landmark Envirocheck Report obtained for the study area (Jacobs, 2013) provided details of a further two sand and gravel opencast sites (referred to as TB-C6 and TB-C11 in Appendix A10.1 (Contaminated Land Sources) and on Figure 10.2. Both were operated by Balfour Beatty and have now ceased operations but the period of activity is unknown. Approximate grid references for both sites were provided and indicated they operated close to Guay and north of Kindallachan respectively.

10.3.21 Based on this historical evidence of sand and gravel extraction and drift geology descriptions, there is potential for further sand and gravel resources to be available within the study area. Future sand and gravel extraction resources are assessed to be of local importance and therefore of low sensitivity based on the criteria in Table 10.2.

Geotechnical Hazards

10.3.22 There is potential for future landslide risk within the study area (Jacobs, 2013). Areas of sloping ground to the east of the existing A9 are considered to be at risk. A number of landslides took place following a period of heavy rainfall in August 2004, located in two main areas between ch300 and ch600, and ch2200 and ch2400. It is considered that the combination of the adverse weather and the poorly maintained/undersized road drainage system of the former A9 were responsible for the resultant landslides (Jacobs, 2013).

Contaminated Land

10.3.23 Details of the 23 contaminated land sources identified in the study are provided in Appendix A10.1 (Contaminated Land Sources) and locations shown on Figure 10.2.

10.3.24 The Advanced and Preliminary GIs identified 35 areas of made ground. These areas were all associated with the existing A9 or existing side roads/access tracks (including the former A9) as discussed in paragraph 10.3.8, with the exception of one location, associated with a former sand and gravel mineral extraction pit. Composition of the identified made ground most commonly included a layer of tarmacadam with interbedded sands and gravels. Within a few locations the made ground comprised interbedded sands and gravels containing fragments of concrete, brick, glass, pipe, clinker and slate, or clay.

10.3.25 Olfactory evidence of strong hydrocarbon odours was identified in two borehole locations. One (to the east of ch700) was associated with gravel deposits directly underlying sandy clayey made ground, approximately 0.35 meters below ground level (mbgl) and in the vicinity of the former A9. The second (to the east of ch1970) while also within the vicinity of the former A9 was encountered at a greater depth, 2.3mbgl within sand deposits with no made ground recorded in the borehole log. A distinct sulphurous odour was noted in one trial pit location (to the west of ch5150), within the vicinity of the existing A9. This location has no evidence of made ground present and is associated with sands and gravels. Another trial pit location (to the east of ch2350) noted a strong organic odour with no evidence of made ground or contamination present.

10.3.26 The soil sample chemical analysis results from the Advanced and Preliminary GIs have been compared against Generic Assessment Criteria (GAC; industry standard criteria). The following hierarchy of GACs has been used to screen soil sample analysis results (based on a soil organic matter concentration of 1% to provide the most conservative approach):

- Suitable for Use Limits (S4ULs) for Human Health Risk Assessment, Land Quality Management (LQM)/Chartered Institute of Environmental Health (CIEH) (CIEH, 2015); and
- Category 4 Screening Levels (C4SL) for Assessment of Land Affected by Contamination, Department for Environment, Food and Rural Affairs (Defra) (Defra, 2014).

10.3.27 There will be limited potential exposure pathways to end users given the proposed use as a road, however, potential pathways remain, including those for maintenance workers. Therefore, the soil sample chemical analysis results while primarily compared against GACs suitable for a public space (park) end use consideration has also been given to residential and commercial/industrial end uses. The aim of the assessment is to identify any contaminants that exceed the GACs and may be considered as Contaminants of Potential Concern (COPCs).

10.3.28 The vast majority of soil samples are below GACs for all criteria (public space, residential and commercial/industrial end uses) with the exception of a small number of polycyclic aromatic hydrocarbons (PAHs) as indicated in Table 10.12. These six COPCs were encountered within four isolated locations, all of which are associated with existing side roads/access tracks (including the former A9). Two of these locations are associated with the hydrocarbon odours described in paragraph 10.3.25.

Table 10.12: Identified COPCs following soil chemical analysis screening against GAC

COPC	GAC Threshold value (number of exceedances)			
	S4UL			C4SL
	Public Space (Park)	Residential without Plant Uptake	Commercial/ Industrial	Public Space
Naphthalene	1200 mg/kg (0)	2.3mg/kg (4)	190mg/kg (1)	-
Benzo (a) anthracene	49mg/kg (1)	11mg/kg (3)	170mg/kg (0)	-
Chrysene	93mg/kg (0)	30mg/kg (1)	350mg/kg (0)	-
Benzo (b) fluoranthene	13mg/kg (1)	3.9mg/kg (3)	44mg/kg (1)	-
Benzo (a) pyrene	11mg/kg (3)	3.2mg/kg (3)	35mg/kg (1)	21mg/kg (1)
Dibenzo (ah) anthracene	1.1mg/kg (3)	0.31mg/kg (4)	3.5mg.kg (3)	-

10.3.29 Up to nine rounds of ground gas monitoring have been undertaken within 35 monitoring boreholes since completion of the Advanced and Prelim GI from October 2015 through to October 2017, with only 1 out of the 35 locations monitored having had 9 rounds and with the average number of visits being 3. Ground gas concentrations could pose a potential risk to site construction and workers working below ground and/or within confined spaces. Ground gas concentrations were compared to GACs considered appropriate for the protection of construction and maintenance workers from the following UK guidance for methane, carbon dioxide and depleted oxygen, carbon monoxide and hydrogen sulphide respectively:

- National House Building Council, Guidance On Evaluation Of Development Proposals On Sites Where Methane And Carbon Dioxide Are Present (NHBC, 2007);
- Health and Safety Executive (HSE), Workplace Exposure Limits:2011 (HSE, 2011); and
- Mines and Quarries Act 1954, 27 (Section 55(2)(b)).

10.3.30 Recorded methane concentrations were below the recommended safety threshold of 20% of the lower explosive limit for methane (1% volume per volume (v/v)) in all locations.

10.3.31 Carbon dioxide (CO_2) concentrations exceeded the short term (15 minutes) occupational exposure limit (1.5% v/v) in 13 locations and the long term (8 hour) exposure limit (0.5% v/v) in 24 locations. Carbon monoxide (CO) concentrations are above the long term (8 hour) exposure limit (30ppm) in four locations and above the short term (15 minute) exposure limit (200ppm) in three locations.

10.3.32 Depleted concentrations of oxygen were also recorded below the Mines and Quarries Act value of 19%v/v in 14 locations.

10.3.33 Hydrogen sulphide concentrations were predominantly below the monitoring equipment's level of detection (1ppm). However, one location recorded a hydrogen sulphide concentration of 22ppm, above both the long term (8 hour) and the short term (15 minute) exposure limits of 10ppm. The location was only monitored on one occasion and is also where the maximum carbon monoxide value was recorded, however, only trace amounts of methane and carbon dioxide were noted. There is no obvious source for the ground gas within either the borehole log or the surrounding area.

10.3.34 Flow rates were generally low between 0 and 1l/hr with occasional higher flow rates between 5.5 and 6.8l/hr at four locations.

Groundwater

10.3.35 The Hydrogeological Map of Scotland (BGS, 1988) notes that the Quaternary (superficial) deposits situated on the Tay Valley floor are considered to be an aquifer of limited local potential, in which intergranular flow is significant. Higher ground, underlain by Precambrian rocks (bedrock) is considered to be impermeable and generally without groundwater, except at shallow depth. The BGS Groundwater Vulnerability Map of Scotland (1995) indicates that the granular superficial deposits over

the valley floor are moderately permeable while areas underlain by glacial till or bedrock are weakly permeable.

10.3.36 The SEPA River Basin Management Plan (RBMP) interactive map (SEPA, accessed June 2016) identifies the aquifer underlying the site as the Upper Tay Valley sand and gravel aquifer. The spatial extent of the Upper Tay Valley Sands and Gravels corresponds with the spatial extent of the alluvium, glaciofluvial and river terrace deposits associated with the River Tay. Underlying and adjacent to the superficial material aquifer is the Upper Tay bedrock (referred to as Southern Highland Group on BGS maps) and localised sand and gravel aquifers. The status of both groundwater bodies was assessed by SEPA as Good with High confidence in 2008, with no trend of pollutants.

10.3.37 Groundwater monitoring data were available from 48 observation boreholes. Of these, 44 were screened solely in the superficial deposits and four spanned the boundary between the superficial deposits and bedrock.

10.3.38 Thirty-seven groundwater strikes were recorded during fieldwork, between 0.9mbgl and 16.10mbgl. Groundwater levels have since been recorded to vary from artesian conditions (ch4350 and ch6800) to 24.9mbgl (ch1950), which equates to 64.25mAOD to 59.47mAOD.

10.3.39 From available variable head tests, permeability in the superficial deposits was found to range from $2.0x10^{-8}$m/s (ch3050) to $3.5x10^{-5}$m/s (ch7700).

10.3.40 Groundwater flow within the study area is dominated by localised flow towards the River Tay, following the local topography. Due to the absence of well screens within the bedrock, no local information on bedrock groundwater is available.

10.3.41 The hydrogeological characteristics of drift and bedrock units within the study area are described in Table 10.13.

Table 10.13: Hydrogeological characteristics of superficial and bedrock units (flow and quality)

Geological / Hydrogeological Unit		Geological Characteristic	Hydrogeological Characteristic	Sensitivity
Superficial	Made Ground	Composition of any made ground present is unconfirmed.	Variable - dependent on composition.	Low
	Alluvium	Composed of clay, silt, sand and gravel.	Local groundwater potential. Groundwater system is expected to be hydraulically connected to surface water.	High
	River Terrace Deposits	Composed of gravel, sand, silt and clay.	Local groundwater potential. Groundwater system is expected to be hydraulically connected to surface water.	High
	Glaciofluvial Deposits	Composed of gravel, sand and silt	Local groundwater potential. Groundwater system is expected to be hydraulically connected to surface water.	High
	Glacial Till	Heterogeneous deposits	Poor groundwater potential due to generally low and variable permeable nature.	Medium
Bedrock	Southern Highland Group	Metamorphic – Psammites and semipelites.	Low productivity aquifer – small amount of groundwater in near surface zone and secondary fractures.	Medium

Abstractions and Groundwater Flow

10.3.42 Details of the PWS identified within the study area are presented in Table 10.14 and the active PWS are shown on Figure 10.1. It should be noted that some of the PWS identified at the DMRB Stage 2 using OS map information have now been found to be abandoned/inactive following landowner consultation; these are included in Table 10.14 with an update on their status. Abandoned/inactive PWS have not been assessed.

Table 10.14: Summary of identified PWS

PWS Reference	Source of Information	Nature of PWS	Property	Status	Comments
PBTC-W1	OS Map and landowner consultation	Well	n/a	Abandoned/ not active	n/a
TB-W2	OS Map and landowner consultation	Well	n/a	Abandoned/ not active	n/a
TB-W3	OS Map and landowner consultation	Well	n/a	Abandoned/ not active	n/a
TB-W4	OS Map and landowner consultation	Well	n/a	Abandoned/ not active	n/a
TB-PWS1	PKC and landowner consultation	Borehole	Woodlands Cottage	Active	Domestic supply to this property only.
TB-PWS2	Land owner meeting and site visit	Borehole	East Dowally Farm	Active	Domestic, commercial and agricultural use. Supplies a total of 13 properties including four houses, three caravans, four chalets, a workshop and fields. Supply is understood to be 26m deep.
TB-PWS3	Landowner consultation and meeting and site visit	Borehole	Westhaugh of Tulliemet	Active	Agricultural and livestock use as well as supplying a BEAR compound at the rear of property. Alternative mains supply for farmhouse. Supply is understood to be 21m deep.
TB-PWS4	Landowner consultation	Surface water	1&3 Inchfield; 1,2&3 Inchmagrannachan Cottages, Dunkeld	Active	Gravity fed to five properties. Domestic supply.
TB-PWS5	PKC and landowner consultation	Spring	Ballintuim	Active	Class B Supply. Supply collected in Capture box and piped to farm by gravity for domestic and livestock use.
TB-PWS6	SEPA consultation (licensed abstraction)	Surface water	Inchmagrannachan Farm, Dunkeld	Active	Agricultural abstraction from mobile irrigation plant (NO 00449 44434) and fixed intake for irrigation (NO 00110 47135)

10.3.43 All active PWS networks identified are of high sensitivity, except abstraction site referenced as TB-PWS2 which is of very high sensitivity. TB-PWS4 and TB-PWS6 are surface water fed and potential impacts on these PWS are discussed in Chapter 11 (Road Drainage and the Water Environment).

Groundwater Quality

10.3.44 No data on groundwater quality for the study area are available from BGS.

10.3.45 The groundwater sample chemical analysis results from the Advanced and Preliminary GIs have been compared against Resource Protection Values (RPV) as defined within SEPA Position Statement WAT-PS-10-01 (SEPA, 2014). This screening exercise has identified seven exceedances of RPVs for dissolved mercury, two for ammoniacal nitrogen and one for each of the following: chloride, total PAH and aromatic petroleum hydrocarbons C16-C21.

Ecological receptors with potential groundwater component

10.3.46 The Shingle Islands SSSI covers the same area as the Shingle Islands SAC, which is considered to be of international importance and has been designated under the EU Habitats Directive for alder woodland on floodplains. The Shingle Islands SSSI/SAC also overlaps part of the River Tay SAC. The Shingle Islands SSSI/SAC is understood to be dominantly dependant on the River Tay/Tummel water level fluctuations and associated flooding. Therefore, even though a degree of a groundwater contribution cannot be ruled out, the Shingle Islands SSSI/SAC is not considered to be a GWDTE.

10.3.47 An assessment of potential groundwater dependant ecological receptors has been undertaken based on updated Phase 1 Habitat surveys carried out in 2016. This involved review of habitat data to determine the presence of wetland habitat and the likelihood of a groundwater component, based on habitat characteristics and association with watercourses. This assessment concluded that there are no GWDTEs in the study area, as summarised in Appendix A10.2 (Ecological Receptors with potential Groundwater Component).

10.3.48 Reference is made to Chapter 12 (Ecology and Nature Conservation) for the assessment of impacts on ecology and nature conservation.

Surface Water Features

10.3.49 Surface water features are expected to have a groundwater baseflow component.

10.3.50 The main watercourse within the study area is the River Tay with the existing A9 generally following the eastern side of the river from north of the Jubilee Bridge (Tay Crossing) to Ballinluig. The River Tay is a Special Area of Conservation (SAC) designated for the protection of Atlantic salmon, lamprey (sea, brook and river), otter and aquatic vegetation. Additional information is provided in Chapter 12 (Ecology and Nature Conservation) on protected species and habitats.

10.3.51 The River Tummel is found at the northern extent of the study area, flowing north-west to south-east, approximately 250m and 800m to the west of the existing A9 towards its confluence with the River Tay approximately 800m to the south-west of ch8200. The River Tummel is also designated as part of the River Tay SAC.

10.3.52 Based on the criteria in Table 10.9 the River Tay SAC (which includes the River Tummel) is considered to be of very high sensitivity.

10.3.53 All watercourses are identified and described further in Chapter 11 (Road Drainage and the Water Environment).

10.4 Potential Impacts

Introduction

10.4.1 Potential impacts are assessed prior to the implementation of mitigation. Mitigation measures are then identified and described in Section 10.5 (Mitigation).

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

10.4.3 There are a variety of ways in which road development schemes can impact on geology, soils, land quality and hydrogeology. Most common impacts are as follows:

- excavating or masking exposures of bedrock or superficial geological deposits of specific scientific interest if the features of interest are not reproduced elsewhere in the area;
- constraint/limitation to existing or potential commercial exploitation of resources;
- effects on underlying groundwater aquifers, for example, through the dewatering of aquifers as a result of construction works involving excavation;
- risk of spillage or leakage of fuel or oil from storage tanks or construction plant, which without suitable mitigation measures, can enter aquifers;
- effects of changes to groundwater flow or quality on secondary receptors such as groundwater abstractions, surface water or GWDTE; and

- surface runoff from the operational dual carriageway alignment may contain elevated concentrations of pollutants such as oils, suspended solids, metals (e.g. copper and zinc) and, in winter, salt and antifreeze agents (e.g. ethylene glycol), leading to pollution of the aquifers.

10.4.4 A key aspect of the impact assessment is to identify areas of excavations. Information on proposed excavated areas is provided in Table 10.15 and shown on Figures 10.1 and 10.2. It should be noted that only proposed cuttings deeper than 1m are included and that a differentiation has been made between widening of existing cuttings (labelled as "W") and new proposed cuttings (labelled as "C"). Groundwater level and depth to bedrock data from recent site investigation and monitoring work has been assessed and interpolated to produce indicative bedrock and groundwater levels as far as possible across the footprint of the proposed scheme. These interpolated levels are indicative only and have been used to perform an initial screening assessment. This screening assessment is conservative.

Table 10.15: Cutting depths

Name	Approximate Chainage	Approximate maximum Excavation Depth (mbgl)	Depth to bedrock (drift thickness) (m)	Depth to Groundwater (mbgl)	Likelihood of Intercepting Bedrock	Likelihood of Intercepting Groundwater
W1	525-1060	5.4	12	13	unlikely	unlikely
W2	1895 - 2095	9.2	18.5	19.5	unlikely	unlikely
W3	3540 - 3810	6.1	13	14	unlikely	unlikely
W4	4710 – 5245	7.5	15	11.5	unlikely	unlikely
W5	6145 – 6320	3.0	13	5.5	unlikely	unlikely
W6	6960 – 7350	20.5	8	7-23	likely*	likely
W7	1180 – 1590	7.1	11.5	10.5	unlikely	unlikely
W8	2610 – 2715	3.9	8.5	10.5	unlikely	unlikely
W9	2920 – 2985	3.2	14	13.5	unlikely	unlikely
W10	3835 – 4125	3.8	14	13	unlikely	unlikely
W11	7700 – 7800	2.1	9	1.5	unlikely	likely
W12	7955 – 8195	4.6	9	6.5	unlikely	unlikely
W14	2735-2810	1.9	15	12.5	unlikely	unlikely
W17	1615 – 1735	12.7	20	18	unlikely	unlikely
W18	6830 - 6930	2.6	7	0.5	unlikely	likely
CS2	5550 – 5600	1.8	12	7.5	unlikely	unlikely
CS3	755 – 785	1.8	20	17	unlikely	unlikely
CS4	4020 – 4040	3.3	15	10	unlikely	unlikely
CS11	3000 – 3300	11.2	17	9	unlikely	likely
CS13	145-190	1.6	14	8	unlikely	unlikely
CS15	730-810	1.2	19.5	16.5	unlikely	unlikely
CS17	2770-2830	1	16	12.5	unlikely	unlikely
CS21	7350-7700	8.4	10	2-10	unlikely	likely
CS24	3300 – 3540	3.1	9	8	unlikely	unlikely
CS26	5660 – 5880	1.2	11.5	5	unlikely	unlikely
CS29	6100 - 6140	2.5	16	2.5	unlikely	unlikely
SP1	665 – 760	4.9	20	16	unlikely	unlikely
SP2	3895 – 4020	6.8	15	11	unlikely	unlikely
SP3	180 - 280	12.6	11.5	1.5	possibly*	unlikely
SP4	6400-6520	1.7	12	2	unlikely	unlikely
SP5	8150-8225	1.2	7	7	unlikely	unlikely
SP6	5360 - 5400	1.4	13	2	unlikely	unlikely
FCSA2	5340-5760	4.8	9	2	unlikely	likely
FCSA3	5800 - 5880	1.9	9	2	unlikely	unlikely

Name	Approximate Chainage	Approximate maximum Excavation Depth (mbgl)	Depth to bedrock (drift thickness) (m)	Depth to Groundwater (mbgl)	Likelihood of Intercepting Bedrock	Likelihood of Intercepting Groundwater
FCSA4	7220 - 7330	2.9	15	10.5	unlikely	unlikely
FCSA5	4580 - 5120	1.5	10	7	unlikely	unlikely
D1	6920 - 6960	3.2	5	2	unlikely	likely

** cuttings which have been assessed in more details in Appendix A10.4 and where the likelihood of intercepting the bedrock is reduced to unlikely*

Geology

Designated Geological Receptors

10.4.5 The Shingle Islands SSSI is located outside the 250m study area and is not expected to interact either directly or indirectly with the scheme and so no impacts are expected.

Soils

10.4.6 Based on available mapping and ground investigation information, peat deposits are not expected to be encountered during construction of the proposed scheme. Therefore, the overall impact significance is Neutral during both construction and operation phases.

10.4.7 Chapter 8 (People and Communities – Community and Private Assets) includes an assessment of the impacts on soil resources from the construction of Compensatory Flood Storage areas.

Superficial Geology

10.4.8 Superficial geology within the study area is likely to be impacted by the construction of all cuttings and other earthworks as part of the proposed scheme. The reduction in extent of superficial deposits, including made ground, as a result of the construction activities is considered to be of minor magnitude because of the widespread presence of these deposits elsewhere in the region. This results in an overall impact significance of Neutral during both the construction and operation phases.

Bedrock Geology

10.4.9 The screening assessment presented in Table 10.15 and additional cross sections in Appendix A10.4 (Surface Water Indirect Dewatering Assessment) indicate that bedrock is unlikely to be intercepted by the proposed cuttings.

10.4.10 On this basis, the overall significance of potential impacts from blasting operations on solid geology is considered as Neutral.

Mineral Extraction

10.4.11 There is evidence of previous mineral extraction from the superficial deposits within the study area, and there is potential for future exploitation of these resources. Due to the relatively widespread occurrence of these deposits (low sensitivity) within the region, the construction impact of the proposed scheme is considered to be of negligible magnitude, resulting in a potential impact of Neutral significance during both construction and operation phases.

Geotechnical Hazards

10.4.12 It is considered that there is potential for the failure of both natural and engineered cut slopes to the east of the A9 in the future if the hazard is not mitigated, particularly between approximate ch0 and ch3200.

10.4.13 Erosion impacts and changes in fluvial geomorpohology along surface waters are assessed separately in Chapter 11 (Road Drainage and the Water Environment).

Contaminated Land

10.4.14 A number of potential pollution sources, migration pathways and potential receptors that may be at risk as a result of the proposed scheme have been identified. Potential risks have been assessed where complete pollutant linkages have been identified between contamination sources and receptors.

10.4.15 There are two potential ways in which the proposed scheme could impact contaminated land:

- Direct disturbance of potentially contaminated land sites (i.e. sources are within the footprint of proposed scheme); and/or
- Indirect disturbance of potentially contaminated land sites as a result of the proposed scheme (i.e. potential pathways which exist within the footprint of the proposed scheme).

Construction Phase - Direct Disturbance

10.4.16 Direct disturbance of a number of potential contaminated land sources has the potential to impact on human receptors as summarised in Table 10.16.

Table 10.16: Potential direct contaminated land impacts during construction

Source Ref	Source Name	Pollutant Pathway	Magnitude	Likelihood	Impact Significance
TB-C1	Existing A9 Carriageway	PP1 & PP3	mild	likely	**Moderate/Low**
TB-C2	Highland Main Line railway	PP1 & PP3	mild	likely	**Moderate/Low**
TB-C4	Sand Pit	PP1, PP2, PP3 & PP4	medium	likely	**Moderate**
TB-C7	Smithy	PP1, PP2, PP3 & PP4	mild	likely	**Moderate/Low**
TB-C11	Sand and Gravel mineral extraction point	PP1 & PP2, PP3 & PP4	mild	likely	**Moderate/Low**
TB-C18 & TB-C29	Septic Tanks	PP1 & PP3	mild	likely	**Moderate/Low**
n/a	Existing Minor/Residential Side roads	PP1 & PP3	mild	likely	**Moderate/Low**
n/a	Made ground removed and temporarily stored	PP1, PP3, PP5 & PP9	medium	likely	**Moderate**

Construction Phase - Indirect Disturbance

10.4.17 Indirect disturbance may occur where proposed cuttings intercept groundwater, as they could draw contaminated groundwater towards the cutting. Seven of the proposed cuttings/widenings have the potential to intercept groundwater. The risk assessment for cuttings drawing in contaminated groundwater which then needs to be discharged (PP10) is presented in Table 10.17 with all cuttings having a predicted **Moderate/Low** significance of impact on at least one contaminated land source and W6 having a **Moderate** significance impact on contaminated land sources TB-C10 and TB-C11.

Table 10.17: Potential indirect contaminated land impacts during construction

Cutting	Sources	Likelihood	Magnitude of Impact	Impact Significance
W6	TB-C1, TB-C18	likely	mild	**Moderate/Low**
W6	TB-C10, TB-C11	likely	medium	**Moderate**
W6	TB-C2, TB-C23, TB-C28	low	mild	Low
W11	TB-C1	likely	mild	**Moderate/Low**
W18	TB-C1, TB-C18	likely	mild	**Moderate/Low**
CS11	TB-C1	likely	mild	**Moderate/Low**
CS21	TB-C2, TB-C23	low	mild	Low
CS21	TB-C11	unlikely	medium	Low
CS21	TB-C1, TB-C28	likely	mild	**Moderate/Low**

Cutting	Sources	Likelihood	Magnitude of Impact	Impact Significance
FCSA2	TB-C1, TB-C2, TB-C7	likely	mild	**Moderate/Low**
FCSA2	TB-C6	low	medium	**Moderate/Low**
FCSA2	TB-C5, TB-C17, TB-C29	low	mild	Low
D1	TB-C1	likely	mild	**Moderate/Low**
D1	TB-C18	low	mild	Low

10.4.18 Construction personnel could be at risk of direct contact with contaminated groundwater through pathway PP1. The potential of this event occurring has been assessed as being likely with an impact magnitude of medium, resulting in a potential impact of **Moderate** significance.

Operation Phase - Direct Disturbance

10.4.19 The same list of potential contaminated land sources as shown in Table 10.16 has the potential to be directly disturbed during the operation phase as during the construction phase, but with a reduced likelihood, except for made ground potentially re-used during the construction of the proposed scheme.

10.4.20 The potential impact significance for all sources, other than made ground, during the operational phase has therefore been determined using the magnitude shown in Table 10.16 and a likelihood one level lower than that shown in Table 10.16. Potential pollutant pathways during the operation phase include PP12, PP13, PP14 and PP15. Five of the identified potential sources (TB-C1, TB-C2, TB-C7, TB-C11 and TB-C18) have an impact significance of Low, with TB-C4 having an impact significance of **Moderate/Low**.

Operation Phase - Indirect Disturbance

10.4.21 Groundwater intercepted by proposed cuttings will need to be drained and discharged (PP21). The same list of potential contaminant sources as shown in Table 10.17 has the potential to impact on the receiving water environment as during the construction phase, but with a reduced likelihood due to reduced rates of discharge.

10.4.22 The potential impact significance for all cuttings and sources has therefore been determined using the magnitude shown in Table 10.17 and a likelihood one level lower than that shown in Table 10.17. The majority of cuttings have a potential impact significance ranging from Very Low to Low with W6 identified to have a potential **Moderate/Low** impact significance.

10.4.23 Maintenance personnel could be at risk of having direct contact with contaminated groundwater, through pathway PP12. The potential of this event occurring has been assessed as being of low likelihood with an impact magnitude of medium, resulting in potential impact of **Moderate/Low** significance.

Groundwater

10.4.24 The Sichardt method (e.g. Preene et al, 2000) was used to estimate the zone of influence of dewatering around each of the cuttings considered likely to intercept groundwater, using the dimensions of the cuttings and the estimated drawdown of groundwater levels due to the excavation. The potential impacts on receptors within this zone of influence were then assessed for each proposed cutting.

10.4.25 The same zone of dewatering influence was also used to determine potential indirect contaminated land impacts via the groundwater pathway (refer to paragraph 10.4.36).

Groundwater Flow

10.4.26 Table 10.15 indicates that seven cuttings have the potential to intercept groundwater within the superficial deposits. This is expected to create a local dewatering effect within the superficial deposits (medium to high sensitivity) around these locations, assessed of being of moderate magnitude. This

results in an overall potential impact significance of **Moderate** and **Moderate/Large** during both construction and operation phases on glacial till and glaciofluvial deposits/alluvium/River Terrace deposits respectively.

10.4.27 Bedrock groundwater is not expected to be intercepted. Therefore, no impact is expected on bedrock groundwater flow.

10.4.28 Where dewatering occurs in superficial deposits, there is a risk that differential settlement could impact nearby infrastructure and properties, as well as listed buildings and scheduled monuments. Listed buildings and scheduled monuments have been attributed a very high sensitivity, while the remaining infrastructure and properties are of medium sensitivity. Potential settlement at these receptors was analysed using the Burland and Burbidge method, which is laid out in Foundation Design and Construction, 7th Edition (Tomlinson, 2001). This method of analysis was selected as the ground conditions throughout the site, where infrastructure and properties are located, were generally consistent (i.e. predominately silty sands and gravels). The potential impacts due to settlement along the proposed scheme are summarised in Appendix A10.3 (Infrastructure, Properties and Cultural Heritage Receptors). Appendix A10.3 indicates that settlement within the sands and gravels due to the drawdown of groundwater are generally negligible in magnitude, resulting in an overall impact significance of Neutral. One cutting (W6) was considered to represent a potential minor impact magnitude resulting in an overall impact significance of Slight.

10.4.29 The construction of embankments may result in localised compaction of superficial deposits. This would result in localised impacts of negligible magnitude for groundwater flow and has therefore been assessed as being of Neutral significance on groundwater within the superficial deposits.

Groundwater Quality

10.4.30 In the event of accidental spillage during construction or operation, potential contamination may migrate from the ground surface through the unsaturated zone, reaching the shallow superficial aquifers and impairing groundwater quality, unless appropriate measures for control of discharge and drainage are taken.

10.4.31 The magnitude of potential impact from accidental spillages is considered to be moderate for superficial groundwater and minor for bedrock groundwater, because of the potential for attenuation and dilution of contamination before it reaches bedrock groundwater. The assessment of accidental spillage impacts on these aquifers is provided in Table 10.18. Hydrogeological units are groupings of geological units with similar hydrogeological characteristics.

Table 10.18: Potential impact of accidental spillages on key hydrogeological units during both construction and operation phases

Hydrogeological Unit	Sensitivity	Magnitude of Impact	Impact Significance
Superficial Aquifers – Alluvial Deposits, River Terrace Deposits, Glaciofluvial Deposits	high	moderate	**Moderate/Large**
Superficial Aquifers – Glacial Till	medium	moderate	**Moderate**
Superficial Aquifers – Made Ground	low	moderate	Slight
Bedrock Aquifers – Southern Highland Group	medium	minor	Slight

10.4.32 Potential impacts of accidental spillages on surface water features are discussed in Chapter 11 (Road Drainage and the Water Environment).

Abstractions

10.4.33 One active groundwater PWS (TB-PWS3) is located in proximity to two cuttings (W6 and CS21) which are likely to intercept groundwater. The potential impact on the PWS has been determined based on the anticipated drawdown at the location of the water supply and the type of groundwater source (i.e. a drawdown effect is expected to have a greater impact on a spring than a well, and the depth of a well will also have influence on the magnitude of impact). TB-PWS3 is a 21m deep borehole located approximately 160m west of CS21 and 385m northwest of W6. Based on this information, potential

impacts on TB-PWS3 are assessed being of minor magnitude (W6) and moderate magnitude (SC21), which results in a potential Slight/Moderate and **Moderate/Large** significance of impact respectively.

10.4.34 In addition to potential impacts from groundwater dewatering, one groundwater water supply (TB-PWS2) is located within the footprint of the proposed scheme and the supply would be expected to be directly impacted. The PWS is of high sensitivity and the potential impact magnitude in both cases is major, resulting in a potential impact of **Very Large** significance.

10.4.35 TB-PWS1 is in the vicinity of Cutting W1 which is not expected to intercept the groundwater table, therefore no impact on yields are expected. The depth of the borehole could not be confirmed. Any form of contamination resulting from spillage incident is likely to migrate towards the river, away from the borehole. However, given the uncertainty on the depth of the supply, a minor magnitude of impact remains from groundwater quality point of view. This would result in a potential significance of impact of Slight/Moderate.

Ecological Receptors with Potential Groundwater Component

10.4.36 As no ecological receptors with a potential groundwater component have been identified within the study area, no impacts are expected on this type of receptor.

Groundwater Effects on Surface Water

10.4.37 Potential surface water quality impairment or reduction in baseflow contribution as a result of impacts on the groundwater environment has been assessed based on the proximity of surface water features to areas where impacts on the groundwater environment could potentially occur. It is assumed that a degree of hydraulic connectivity exists between the groundwater and surface water systems.

10.4.38 Surface water features are referenced as per the water feature (WF) numbering system developed in Chapter 11 (Road Drainage and the Water Environment). The assessment of potential impacts on surface water features as a result of interaction with proposed road cuttings is summarised in Appendix A10.4 (Surface Water Indirect Dewatering Assessment).

10.4.39 Magnitude of impact is assessed based on both the degree of potential impact on the groundwater environment and the ecological sensitivity of the surface water feature.

10.4.40 Appendix A10.4 (Surface Water Indirect Dewatering Assessment) details a tiered assessment reviewing potential impacts on surface water receptors and no impacts of significance are expected. In addition, groundwater abstracted via road cuttings and widenings will be returned to the same general catchment during the operational phase, which will compensate the losses at the catchment scale. Further details are provided in Appendix A10.4 (Surface Water Indirect Dewatering Assessment).

10.5 Mitigation

10.5.1 Mitigation measures for the proposed scheme in relation to geology, soils, contaminated land and groundwater are detailed below and take into account best practice, legislation, guidance and professional experience. Mitigation measures applying throughout the proposed scheme (prefixed G) and project specific measures (prefixed P03) are set out in Chapter 21 (Schedule of Environmental Commitments).

10.5.2 This chapter makes reference to overarching standard measures applicable across A9 dualling projects (‘SMC’ mitigation item references), and also to project-specific measures (‘P03’ mitigation item references). Those that specifically relate to geology, soils, contaminated land and groundwater as assigned a ‘G’ reference.

10.5.3 The DMRB Stage 3 design process has avoided or reduced many potential impacts by reducing land-take wherever possible.

Embedded Mitigation

10.5.4 No embedded mitigation measures have been proposed for geology, soils or contaminated land as part of the proposed scheme.

Standard Mitigation

Geology

10.5.5 No peat is expected to be encountered during construction of the scheme, however, to avoid localised detrimental effects if peat is encountered, it will be extracted, excavated, stored, with any off-site removal undertaken with cognisance of 'Development on Peatland: Guidance on the Assessment of Peat Volumes, Reuse of Excavated Peat and the Minimisation of Waste' (Scottish Renewables and SEPA, 2012) and will comply with relevant waste management practices under The Waste Management Licensing (Scotland) Regulations 2011 (**Mitigation Item SMC-G10**).

10.5.6 Risk assessments will be undertaken before explosives can be used on site to minimise or control the impact of blasting on bedrock geology (**Mitigation Item SMC-G15**).

Contaminated Land

10.5.7 Direct 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 Moderate to Moderate/Low significance. The standard 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.

10.5.8 Prior to construction, consultation will be undertaken with the relevant local authorities and SEPA 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, 2000). Any remedial action undertaken in relation to land affected by contamination will be carried out under the appropriate remediation licencing (**Mitigation Item SMC-G1**).

10.5.9 Prior to construction and where potential contamination has been identified, further site investigations sufficient to determine the extent and type of contaminants present will be undertaken as necessary to inform identification of appropriate construction methods and any additional mitigation (**Mitigation Item SMC-G2**).

10.5.10 Prior to construction, appropriate health and safety and waste management procedures for working with potentially contaminated soils will be established. 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), HSE Guidance Note MS31 (HSE, 2012) and the Health and Safety Commission Approved Code of Practice and Guidance Note L143. These procedures will be implemented as appropriate during construction (**Mitigation Item SMC-G3**).

10.5.11 Risks to construction and maintenance staff working with/near contaminated land will be mitigated by the implementation of **Mitigation Item SMC-G3** 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 (**Mitigation Item SMC-G4**).

10.5.12 Appropriate training of personnel involved in earthworks activities to implement a watching brief to identify potential presence of previously unidentified contamination (**Mitigation Item SMC-G5**).

10.5.13 Where required, landowner consultation and site visits will be undertaken to confirm the location and network of septic tanks. Where septic tanks are located within the land made available (LMA) they will be relocated and/or rebuilt subject to discussion and agreement with the affected landowner(s) (**Mitigation Item SMC-G6**).

10.5.14 To prevent cross contamination and pollution from piling works undertaken in areas of land affected by contamination, the Contractor will 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' (**Mitigation Item SMC-G7**).

10.5.15 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 SMC-G9**)

10.5.16 If excavated soils are deemed unsuitable for reuse 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, May 2015) 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 SMC-G8**).

10.5.17 Where concrete materials are proposed to be used, appropriate guidance such as 'Building Research Establishment (BRE) SD1:2005' and 'British Standard (BS) BS8500' should be followed to ensure that ground conditions are appropriate for the use of concrete at each given location (**Mitigation Item SMC-G11**).

10.5.18 Where potential pollutant pathways for ground gas have been identified and given the rounds of gas monitoring are limited in some areas, a ground gas monitoring programme will be developed prior to construction in adherence to 'BS 8485:2015 - Code of practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings'. This will include an assessment of gassing issues following receipt of additional ground gas monitoring results at selected boreholes. Appropriate working methods will be developed and adopted during below ground site construction works (including piling works and excavations). This should include as a minimum, gas monitoring undertaken prior to any entry into excavations, confined spaces or below ground structures and use of PPE as a last resort. If ground gas issues are identified during construction, further post construction monitoring will be undertaken and/or appropriate gas protection measures will be incorporated into the final design (**Mitigation Item SMC-G12**).

Groundwater Quality

10.5.19 Unless it can be demonstrated by the Contractor via a Quantitative Risk Assessment that no water quality impacts will occur due to leaching from Sustainable Urban Drainage System (SuDS) ponds, basins or wetland features, operational SuDS features should be lined. Any potential water quality impacts due to leaching from SuDS features will be addressed through the Controlled Activities Regulations (CAR) process (**Mitigation Item SMC-G13**).

10.5.20 Where required, 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 SMC-G14**).

Cross-chapter Mitigation

10.5.21 In addition to the mitigation measures identified specifically with respect to geology, soils, contaminated land and groundwater, standard mitigation items from Chapter 8 (People and Communities – Community and Private Assets), Chapter 11 (Road Drainage and the Water Environment) and Chapter 16 (Air Quality) will offer additional protection.

Specific Mitigation

Geotechnical Hazards

10.5.22 The risk of future landslides should be mitigated by appropriate design and construction methods, in particular by the provision of suitable drainage, including cut-off drainage. Some minor watercourses running down-slope towards the A9 may also require debris protection measures locally, for example the installation of catch fences (**Mitigation Item P03-G16)**.

Contaminated Land

10.5.23 Additional groundwater quality investigations will be undertaken in areas of cuttings intercepting the water table, where necessary. This will be the basis for a risk assessment to be carried out, including assessment of risks from migration of groundwater. Where required, water treatment will be put in place prior to discharge (**Mitigation Item P03-G17**).

Groundwater Flow

10.5.24 Seven cuttings are expected to intercept groundwater as per Table 10.14. The potential volume of groundwater drainage would be considered in the context of potential groundwater abstraction CAR licences prior to works commencing (**Mitigation Item P03-G18**).

Abstractions

10.5.25 TB-PWS2 has been identified as being directly impacted by the proposed scheme and TB-PWS3 has been identified as potentially at risk in paragraphs 10.4.33. Potential impacts on TB-PWS1 are lesser, however TB-PWS1 has been included in mitigation measures as a precautionary approach and factoring uncertainty on the depth of the well.

10.5.26 Given the direct impact on TB-PWS2, a supply specific replacement strategy will be developed in communication with affected landowners and in consultation with SEPA and implemented by the Contractor. The replacement strategy (**Mitigation Item P03-G19)** will include the following elements, based on initial correspondence with the land owner:

- Decommissioning of the existing borehole.
- Two drilling attempts within land ownership boundaries will be made to replace the existing supply by another well. The strategy should consider monitoring current water usage for a period of 12 months' prior replacement is undertaken, with permission from the land owner, to ensure that the demand is well understood and a like-for-like alternative well is provided. The sustainability of the newly drilled wells will be demonstrated by pumping tests and the water quality will need to be tested and verify it conforms with Drinking Water Standards.
- Should the two drilling attempts fail, mains connection will be adopted.
- The replacement will be completed prior construction works starting in vicinity of the property.
- A contingency plan will be in place to provide bottled water supply to the parties affected in the unlikely eventuality that the supply would be accidently impacted before the alternative supply is in place.

10.5.27 TB-PWS3 and TB-PWS1 will be monitored 12 months prior to construction to establish a baseline on groundwater levels and groundwater quality and during construction, with permission from the land owner. Standard mitigation measures related to the protection of the water environment (W6, W7 and W8) will also offer protection of the groundwater environment. Should a potential impact on a PWS be confirmed, an alternative source of water will be provided. To this effect, the Contractor will be required to prepare a supply-specific monitoring plan and mitigation strategy in communication with affected land owners and in consultation with SEPA (**Mitigation Item P03-G20**).

10.6 Residual Impacts

10.6.1 Residual impacts on geology are expected to be of Neutral significance, with potential beneficial effects as a result of the exposure of new rock cuttings.

10.6.2 The implementation of mitigation measures in relation to contaminated land issues and direct/indirect impacts is expected to reduce potential impacts to a residual impact of Low significance during the construction phase and Very Low significance during the operational phase.

10.6.3 Localised residual impacts of **Moderate** to **Moderate/Large** significance are expected on groundwater flow within superficial deposits of medium and high sensitivity (respectively).

10.6.4 Residual impacts on differential settlement are assessed as Negligible to Slight.

10.6.5 The implementation of mitigation measures in relation to the protection of the water environment against pollution incident is expected to reduce the potential impacts on groundwater quality and associated receptors to a residual impact of Slight and Neutral significance (respectively).

10.6.6 After implementation of mitigation measures, residual impacts on PWS identified at potential risk is expected to reduce to Neutral.

10.6.7 Residual impacts on surface water receptors from indirect dewatering are expected to be Neutral to Slight.

10.7 Statement of Significance

10.7.1 With the proposed scheme in place, and taking into account mitigation measures as described in Section 10.5 (Mitigation), a **Moderate** to **Moderate/Large** significance on groundwater flow within glacial till and glaciofluvial deposits/alluvium/river terrace deposits (respectively) is anticipated.

10.7.2 All other impacts on geology, contaminated land and groundwater are not predicted to be significant.

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