10 Geology, Soils, Contaminated Land and Groundwater

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

The Glen Garry geological SSSI and Geological Conservation Review (GCR) sites present within the study area have been assessed and input provided by SNH and BGS have been taken into account. Adverse impacts on these designations caused by alterations to existing rock cuttings along the existing A9 are expected to be offset by mitigation measures and enhancement opportunities that the proposed scheme will provide.

Residual impacts on groundwater flow in superficial aquifers have been assessed as Moderate to Moderate/Large significance, while impacts on bedrock aquifers and associated receptors have been assessed as Slight significance. Five groundwater fed Private Water Supplies have been identified as being potentially impacted by the proposed scheme and the residual impact has been assessed as Neutral, taking account of the proposed mitigation measures during construction and operation.

Residual impacts on the hydrogeology of three ecological receptors have been assessed as Moderate to Large; however, as discussed in Chapter 12 (Ecology and Nature Conservation) the habitat at these three sites is not of high quality, being relatively species poor due to the effects of land drainage and existing road infrastructure and therefore no significant ecological losses are expected to result from these impacts.

Several potential sources of contamination have been identified within the study area (including made ground; backfilled quarries/pits; railway; storage tanks; a former rifle range and an active quarry). A number of potential contaminated land issues were identified, which would require mitigation measures during construction. The residual impacts receptors on contaminated land are expected to be of Low to Very Low significance.

10.1 Introduction

10.1.1 This chapter presents the DMRB Stage 3 assessment of the proposed scheme in relation to geology, groundwater and contaminated land. This includes impacts to bedrock and superficial geology, mineral extraction, soils, contaminated land, groundwater and associated receptors including private water supplies (PWS).

10.1.2 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 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.

10.1.3 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 degrading water quality. Construction work can also lead to the dewatering of these aquifers.

10.1.4 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.

10.1.5 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;
- Appendix A10.4: Surface Water Indirect Dewatering Assessment; and
- Appendix A10.5: Contaminated Land Indirect Impact 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 (The 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 10.2.22), and DMRB, Volume 11, Section 3, Part 10, HD45/09 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 of 100m from the existing A9 was used and was extended where required for the purpose of dewatering impacts 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 licensing 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 and associated receptors, including PWS; and
- contaminated land.

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

Desk-based Assessment

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

- BGS data including BGS Superficial and Bedrock Geological Maps (BGS, 2014), 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).
- UK Soil Observatory Soils map viewer (http://www.ukso.org/mapViewer.html).
- 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 interactive River Basin Management Plan (http://gis.sepa.org.uk/rbmp/).

- SNH designation database (https://gateway.snh.gov.uk/natural-spaces/index.jsp).
- Scotland's Environment website (Scottish Government, http://www.environment.scotland.gov.uk).
- Previous assessments:
  - A9 Dualling Programme SEA Reports (Transport Scotland, 2013, 2014a, 2014b).
  - Geotechnical Preliminary Sources Study Report (PSSR). Woodend to Glengarry (Jacobs, October 2013).
  - Geotechnical Preliminary Sources Study Report (PSSR) Pitlochry to Woodend (Jacobs, 2013a).
  - Geotechnical Preliminary Sources Study Report (PSSR) Woodend to Glen Garry (Jacobs, 2013b).

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;
- 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;
- SNH and BGS on designated geological features;
- 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 walkover was conducted on 20 and 21 September 2016 to obtain further information on targeted PWS and septic tanks.

10.2.11 Targeted National Vegetation Classification (NVC) and hydro-ecological surveys also took place between 29 November and 01 December to obtain information on areas suspected of being potential GWDTEs. In addition, a subsurface hand coring survey was conducted on 23 March 2017, aimed at confirming the nature and extent of the superficial deposits in the Tullach Hill SSSI.

Ground Investigation

10.2.12 Fugro Engineering Services undertook a ground investigation (GI), designed by Jacobs, between September and December 2015, reported in two parts (referred to jointly as the Advanced GI):

- A9 Dualling Southern Section Killiecrankie to Pitagowan Report on Ground Investigation without Geotechnical Evaluation (Fugro, 2016a); and
- A9 Dualling Southern Section Pitagowan to Glen Garry Report on Ground Investigation without Geotechnical Evaluation (Fugro, 2016b).

10.2.13 The investigation consisted of 44 cable percussive boreholes, 62 rotary boreholes and six sonic boreholes. 12 cable percussive boreholes were extended by rotary drilling. Samples of soils and encountered groundwater were collected during the investigation and sent to Derwentside Environmental Testing Services for chemical analysis.

10.2.14 Sixty-nine boreholes were installed with slotted 50mm standpipes, and six with slotted 25mm standpipes. These standpipes were monitored for groundwater and ground gas following completion of fieldwork. Twenty-nine variable head permeability field tests were carried out.

10.2.15 Soil Engineering Geoservices undertook a subsequent ground investigation, also designed by Jacobs, between 14 August and 15 November 2016, reported in two parts (referred to jointly as the Preliminary GI):

- Report on the A9 Dualling – Killiecrankie to Pitagowan Preliminary Ground Investigation Volume One (Soil Engineering, 2017a); and
- Report on the A9 Dualling – Pitagowan to Glen Garry Preliminary Ground Investigation Volume One (Soil Engineering, 2017b).

10.2.16 The preliminary GI consisted of 8 cable percussive boreholes extended by rotary open holing and/or coring techniques, 62 rotary boreholes and 70 sonic boreholes, ten of which were extended into bedrock by rotary open holing and/or coring techniques. The investigation also included 77 trial pits which were excavated using either a wheeled backhoe or a tracked 360-degree excavator.

10.2.17 Eighty-six boreholes were installed with slotted 50mm standpipes and 4 boreholes were installed with dual installations comprising both a 50mm diameter standpipe and a 19mm diameter piezometers.

Impact Assessment

10.2.18 Potential impacts in relation to geology, hydrogeology and contaminated land were assessed individually as per the methodologies provided below. The criteria outlined in Tables 10.1 to 10.3 and 10.5 to 10.9 are based on those that have been applied to similar schemes in Scotland and are designed to comply with DMRB guidance.

Geology

10.2.19 The sensitivity and magnitude criteria in Table 10.1 and Table 10.2 were used for bedrock and superficial geology (including soils), features of geological importance and mineral extraction. The impact significance was then determined using Table 10.3.

Table 10.1: Sensitivity criteria – geology and soils

Sensitivity	Description
High	Areas containing geological or geomorphological features considered to be of a national interest such as 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, SAC or 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. 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

Sensitivity	Description
	not typically found), Class -1 (unknown soil types) and Class -2 (non-soil (i.e. loch, built up area, rock and scree)).

Table 10.2: 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 10.3: 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

10.2.20 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 within the context of the assessment categories set out in Table 10.2 and Table 10.3.

10.2.21 Impacts on geology and soils 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

10.2.22 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.

10.2.23 The pollutant pathways and receptors used within the assessment are provided in Table 10.4, with individual references assigned for linkages (PP1 to PP22).

Table 10.4: Potential pollutant pathways

Pollutant Pathway	Receptor	Pathway
Construction		
PP1	Human Health (Construction)	Ingestion, inhalation and dermal contact with soils, soil dust, deep and shallow groundwater and surface water.
PP2		Migration of ground gases into shallow pits or site buildings.
PP3	Off Site Receptors (Local residents, transient traffic (foot, road and rail traffic) in the surrounding area.)	Ingestion, inhalation and dermal contact with wind-blown dust 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 bedrock aquifer.
PP7	Surface waters	Migration of contaminated shallow groundwater through superficial deposits or made ground.
PP8		Run-off 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 & 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, deep and shallow groundwater or 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 or accommodation buildings, creating an asphyxiation /explosion risk.
PP14	Off Site Receptors	Ingestion, inhalation and dermal contact with wind-blown dust 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 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 bedrock aquifer.
PP18	Surface waters	Migration of shallow groundwater through superficial deposits or made ground.
PP19		Run-off 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.

10.2.24 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.

10.2.25 Potential impacts are discussed in terms of likelihood (Table 10.5) and magnitude/consequence (Table 10.6). The Generic Qualitative Assessment is then undertaken based on the matrix shown in Table 10.7.

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

Table 10.5: Likelihood criteria - contaminated land

Likelihood	Definition
High likelihood	There is a complete pollution linkage and 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 10.6: 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 10.7: 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**

10.2.27 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

10.2.28 The assessment of the magnitude of impact on the quality and level of groundwater are based primarily on the type of road section (e.g. cutting, embankment or transition) in the vicinity of 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 on 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).

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

10.2.30 Criteria for the definition of groundwater sensitivity and magnitude are reported in Tables 10.8 and 10.9. 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).

10.2.31 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).

10.2.32 The impact significance for groundwater aspects was determined using the matrix as shown in Table 10.10.

Table 10.8: Sensitivity criteria - groundwater

Sensitivity	Description
Very High	Groundwater aquifer(s) with very high productivity or 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 (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 (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 (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 10.9: 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

Magnitude	Description
	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.
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 10.10: 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

10.2.33 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

10.2.34 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.

10.2.35 Geological and hydrogeological information obtained from the Advanced and Preliminary 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.

10.2.36 Information on PWS depends on the accuracy provided through consultations with landowners and the local authority, and the sections of the network infrastructure that were observed in the field during targeted surveys.

10.2.37 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 Glen Garry Geological SSSI is a series of rock exposures created by the River Garry and by road cuttings of the existing A9. Within the study area, the SSSI is present as two discrete sections along the River Garry (south of Clunes and at Calvine), and three sections of road cutting on the A9 (between Clunes and Dalnamein Lodge). These locations are shown on Figure 10.1.

10.3.2 The site is designated because the exposures provide a nationally important almost continuous cross-section through Dalradian rocks, an ancient group of rocks underlying much of the southern Highlands of Scotland from Aberdeen to Kintyre. The SSSI site is valuable for its wealth of minor folds and sedimentary structures, which enable geologists to interpret the broader geological structure of the Grampian fold belt. Meetings were held between Jacobs, BGS and SNH to discuss the designated rock exposures in June 2015 and August 2016, identifying features of interest, potential impacts and opportunities for enhancement. The three sections of road cuttings relevant to the proposed scheme and which were discussed are:

- The existing cutting at Clunes Lodge (ch15200-16100) which reveals first generation folds that have been refolded by folds of the second generation. A major upfold of the second generation, the Clunes antiform, can be identified from study of the structures in the cutting and the original sedimentary layering can be identified. Other structures associated with the second generation folds, such as cleavage and lineation, are also well developed.
- The existing Black Tank cut (ch17000-17600) (Photograph 10.1) which also displays a second generation upfold. Mineralised fractures (joints) also occur, as well as faults which cut volcanic sills of porphyrite.
- At Allt Crom Bhruthaich the existing road cutting (ch18200-18800) which displays a large third generation upfold, the Bohespic Antiform, with strongly developed associated features such as cleavage and lineation.

Photograph 10.1: Black Tank cut (ch17000-17600)

10.3.3 With the exception of the River Garry section south of Clunes, the Geological SSSI areas within the study area are also recorded as the A9 Road Cuttings and River Garry Gorge GCR site. GCRs are identified by the Joint Nature Conservation Committee (JNCC) as areas considered to be of SSSI quality. The GCR site locations are indicated on Figure 10.1.

10.3.4 In addition, Tulach Hill and Glen Fender Meadows SAC and the Tulach Hill SSSI are both in proximity of the existing A9 and encompass most of the hill ground west of the Pass of Killiecrankie, including

the summits of Tulach Hill, Meall na h-Imrich and Craig Fonvuick (please refer to Figure 10.1). The Dalradian limestone bedrock in the form of limestone pavements is listed as one of the SAC qualifying interests for which the Tulach Hill and Glen Fender Meadows SAC is designated. The limestone bedrock is also integral to the Tulach Hill SSSI notified upland habitats, giving rise to a range of important plant communities which support a rich variety of higher plants and insects.

10.3.5 Based on the criteria presented in Table 10.1, the Glen Garry SSSI and the A9 Road Cuttings and River Garry Gorge GCR site are both defined as being of high sensitivity. The Tulach Hill and Glen Fender Meadows SAC and the Tulach Hill SSSI are considered to be of national importance and are also assessed to also be of high sensitivity.

10.3.6 Other SSSIs, not designated for their geological interest, are present within the study area and are described in Chapter 12 (Ecology and Nature Conservation).

Soils

10.3.7 A review of the Macaulay Institute Soils Survey of Scotland Soil Map of Scotland (1:250,000 scale) (Macaulay Institute, 1981), in conjunction with the UK Soil Observatory interactive soils map viewer indicates that the majority of the study area is underlain by a mixture of brown forest soils, humus-iron podzols with some gleys and localised peat associated with hummocky valley moraines.

10.3.8 To the south of Killiecrankie, brown forest soils are the more dominant soil type (humus iron podzols and humic gleys are also associated with this area). Brown forest soils are also found from Blair Atholl towards Pitagowan.

10.3.9 Brown forest soils and humus-iron podzols are derived from schists, gneisses, granulites and quartzites, and are typically capable of supporting acid bent-fescue grassland, arable and permanent pasture as well as oak and birchwood.

10.3.10 In the vicinity of Pitagowan the existing A9 is underlain predominantly by humus iron podzols, with some alluvial soils associated with the valley floors, terraces and mounds. The alluvial soil and humus-iron podzols 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.

10.3.11 Further information on the agricultural value of the soils is provided in Chapter 8 (People and Communities – Community and Private Assets).

10.3.12 No peat deposits are recorded on BGS maps within the study area.

10.3.13 SNH's Carbon and Peatland 2016 Map (SNH, 2016) indicates that priority peatland habitat is present within 250m of the proposed scheme, as shown in Figure 10.1. This includes an area of Class 5 peat 200m to the north-east of the proposed scheme at ch16100; an area of Class 2 peat 80m to the north-east of the proposed scheme at ch18500 and an area of Class 3 peat 50m to the north-west of the proposed scheme at ch22300.

10.3.14 In addition, peaty topsoil was noted during previous walkovers and recorded during previous ground investigation work at depths of 0.2-0.9m below ground level (mbgl) along the corridor of the proposed scheme west of Clunes Lodge (Jacobs, 2013).

10.3.15 Localised peat deposits were recorded during both the Advanced and Preliminary GIs in 19 exploratory hole locations:

- Fibrous peat was recorded in two boreholes, located north of ch13900 (0.15m thick) and ch19400 (0.25m thick), both underlain by clayey, gravelly sand. Peat was visually confirmed during the targeted NVC surveys as being present between ch19500 and ch19700.
- Spongy fibrous peat was recorded in three boreholes located north of ch19700 up to 0.3m thick and underlain by gravel and in one borehole west of ch19700 (1.20m thick) with lenses of grey silty gravelly sand.

- Plastic pseudofibrous peat was recorded in one borehole located south of ch2900 (1.3m thick), buried by 1m of river terrace deposits and underlain by glaciofluvial deposits.
- Plastic amorphous gravelly peat over spongy fibrous peat was encountered to a depth of approximately 0.85m in one borehole located north of ch20900 and buried by 0.1m of topsoil.
- Spongy dark brown, slightly sandy, silty fibrous peat with rootlets was recorded in one borehole located northwest ch20100 (0.20m thick) and two trial pits located southwest ch20500 (0.80m thick) and south ch20700 (1.20m thick).
- Peaty clay with boulders/cobbles was recorded in three boreholes, two located northeast ch14200 (0.70m and 0.80m thick), and one located northwest ch19800 (0.60m thick).
- Slightly gravelly peat with cobbles (0.20m thick) overlying dark brown silty fibrous peat with occasional rootlets (0.30m thick) was recorded in one borehole northwest ch14300.
- Peat was recorded in 3 boreholes at ground level in locations north ch15000 (0.70m thick), north ch18800 (0.15m thick) and northwest ch20200 (0.20m thick).
- A peat horizon was recorded in one borehole located north ch13500 at a depth of 1.70m (0.10m thick).

10.3.16 The targeted NVC survey recorded the presence of peat deposits in two additional areas away from the existing A9: up gradient of TN185 and within TN197 as reported in Appendix A10.2 (Ecological Receptors with Potential Groundwater Component).

10.3.17 Based on the criteria presented in Table 10.1, the areas of SNH priority peatland Class 2 are assessed as high sensitivity and Class 3 areas are assessed as medium sensitivity. Class 5 areas are assessed as low sensitivity, as are the areas of localised peat deposits encountered during the GIs. The remaining soils present in the study area have been assessed to be of negligible sensitivity.

Made Ground

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

10.3.19 Records of initial ground investigations pre-dating the existing A9 did not record the presence of any made ground (Jacobs, 2013, 2013a and 2013b).

10.3.20 However, both the Advanced and Preliminary GIs confirmed the presence of made ground in twenty boreholes and thirteen trial pits with a greatest proven thickness of 2.1m. The description of made ground is incorporated in Appendix A10.1 (Contaminated Land Sources) associated with the identification of contaminated land.

10.3.21 Based on the criteria presented in Table 10.1, made ground present in the study area is considered to be of negligible sensitivity.

Superficial Geology

10.3.22 Superficial deposits underlying the study area are primarily composed of glacial till, river terrace deposits and alluvium, with hummocky glacial deposits, glaciofluvial deposits and areas with no superficial deposits also noted to be present.

10.3.23 Glacial till and areas without superficial deposits are generally found over the hillsides of the River Garry valley throughout the study area. Glacial till is typically composed of poorly sorted granular sediments (sands and gravels) within a clay matrix.

10.3.24 The alluvium and river terrace deposits are found within the valley floor throughout the eastern half of the study area from Calvine to Killiecrankie and also within the area west of Dalnamein Lodge. River alluvium is generally comprised of silty clay which can contain layers of silt, sand, peat or basal gravel while river terrace deposits primarily comprise sand and gravel with localised areas of silt, clay or peat.

10.3.25 Hummocky glacial deposits are mapped predominantly on the southern bank of the River Garry, west of Calvine. They are described as lithologically diverse and complex deposits that have a characteristic moundy topographic form and are composed of rock debris, clayey till and a mix of poorly to well-stratified sand and gravel. Small areas are also noted within the Aldclune area north of the River Garry. Glaciofluvial deposits are also noted in the area on both banks of the River Garry in-between areas of glacial till and river alluvium deposits. Glaciofluvial deposits are generally comprised of sand and gravel with localised lenses of silt, clay or organic material.

10.3.26 The Advanced and Preliminary GI records generally support the historical and published information. Heterogeneous superficial deposits were encountered in the majority of exploratory holes, consisting of varying sequences of clay, silt, sand, gravel, cobbles and boulders. The superficial deposits were defined variously as river terrace deposits, alluvium and glaciofluvial deposits. This suggests a greater extent of glaciofluvial deposits than identified in previous GI records (Jacobs, 2013, 2013a and 2013b), whilst it is likely that the till areas were not sampled due to their location up the valley slopes.

10.3.27 The average thickness of superficial deposits recorded from the ground investigations was in the range of 5m, with a maximum proven thickness of 29.5m, and a minimum recorded thickness of 0.2m. Superficial deposits thickness is highly variable over short distances.

10.3.28 Based on the criteria presented in Table 10.1, superficial deposits present in the study area are considered to be of negligible sensitivity.

Bedrock Geology

10.3.29 Underlying the superficial geology is metamorphic bedrock of Neoproterozoic age belonging to the Argyll, Appin and Grampian Groups of the Dalradian Supergroup.

10.3.30 The Killiecrankie Schist of the Argyll Group is identified to underlie superficial deposits at Killiecrankie and Aldclune. This formation includes pelite, semipelite and psammite metamorphic rocks with quartzite beds.

10.3.31 In the Blair Atholl area, the superficial deposits are underlain by the Blair Atholl, Ballachulish and Lochaber Subgroups of the Appin Group. The Appin Group is a succession of pelite, semipelite, psammite and quartzite metamorphic rocks interbedded with sedimentary limestones.

10.3.32 West of Woodend, the underlying bedrock is the Strathtummel Subgroup of the Grampian Group. The Strathtummel Subgroup comprises interbedded psammite and quartzite.

10.3.33 Silurian/Devonian age igneous intrusions of felsite and microdiorite are also recorded crossing the proposed scheme in the vicinity of Clunes Lodge.

10.3.34 The Advanced and Preliminary GIs encountered bedrock in 193 locations and both support the BGS data by confirming the presence of various metamorphic sequences beneath the proposed scheme:

- the Killiecrankie Schist, described variously as schist, pelite, psammite and quartzite, was identified beneath the proposed scheme from ch850 to ch3900;
- the Strathtummel Subgroup (Tummel Psammite, Tummel Quartzite, Gaick Psammite, Bruar Psammite and Kynachan Quartzite formations), consisting predominantly of psammite, but also including pelite, schist, phyllite and quartzite with various igneous intrusions including microgranite dykes, diorite dykes, andesite, gneiss and microdiorite intrusions, was identified from ch10400 to ch22000;
- the Blair Atholl Dark Limestone & Dark Schist, consisting of pelite and psammite, was identified from ch3800 to ch8400;
- the Cnoc An Fhithich Banded Semipelite formation, consisting of quartzite and psammite, was identified in three boreholes at ch8450;
- the Blair Atholl Light Group, described as a metagranite, was encountered in one borehole at ch8350; and

- the Glen Banvie Group (including the forest lodge member), described as pelite, was encountered in two boreholes between ch8700 and ch9150.

10.3.35 Generally, the rockhead elevation increased from south to north, with a large step change in the Calvine area.

10.3.36 Based on the criteria presented in Table 10.1, bedrock in the study area is considered to be of negligible sensitivity.

Mineral Extraction

10.3.37 There is evidence of limestone, sand and gravel mineral extraction within the study area but there are no records of historic or current coal mining activity.

10.3.38 Shierglas Quarry, situated approximately 50m south of the existing A9 at ch4900-5200 of the proposed scheme is an operational limestone quarry. The quarry is currently operated by Breedon Aggregates and has been identified as KP-C15 (refer to Appendix A10.1: Contaminated Land Sources and Figure 10.2).

10.3.39 Three disused quarries exploiting metamorphic rock (referred to as PGG-C4, PGG-C5 and PGG-C6) and three sand and gravel pits (referred to as PGG-C7, KP-C6 and KP-C24) were identified. Further three historical quarries were noted in close proximity to Shierglas Quarry (KP-C14, KP-C17 and KP-C21). All mineral extraction sites are shown in Appendix A10.1 (Contaminated Land Sources) and on Figure 10.2.

10.3.40 It is unknown if these historical quarries and pits have been subsequently infilled. It has been conservatively assumed at this stage that they have been infilled with potentially contaminative material.

10.3.41 Based on this historical evidence of limestone, sand and gravel extraction and the superficial and bedrock descriptions, there is potential for further limestone, sand and gravel resources to be available within the study area. Future limestone, sand and gravel extraction resources are assessed to be of low sensitivity, based on the criteria presented in Table 10.1.

Geotechnical Hazards

10.3.42 There is evidence of historic instability within the study area, with previous landslides known to have occurred and various road defects reported.

10.3.43 Previous reports have highlighted a potential soil instability as a result of landslide risk reported at several locations along existing A9 road cuttings. This is generally associated with areas of compressible ground relating to alluvial soils, and in areas where erosion may have occurred (Jacobs, 2013a; 2013b). Erosion impacts and changes in fluvial geomorphology along surface waters are assessed separately in Chapter 11 (Road Drainage and the Water Environment).

Contaminated Land

10.3.44 Details of the 93 contaminated land sources identified in the study are provided in Appendix A10.1 (Contaminated Land Sources) and locations shown on Figure 10.2.

10.3.45 The Advanced and Preliminary GIs identified 33 areas where made ground was proven to be present. Sixteen of these locations are associated with the existing A9, four with the Highland Main Line railway and associated railway land, seven with existing unnamed side roads and/or access roads, four are associated with three previously identified potentially contaminated sites (KP-C15, PGG-C6 and PGG-C7) and two with no obvious source. Made ground generally comprises of sandy gravel of varying lithologies, including limestone, psammite and pelite; at the exception of the two areas with no obvious source which are characterised by tarmac/bituminous materials. No visual or olfactory evidence of contamination within any of the made ground deposits were noted.

10.3.46 The soil sample chemical analysis results from the Advanced and Preliminary GIs have been compared against Generic Assessment Criteria (GAC; industry standard criteria) suitable for a residential end use to assess the potential risks to construction workers. This is considered to be a conservative approach. There will be limited potential exposure pathways to end users given the use of the proposed scheme as a road; however, potential pathways remain, including for maintenance workers. Therefore, the soil sample chemical analysis results have also been compared against GAC suitable for public spaces 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.

10.3.47 A soil organic matter concentration of 6% has been used (Laboratory results ranged from 0.4 to 6.8%). The following hierarchy of GACs has been used to screen soil sample analysis results:

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

10.3.48 With the exception of three samples discussed separately, all samples analysed recorded results below the most conservative GAC (residential without plant uptake end use). Three samples (all within 1.0mbgl in BH PGB1020) were noted to exceed the residential without plant uptake GAC criteria for speciated total petroleum hydrocarbons (TPH) (aromatic fractions C10-C35), and selected polycyclic aromatic hydrocarbons (PAH) (including naphthalene, benzo(a)anthracene, benzo(b)fluoranthene and benzo(a)pyrene). Of these exceedances, only two samples recorded exceedances above the GACs for a public open space end use but below the commercial/industrial end use GACs for benzo(b)fluoranthene and benzo(a)pyrene. The Engineer's logs for PGB1020 indicate the presence of tarmac surfacing and a "strong smell" which could be attributable to these locally elevated concentrations.

10.3.49 Up to nine rounds of ground gas monitoring have been undertaken within 60 Advanced GI and 91 Preliminary GI monitoring boreholes between January 2015 and February 2017, with only 9 out of the 150 locations monitored having had 9 rounds and with the average number of visits being 3. Ground gas concentrations could pose a potential risk to human receptors 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:

- CIRIA C665 Assessing risks posed by hazardous ground gases to buildings. CIRIA 2007;
- Health and Safety Executive (HSE), 'EH40/2005 Workplace Exposure Limits':2011; and
- Mines and Quarries Act 1954, 27 (Section 55(2)(b)).

10.3.50 Recorded methane concentrations were below the recommended safety threshold based on the lower explosive limit for methane (1% volume per volume (v/v)) with the exception of four locations. At these locations a peak value of 1% v/v was recorded on isolated occasions for two boreholes and for all three monitoring rounds for the other two boreholes. All locations have no identifiable source for the methane, being located away from identified potential contaminated land sources and none of the boreholes contain made ground nor peat soils. It is possible that the two isolated occurrences are erroneous readings, as they were not repeated in other monitoring rounds at one location, while the second location was not monitored again.

10.3.51 Carbon dioxide concentrations exceed the short term (15 minutes) occupational exposure limit (1.5% v/v) in 77 boreholes and the long term (8 hour) exposure limit (0.5% v/v) in 115 boreholes. Carbon monoxide concentrations are above the long term (8 hour) exposure limit of 30ppm in eight locations and above the short term (15 minute) exposure limits of 200ppm in one location.

10.3.52 Depleted concentrations of oxygen were also recorded below the Mines and Quarries Act value of 19%v/v in 86 locations.

10.3.53 Hydrogen sulphide concentrations were predominantly below the monitoring equipment's level of detection (1ppm). However, two locations have recorded hydrogen sulphide concentrations above the long term (8 hour) exposure limit of 5ppm and the short term (15 minute) exposure limit of 10ppm. These locations are not associated with any identified potential contaminated land sources. However, peat soils are present at both locations, which is a credible explanation for the levels of hydrogen sulphide encountered.

Groundwater

10.3.54 The BGS Onshore Geoindex indicates that the underlying bedrock units (the Argyll, Appin and Grampian Groups) are all low productivity aquifers with little potential for groundwater storage and transport other than within the near surface weathered zone and secondary fractures. The BGS Hydrological Map of Scotland (1988) differentiates the interbedded limestones of the Appin Group and the Quaternary river alluvium from the main geological units described above and although they are still considered to have a low overall productivity they can be important locally, dependent upon their areal extents. 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.

10.3.55 The SEPA River Basin Management Plan (RBMP) interactive map identifies the aquifer underlying the site as the Glen Garry Sand and Gravel aquifer. The spatial extent of the Glen Garry Sand and Gravel aquifer corresponds with the spatial extent of the alluvium and river terrace deposits associated with the River Garry. Underlying and adjacent to the superficial material is the Garry and Loch Rannoch bedrock aquifer and localised sand and gravel aquifers. The Hydrogeological Map of Scotland (1988) reports these deposits as aquifers of limited potential without significant groundwater, with small borehole yields of typically 1-2 litres/second.

10.3.56 The status of both groundwater bodies was assessed by SEPA as Good with High Confidence in 2008 for both quantity and quality, with no trend of pollutants.

10.3.57 Groundwater monitoring data were available from 169 observation boreholes. Of these, 106 were screened exclusively in the superficial deposits, 34 exclusively in the bedrock, and 29 spanning the drift and bedrock. Two boreholes were nested to monitor the superficial deposits and bedrock separately, and one borehole was nested to span the superficial deposits and bedrock and the bedrock separately.

10.3.58 The monitoring data cover the period of September to December 2015 and August to November 2016. Artesian groundwater pressures were recorded in bedrock at three boreholes locations in the vicinity of ch7500, ch20900 and ch21300. The monitoring also confirms the presence of shallow groundwater in some parts of the superficial deposits, with groundwater levels reaching ground surface at times in one area around ch14350. Average groundwater levels were found to range between 115m and 282m AOD. No groundwater flow direction can be defined as the proposed scheme is linear and the GI follows the proposed alignment, however groundwater flow directions are expected to follow the topography.

10.3.59 The hydrogeological characteristics and sensitivity of superficial and bedrock units within the study area are presented in Table 10.11.

Table 10.11: Hydrogeological characteristics of superficial and bedrock units (flow and quality)

Geological / Hydrogeological Unit		Geological Characteristic	Hydrogeological Characteristic	Sensitivity
Superficial Deposits	Peat	Decomposed organic deposits	Very poor groundwater potential due to compacted nature, low permeability and limited spatial extent.	low (from a resource point of view).
	Made Ground	Composition of any Made ground present 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
	Hummocky (moundy) glacial deposits	Heterogeneous glacial deposits composed of rock debris, clayey till and poorly- to well-stratified sand and gravel	Poor groundwater potential due to generally low and variable permeability.	medium
	Glacial Till	Heterogeneous deposits	Poor groundwater potential due to generally low and variable permeable nature.	medium
Bedrock	Argyll Group	Metamorphic - pelite, semipelite, psammite and quartzites	Poor groundwater potential except within near surface weathered zone and secondary fractures.	medium
	Appin Group	Metamorphic – pelite and semipelite with interbedded limestones.	Poor groundwater potential except within near surface weathered zone and secondary fractures. The limestone units have local groundwater potential.	medium
	Grampian Group	Metamorphic – psammites, pelites, semi-pelites and quartzites.	Poor groundwater potential except within near surface weathered zone and secondary fractures.	medium
	Felsite and microdiorite igneous intrusions	Igneous dykes	Very poor groundwater potential.	low

Abstractions and Groundwater Flow

10.3.60 Details of the PWS identified within the study area are presented in Table 10.12 and the active PWS are shown on Figure 10.1. It should be noted that some of the PWS identified at Stage 2 using OS map information have now been found to be abandoned/inactive following landowner consultation. These are included in Table 10.12 with an update on their status.

Table 10.12: Summary of Identified PWS

PWS Reference	Source of Information	Nature of PWS	Property	Status	Comments
KP-S1 (Stage 2)	OS Map and landowner consultation	n/a	n/a	Abandoned/ not active	Land owner consultation suggests that only one PWS is used on this land holding. Location of this supply correlated with KP-PWS4. KP-S1 is not in use.
KP-W1 (Stage 2)	OS Map and landowner consultation	Unknown	Clunemore farm & farm house	Active	n/a
KP-W2 (Stage	OS Map and	n/a	n/a	Abandoned/	n/a

PWS Reference	Source of Information	Nature of PWS	Property	Status	Comments
2)	landowner consultation			not active	
KP-S2 (Stage 2)	OS Map and landowner consultation	n/a	n/a	Abandoned/ not active	n/a
KP-S3 (Stage 2)	OS Map and landowner consultation	n/a	n/a	Abandoned/ not active	n/a
KP-S4 (Stage 2)	OS Map and landowner consultation	n/a	n/a	Abandoned/ not active	n/a
KP-S5 (Stage 2)	OS Map and landowner consultation	n/a	n/a	Abandoned/ not active	n/a
KP-S6 (Stage 2)	OS Map and tenant consultation	n/a	n/a	Abandoned/ not active	Land owner consultation suggests that only one PWS is used on this land holding. Location of this supply correlated with KP-PWS11. KP-S6 is not in use.
KP-S7 (Stage 2)	OS Map and landowner consultation	n/a	n/a	Abandoned/ not active	n/a
KP-PWS1 (Stage 2)	Landowner consultation	Surface water	Coille Essan	Active	Collection tanks in poor state of repair. Landowner trying to obtain mains connection.
KP-PWS2 (Stage 2)	Landowner consultation	Stream & spring	Orchilmore	Active	Part of a domestic and agricultural (cattle/irrigation) supply from stream and spring with KP-PWS3 & KP-PWS14. Fed by gravity through underground pipes.
KP-PWS3 (Stage 2)	Landowner consultation	Stream & spring	Craigurrard	Active	Part of a domestic and agricultural (cattle/irrigation) supply from stream and spring with KP-PWS2 & KP-PWS14. Fed by gravity through underground pipes.
KP-PWS4 (Stage 2)	Landowner consultation	Spring	Lettoch Farm	Active	Gravity fed to storage tank (underground) and then on to the property. Domestic use. Serves a total of four houses but these were not identified.
KP-PWS5 (Stage 2)	Landowner consultation	Spring	The Barn, Lettoch Farm,	Active	Domestic use. Supply is six years old.
KP-PWS6 (Stage 2)	Landowner consultation	n/a	n/a	n/a	This is the same supply as KP-PWS4. This reference can therefore be abandoned.
KP-PWS7 (Stage 2)	Landowner consultation	Well	The Barn, Mains Of Orchill	Active	Borehole 65m deep. Domestic supply, including drinking water for four houses. Pumped into storage tanks.
KP-PWS8 (Stage 2)	Landowner consultation	n/a	n/a	n/a	This is the same supply as KP-PWS7. This reference can therefore be abandoned.
KP-PWS9 (Stage 2)	Landowner consultation	Spring / surface water	Fieldstone Mains Of Orchill	Active	Domestic supply to three properties.
KP-PWS10 (Stage 2)	Landowner consultation	Well	Mains of Orchill	Active	Borehole 60m deep located in the rear garden and pumped to storage tanks. Domestic supply.
KP-PWS11 (Stage 2)	Tenant consultation	Spring	Invervack Farm	Active	Gravity fed supply for drinking water and agricultural, specifically animals (ponies,

PWS Reference	Source of Information	Nature of PWS	Property	Status	Comments
					sheep and cattle). Only serves one property.
KP-PWS12 (Stage 2)	Landowner consultation	Surface water	Strathgarry Farm	Active	Gravity fed supply. Supplies only one property.
KP-PWS17	Statutory consultation (PKC) and landowner consultation	Borehole	Strathgarry House	Active	Located 30m to the west of wester Strathgarry House in the shed. Pumped to the house for domestic use.
KP-PWS13 (Stage 2)	Landowner consultation	n/a	n/a	Abandoned/ not active	n/a
KP-PWS14	Landowner consultation	Stream & spring	Orchilmore Farm Buildings and Steadings Units	Active	Part of a domestic and agricultural (cattle/irrigation) supply from stream and spring with KP-PWS3 & KP-PWS2. Fed by gravity through underground pipes.
KP-PWS15	Consultation and Site Observation	Surface water	Shierglas Quarry	Active	Supplies one property for industrial use. Landowner consultation suggests a small volume of water and intermittent use with the rest of the water supply collected from the hillside. Pipe passes through culvert of WF101.
KP-PWS16	Landowner consultation	Unknown	Estate of Urrard	Abandoned/ not active	n/a
PGG-W1 (Stage 2)	OS map and landowner consultation	Spring / surface water	Pitaldonich Farm House	Active	Gravity fed supply. Supply feeds two properties.
PGG-PWS1 (Stage 2)	Landowner consultation	Spring	Dalnamein Lodge, Keeper's Cottage, Tigh-na-Coille and Dalreoch.	Active	Three collection units, with a large concrete tank collecting runoff and interflow from higher ground on the north side of the existing A9 and transmitting it beneath the carriageway to Dalnamein Lodge on the southern side of the existing A9. The PWS is understood to be gravity-fed and supplying water to four properties. PWS for domestic supply, horses and a garden fountain.
PGG-S1 (Stage 2)	OS map and landowner consultation	n/a	n/a	Abandoned/ not active	n/a
PGG-PWS2 (Stage 2)	Tenant consultation	Well	Struan Farm	Active	Supply is from Atholl Estates.
PGG-PWS3 (Stage 2)	Landowner consultation & site visit	Unknown	Tomchitchen	Active	Tenant is new at this property and was unaware of the configuration of existing supply. There was no surface evidence of the location of the PWS source and associated network.
PGG-PWS4 (Stage 2)	Tenant consultation & site visit	Spring	Clunes Cottage	Active	Domestic supply. Consists of two capture tanks capturing water from bedrock fracture north of the A9. Water is piped under the A9 to two large concrete storage tanks which then supply Clunes Lodge, Clunes cottage and the kennels. System is gravity fed. Water level in both of the tanks was approximately 0.8m below the top of cover.

PWS Reference	Source of Information	Nature of PWS	Property	Status	Comments
PGG-PWS5 (Stage 2)	Landowner consultation & site visit	Spring	Braeside	Active	Domestic supply. The source was described as a spring by the resident. The supply was observed to comprise of a perforated plastic capture tank which was 0.57m wide, 0.68m long and 0.5m deep, on high ground north of A9. The depth of water was observed to be 0.38m. Water was fed from the capture tank by two perforated plastic pipes into a black plastic 30mm supply pipe. Supply was understood to be piped through underpass under the A9 into Calvine. The hill slope surrounding the supply was observed to be waterlogged with the depth of water in the tank corresponding with groundwater levels.
PGG-PWS6 (Stage 2)	Landowner consultation	n/a	n/a	Abandoned/ not active	n/a
PGG-PWS7 (Stage 2)	Statutory Consultation (Perth & Kinross Council)	n/a	n/a	Abandoned/ not active	Referred to as "Old Manse Borehole Supply" on OS map.
PGG-PWS8	Landowner consultation	Surface water	Dalreoch Cottage	Active	Surface water abstraction is pumped to the property. Frequent water shortage.
PGG-S2	Statutory Consultation (Perth & Kinross Council) & Landowner consultation	Spring or surface water	Garrybank	Active	Type A Level 1 supply. Described by landowner as a surface water supply, captured in a tank and piped under A9 to property. Unclear if this is surface water or shallow groundwater.
PGG-PWS9 Glackmore	Statutory Consultation (Perth & Kinross Council)	Surface water	n/a	Unknown	Type B supply. Surface water supply sourced is being described as located700m from property by land owners. Gravity fed.

10.3.61 PWS identified as being abandoned/not active are not receptors, and hence are not considered further in this assessment. All remaining PWS networks identified above are of high sensitivity as they supply ten or fewer properties.

10.3.62 Impacts on surface water fed PWS are covered in Chapter 11 (Road Drainage and the Water Environment) and these receptors are not discussed further in this chapter.

Groundwater Quality

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

10.3.64 The groundwater sample chemical analysis results from the Advanced and Preliminary GIs have been compared against Resource Protection Values as defined within SEPA Position Statement WAT-PS-10-01 (SEPA, 2014). This screening exercise has identified elevated concentrations of mercury in thirty-two locations, cadmium in three locations, nickel in one location, nitrate in one location, Bis(2-ethylhexyl) phthalate in one location, benzene in two locations, speciated hydrocarbons in seven locations and total polycyclic aromatic hydrocarbons (PAHs) in eight locations. The majority of exceedances are marginal with a number of isolated greater exceedances observed within mercury, speciated hydrocarbons and PAHs determinands.

Ecological receptors with potential groundwater component

10.3.65 Preliminary assessment of ecological receptors based on the Phase 1 habitat survey (CH2MHill, 2015), has identified a number of habitats which are potentially at least partially supported by groundwater inflows. This was subsequently updated by a comprehensive Phase 1 habitat survey undertaken by Jacobs in September 2016. The outcome of these surveys, with a screening review to consider whether these ecological receptors are potentially groundwater dependant, is summarised in Appendix A10.2 (Ecological Receptors with Potential Groundwater Component), whilst all ecological receptors are identified and described further in Chapter 12 (Ecology and Nature Conservation). The location of the ecological target notes investigated for potential groundwater component are shown on Figure 10.3.

10.3.66 Where ecological receptors were found to be potentially groundwater dependant, targeted NVC and hydro-ecological surveys were undertaken and these are detailed in Section 3 of Appendix A10.2 (Ecological Receptors with Potential Groundwater Component). The targeted surveys incorporated the full extent of the potential GWDTE including areas beyond the initial 100m study area where appropriate.

10.3.67 It was concluded that there are 8 GWDTEs in the study area: 1 with a high groundwater component, 3 with a moderate groundwater component and 4 with a low groundwater component. The location of each GWDTE and the assigned groundwater dependency of each is provided in Figure 10.3.

Surface Water Features

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

10.3.69 The main watercourse within the study area is the River Garry which runs in close proximity to the existing A9 through the majority of the study area. In the area between Killiecrankie and Pitagowan, the River Garry is designated as part of the River Tay SAC and there are two areas of the Glen Garry SSSI relating to the River Garry further upstream near Calvine and Clunes.

10.3.70 The main tributaries to the River Garry within the study area are the Allt Girnaig, Allt Bhaic, River Tilt, River Bruar/Bruar Water, and Banvie Burn. The lower reaches of all five tributaries are also designated as part of the River Tay SAC.

10.3.71 The River Garry is of very high sensitivity. All other identified surface water bodies are of low sensitivity, which includes the tributaries of the River Garry.

10.3.72 All watercourses are identified and described further in the 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 geological resources, 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 groundwater dependant terrestrial ecosystems; and
- surface runoff from the operational carriageway 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 10.13 and shown on Figures 10.1 to 10.3. 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 “widening”) and new proposed cuttings (labelled as “cutting”). Groundwater level and depth to bedrock data from recent site investigation and monitoring work have been assessed and interpolated to produce indicative bedrock and groundwater surfaces as far as possible across the footprint of the proposed scheme.

Table 10.13: Cutting depths

Name	Approximate Chainage	Approximate maximum Excavation Depth (mbgl)	Depth to bedrock (drift thickness) (m)	Depth to Groundwater (m)	Likelihood of Intercepting Bedrock	Likelihood of Intercepting Groundwater
W3	2240 – 2400	3.23	4.5	3	unlikely	likely
W4	4850 – 4910	2.24	10	4	unlikely	unlikely
W5	6100 – 6425	4.82	7.5	1	unlikely	likely
W6	7200 – 8725	7.96	4	0.5	likely	likely
W7	3150 – 3250	1.68	4	4	unlikely	unlikely
W8	3440 – 3680	5.27	4	5.5	likely	unlikely
W9	10300 - 10690	6.88	3	1	likely	likely
W11	12850 – 13050	5.29	10.5	3	unlikely	likely
W12	13400 – 14750	7.58	1	1	likely	likely
W13	15140 - 15200	2.30	1	5	likely	unlikely
W14	15400 - 16100	7.10	2	3	likely	likely
W15	17100 – 17550	9.30	2.5	3.5	likely	likely
W16	18280 – 18825	8.12	3.5	1	likely	likely
W18	19940 – 20175	5.91	3	2	likely	likely
W19	21500 – 21900	5.92	1.5	1.5	likely	likely
W20	13100 – 13250	4.35	8	3	unlikely	likely
W21	16150 – 16380	5.10	2	2	likely	likely
W22	6475 – 7000	12.51	6.5	2	likely	likely
W23	18975 - 19750	5.01	1.5	1.5	likely	likely
C3	20 – 300	12.26	4	7	likely	likely
C5	0 – 390	7.8	3	3	likely	likely
C6	0 – 225	16	8	8	likely	likely
C7	335 – 620	11.49	5	6.5	likely	likely
C8	310 – 700	7.23	4.5	3	likely	likely
C11	500 – 650	4.8	12.5	6	unlikely	unlikely
C12	0 – 140	4.1	12	9	unlikely	unlikely
C13	440 – 510	2.04	11.5	6.5	unlikely	unlikely
CS1	10 - 300	7.8	4.5	3	likely	likely
CS2	0 – 220	10.16	10	6	likely	likely
CS3	0 - 375	11.37	12	4	unlikely	likely
CS4	840 – 1040	2.08	8	1.5	unlikely	likely

Name	Approximate Chainage	Approximate maximum Excavation Depth (mbgl)	Depth to bedrock (drift thickness) (m)	Depth to Groundwater (m)	Likelihood of Intercepting Bedrock	Likelihood of Intercepting Groundwater
CS5	125 - 210	6.7	9	1	unlikely	likely
CS6	0 – 80	1.83	8	3	unlikely	unlikely
CS7	325 – 425	5.5	4	1.5	likely	likely
CS8	500 - 630	1.77	13	4	unlikely	unlikely
CS10	320 – 550	1.7	5	4	unlikely	unlikely
CS11	80 – 870	1.72	10.5	5	unlikely	unlikely
CS12	0 – 220	9.84	6	3	likely	likely
CS13	320 - 470	2.7	10.5	3.5	unlikely	unlikely
CS14	290 - 440	2.11	14	2	unlikely	likely
CS15	0 – 134	6.26	4	1.5	likely	likely
CS16	90 – 425	23.4	4.5	2.5	likely	likely
CS17	0 – 310	1.7	5	1.5	unlikely	likely
CS19	840 – 930	4.1	4	2.5	likely	likely
CS20	240 – 470	8.32	3	1.5	likely	likely
CS21	80 – 100	7.13	2.5	2.5	likely	likely
CS22	430 – 490	1.44	6	4	unlikely	unlikely
CS23	0 – 75	2.45	4	2.5	unlikely	unlikely
CS24	260 – 325	3.04	4	3.5	unlikely	unlikely
CS25	0 – 70	1.31	2	1.5	unlikely	unlikely
CS26	60 – 145	1.78	4	6.5	unlikely	unlikely
CS29	400 – 425	2.9	24.5	2.5	unlikely	likely
CS30	1050 – 1150	2.38	3.5	1	unlikely	likely
CS33	370 - 390	5.19	7	2	unlikely	likely
CS34	0 – 140	2.1	10	2	unlikely	likely
CS35	775 - 830	1.2	4	2.5	unlikely	unlikely
CS38	250 - 300	2.17	8.5	4.5	unlikely	unlikely
CS39	1275 - 1325	5.42	3.5	2	likely	likely
CS40	0 – 160	6.02	3.5	2	likely	likely
CP1	1300	3.92	7.5	5.5	unlikely	unlikely
CP2	1600	3.64	2.5	2	likely	likely
CP3	3200	5.24	3.5	5	likely	likely
CP4	3800	16.53	8	10.5	likely	likely
CP5	4000	3.11	11.5	6.5	unlikely	unlikely
CP7	4700	4.28	10	4	unlikely	likely
CP8	6700	16.01	6.5	1.5	likely	likely
CP10	9300	2.59	17.5	2.5	unlikely	likely
CP11	10600	4.75	3.5	1.5	likely	likely
CP12	11500	3.49	9.5	2.5	unlikely	likely
CP13	11400	5.42	8	3	unlikely	likely
CP14	12600	4.53	6.5	2.7	unlikely	likely
CP15	13600	6.94	3.5	3	likely	likely
CP16	14800	2.73	1.5	3	likely	unlikely
CP17	15400	7.81	3	5.5	likely	likely
CP19	18200	7.93	3	5	likely	likely
CP20	19500	3.66	5	2	unlikely	likely
CP21	19800	4.23	4.5	2	unlikely	likely
CP22	22000	1.13	4	1.5	unlikely	unlikely
CH1	110 - 220	1.9	7	4	unlikely	unlikely
CH2	0 - 80	4.9	7	8.5	unlikely	unlikely
CH3	80 - 270	4.6	4	6.0	likely	unlikely

Name	Approximate Chainage	Approximate maximum Excavation Depth (mbgl)	Depth to bedrock (drift thickness) (m)	Depth to Groundwater (m)	Likelihood of Intercepting Bedrock	Likelihood of Intercepting Groundwater
CH4	780 - 1090	6.1	3	3	likely	likely
CH5	0 - 70	1.5	11	3.5	unlikely	unlikely
CH6	260 - 350	3.7	14.5	5	unlikely	unlikely
CH7	460 - 510	2.3	12	6	unlikely	unlikely
CH9	10 - 50	3.7	4	2	unlikely	likely
CH10	540 - 580	1.7	1.5	9.5	likely	unlikely
CH11	10 - 160	2.9	3	2.5	unlikely	likely
CH12	200 - 310	6.8	4.5	3	likely	likely
CH13	650 - 750	8.8	4.5	4	likely	likely
CH14	130 - 420	1.6	2.5	3	unlikely	unlikely
CH15	0 - 120	5.2	5.5	5.5	unlikely	unlikely
CH16	10 - 100	11	6.5	4.5	likely	likely
CH18	10 - 70	5.5	13	4	unlikely	likely
CH19	600 - 780	1.56	10	5.5	unlikely	unlikely
CH21	900 - 950	1.7	6.5	1.5	unlikely	likely
CH22	1290 - 1360	1.4	5.5	1.5	unlikely	unlikely
CH23	1420 - 1480	2.65	5	4.5	unlikely	unlikely
CH25	950 - 970	2.1	3	1.5	unlikely	likely
CH27	1170 - 1260	1.68	1.5	1	likely	likely
CH29	480 - 570	1.86	5	5	unlikely	unlikely
CH33	80-330	1.6	3.5	1	unlikely	likely
CH35	450-570	1.7	1.5	7	likely	unlikely
CH37	850-890	1.5	2.5	3	unlikely	unlikely

Geology

Designated Geological Receptors

10.4.5 The Tulach Hill SSSI and Tulach Hill and Glen Fender Meadows SAC, including limestone pavement features (geologically assessed as high sensitivity), are located within 5m of the proposed scheme in the central part of the study area. However, as only part of the northern margin of the SAC/SSSI area could potentially be affected by the proposed scheme, any potential impact on the limestone pavement features has been assessed to be of negligible magnitude and therefore of Slight significance.

10.4.6 There are four areas of widening and five new cutting areas associated with the proposed scheme located within the Glen Garry SSSI/GCR sites:

- Widenings 13 and 14 and SuDS CP17 are located within the existing cut of Glen Garry SSSI at Clunes Lodge. The most valued part of the exposure in Clunes Lodge lies opposite existing lay-by 59 (ch15650) adjacent to the southbound carriageway, and this exposure will be slightly re-worked;
- Widening 15 and Haulage Road Cutting CH14 are located within the existing Black Tank cut. A geological fold of interest was highlighted at ch17100 but the proposed scheme is not anticipated to affect this feature; and
- Widening 16, SuDS CP19 and Haulage Road Cuttings CH15 and CH16 are located within the Allt Crom Bhruthaich. A rock fold noted between ch18250 and ch18400 is anticipated to be reworked/reprofiled.

10.4.7 The majority of the proposed widening is on the northbound side at these locations; however, the existing rock slopes of most importance within designated SSSI and GCR sites are on the southbound side, and include the features outlined above. Therefore, these key rock slopes and their features will remain post-construction.

10.4.8 Rock mapping undertaken as part of DMRB Stage 3 has provided an updated record of current exposures and has allowed kinematic analysis to be carried out for each rock slope. This analysis shall inform the specimen design of rock slopes including preferred angles of cut, the requirement for berms and rock traps.

10.4.9 Given that the proposed scheme comprises widening of the existing carriageway and related earthworks, the new rock cuts will be generally parallel to existing cuts. It has been discussed and agreed with the BGS and SNH that the reworking of key geological features through widening and pushing back the rock exposure profile by a few metres is unlikely to impact on the designation of the rock exposure. This confirms the general opportunities for enhancement highlighted at DMRB Stage 2 that proposed works will allow exposures to be clean and clear to view.

10.4.10 The rock mapping exercise has also informed an assessment of the stability of existing rock slopes which shall be retained at their existing profile and where no widening is proposed. This suggests the potential for instability related to a range of failure modes.

10.4.11 Two rock slopes which are to be retained in their existing condition are located immediately adjacent to the southbound carriageway and currently have double height safety barrier along much of their length to protect the carriageway. It is proposed that these shall be replaced with similar barriers or fences to maintain this protection.

10.4.12 The development of the design has also explored ways to maximise bedrock exposures at proposed new SuDS features at cutting locations CP17 and CP19.

10.4.13 On the basis of the above, all cuttings/widenings have been assessed as having on balance a negligible to minor magnitude because of the proportion of rock removal, as per the criteria defined in Table 10.2, resulting in an overall potential impact of Slight significance on the Glen Gary Geological SSSI during both construction and operation phases.

Soils

10.4.14 None of the areas of SNH priority peatland are expected to be impacted by the proposed scheme. Areas of localised peat could potentially be impacted by construction of the scheme with the expected volumes of peat required to be excavated are summarised in Table 10.14. The removal of these peat volumes is expected to represent an impact magnitude of minor, resulting in an impact significance of Neutral/Slight.

Table 10.14: Estimate of Peat Volumes to be Excavated During Construction of the Proposed Scheme

Chainage	Area under Design Footprint (m^2)*	Peat Thickness (m)	Estimated Volume	Estimated Volume Catotelm (m^3)	Estimated Volume Accrotelm (m^3)
ch13900	79	0.15	12	0	12
ch19500-19700	236	0.25	59	0	59
ch19700	157	0.3	47	0	47
ch2900	314	0.3	94	0	94
ch20900	157	0.75	118	55	63
ch1700	314	1.4	440	314	126
ch13500	79	0.1	8	0	8
ch14200	314	0.7	220	94	126
ch14200	314	0.8	251	126	126
ch14400	314	0.5	157	31	126
ch18800	314	0.15	47	0	47
ch19800	314	0.9	283	157	126
ch20300	157	0.2	31	0	31
ch20100	314	0.2	63	0	63
ch19500	50173	0.5	25086	5017	20069

* Where the identification of peat is based on a record from a single borehole a nominal radius of 10m has been assumed.

Superficial Geology

10.4.15 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

10.4.16 Table 10.13 indicates that bedrock is likely to be intercepted by 46 of the proposed cuttings. This is expected to represent a minor magnitude of impact because of the widespread presence of these deposits in the region. This results in an overall impact significance of Neutral during both the construction and operation phases.

10.4.17 The use of blasting to excavate bedrock in places cannot be ruled out at this stage. There are three major mechanisms where rock blasting can impact on rock structure:

- generation of new fractures in previously intact rock;
- dilation of existing joints and discontinuities by the action of high pressure explosive gases; and
- promotion of slip planes along favourably oriented joints and fracture surfaces.

10.4.18 All three mechanisms are vibration controlled. The generation of new fractures in previously intact rock and the dilation of existing joints and discontinuities occur close to the blast zone (termed 'near-field' effects), and the promotion of slippage along favourably oriented joints can occur several hundreds of metres from the blast (termed 'far-field' effects).

10.4.19 Blasting effects on rock mass, as described above, may result in consequential impacts on hydrogeology by creating or changing groundwater pathways. Potential impacts could therefore occur if the Contractor opts to use explosives in the excavation of the cuttings where there are sensitive hydrogeological receptors and significantly contaminated sites in relatively close proximity. The potential impact of blasting on groundwater is assessed in the groundwater section. Blasting on solid geology is considered to be a potential impact of negligible magnitude.

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

Mineral Extraction

10.4.21 There is evidence of previous mineral extraction from both bedrock and 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.

Groundwater

10.4.22 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. The results are presented below.

10.4.23 The same zone of dewatering influence was also used to determine potential indirect contaminated land impacts via the groundwater pathway (Refer to paragraph 10.4.44).

Groundwater Flow

10.4.24 Table 10.13 indicates that 66 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 deposits/glacial till and alluvium/River Terrace deposits respectively.

10.4.25 Bedrock groundwater is expected to be intercepted in 41 cuttings, which is expected to create a local dewatering effect within shallow bedrock groundwater. This would result in a localised impact of minor magnitude with a resultant overall potential impact significance of Slight during both construction and operation phases.

10.4.26 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 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. 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. Eleven Cuttings (W5, W6, W9, W12, W20, CS1, CS4, CS5, CS7, CP14 and CH9) were considered to represent a minor impact magnitude resulting in an overall impact significance of Slight.

10.4.27 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

10.4.28 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.

10.4.29 The magnitude of potential impact from accidental spillages is considered to be moderate for both superficial groundwater and bedrock groundwater, because of bedrock being shallow in various areas and based on 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 10.15. Hydrogeological units are groupings of geological units with similar hydrogeological characteristics, as summarised in Table 10.15.

Table 10.15: Potential impact of accidental spillages on key hydrogeological units during both construction and operation phases

Hydrogeological Unit	Sensitivity	Magnitude	Impact Significance
Superficial Aquifers – Alluvial Deposits, River Terrace Deposits	high	moderate	**Moderate/Large**
Superficial Aquifers – Hummocky Glacial Deposits, Glacial Till	medium	moderate	**Moderate**
Superficial Aquifers – Peat, Made Ground	low	moderate	Slight
Bedrock Aquifers – Appin Group, Argyll Group, Grampian Group	low	moderate	Slight
Bedrock Aquifers – Felsite and Microdiorite Igneous Intrusions	low	moderate	Slight

10.4.30 An impact assessment of accidental spillages on surface water features is included in Chapter 11 (Road Drainage and the Water Environment) and Appendix A11.6 (Water Quality).

Abstractions

10.4.31 Active groundwater PWS located in proximity to a cutting considered likely to intercept groundwater are identified in Table 10.16 below. The potential impact 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 an influence on the magnitude of impact).

Table 10.16: Potential impacts on active groundwater abstractions as a result of groundwater dewatering

Cutting	PWS	Sensitivity	Magnitude of Impact	Significance of Impact
W5	PGG-S2	high	moderate	**Moderate/Large**
W14	PGG-PWS4	high	moderate	**Moderate/Large**
W22	PGG-S2	high	moderate	**Moderate/Large**
CS4	PGG-S2	high	negligible	Neutral
CS12	PGG-S2	high	major	**Large/Very Large**
CS15	PGG-PWS3	high	negligible	Neutral
CS16	PGG-PWS4	high	major	**Large/Very Large**
CP8	PGG-S2	high	minor	**Moderate**
CH13	PGG-PWS4	high	major	**Large/Very Large**

10.4.32 In addition to potential impacts from groundwater dewatering, the water quality at two groundwater water supplies (PGG-PWS3 and PGG-PWS4) located in close proximity to the proposed scheme (<50m) could be impacted by any contamination entering groundwater as a result of spillage incidents during construction of the proposed scheme. Each PWS is of high sensitivity and the potential impact magnitude is major, resulting in a potential impact of **Large/Very Large** significance.

10.4.33 Three groundwater fed PWS connections (i.e. pipelines) cross the footprint of the proposed scheme, at ch13440 (PGG-PWS5), ch15950 (PGG-PWS4) and ch20100 (PGG-PWS1). Along with the PWS they serve, these connections are of high sensitivity and the potential impact magnitude is major, resulting in a potential impact of **Large/Very Large** significance.

10.4.34 Blasting may occur during construction in areas of cutting that are expected to intercept bedrock. PWS within 100m of these works could potentially be negatively impacted by these activities. PGG-PWS3 and PGG-PWS4 all lie between 50m and 70m of an area of expected blasting and are considered to have sensitivities of high. However, most of these supplies are expected to be shallow features, with limited connection with vibration effects in the bedrock. The impact magnitude is considered to be minor, resulting in a potential impact of Slight/Moderate significance.

Ecological Receptors with Potential Groundwater Component

10.4.35 A review of the locality of each identified GWDTE with respect to the predicted zones of dewatering determined in the groundwater flow impact assessment above (paragraphs 10.4.22 and 23) was initially undertaken to assess which GWDTEs were potentially at risk. Subsequently, a detailed assessment of each GWDTE within a predicted zone of dewatering and therefore potentially at risk was undertaken to assign the magnitude of the potential impact. This information was then used to determine the significance of impact. The potential impact on the hydrogeology of identified GWDTEs is shown in Table 10.17 below. Further analysis on the hydrogeology of identified GWDTEs and assessment of impact is provided in Section 4 of Appendix A10.2 (Ecological Receptors with Potential Groundwater Component).

Table 10.17: Potential Impacts on the hydrogeology of identified GWDTEs

Cutting	GWDTE	Sensitivity	Magnitude of Impact	Impact Significance
CS14	TN139	high	none	n/a
CS16	TN160-162	high	moderate	**Moderate/Large**
CS20	TN190-193	medium	moderate	**Moderate**
n/a	TN194	high	none	n/a

Cutting	GWDTE	Sensitivity	Magnitude of Impact	Impact Significance
W18	ANF02	medium	major	**Large**
CS12	CF01	very high	none	n/a
W6	Area Q	medium	none	n/a
W6	Area R	medium	none	n/a

10.4.36 The importance of ecological habitats TN160-162, TN190-193 and ANF02 is discussed in Table 12.9 within Chapter 12 (Ecology and Nature Conservation) where it is noted that these three sites are not of high quality. They are relatively species poor due to the effects of land drainage and existing road infrastructure and therefore no significant ecological impacts have been identified.

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 size (or volume of flow) 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 significant impacts are expected. Further details are provided in Appendix A10.4 (Surface Water Indirect Dewatering Assessment).

Contaminated Land

10.4.41 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.

10.4.42 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

10.4.43 Direct disturbance of a number of potential contaminated land sources has the potential to impact on human receptors as summarised in Table 10.18.

Table 10.18: Potential direct contaminated land impacts during construction

Source Ref	Source Name	Pollutant Pathway	Magnitude	Likelihood	Impact Significance
KP-C1	Existing A9 Carriageway	PP1 & PP3	mild	likely	**Moderate/Low**
KP-C2	Highland Main Line railway	PP1 & PP3	mild	likely	**Moderate/Low**
KP-C13	Old Limekiln 7	PP1, PP2, PP3 & PP4	mild	likely	**Moderate/Low**
KP-C15	Shierglas Quarry	PP1, PP2, PP3 & PP4	medium	likely	**Moderate**
KP-C17	Old Quarry	PP1, PP2, PP3 & PP4	medium	likely	**Moderate**
KP-C18	Old Limekiln 9	PP1, PP2, PP3 & PP4	mild	likely	**Moderate/Low**

Source Ref	Source Name	Pollutant Pathway	Magnitude	Likelihood	Impact Significance
KP-C21	Quarry	PP1, PP2, PP3 & PP4	medium	likely	**Moderate**
KP-C22	Old Limekiln 11	PP1, PP2, PP3 & PP4	mild	likely	**Moderate/Low**
KP-C25	Tanks	PP1, PP2, PP3 & PP4	medium	likely	**Moderate**
KP-C27	Rifle Range	PP1 & PP3	mild	likely	**Moderate/Low**
KP-C37	Septic Tank	PP1 & PP3	mild	likely	**Moderate/Low**
KP-C38	Septic Tank	PP1 & PP3	mild	likely	**Moderate/Low**
KP-C44	Septic Tank	PP1 & PP3	mild	likely	**Moderate/Low**
KP-C92	Septic Tank	PP1 & PP3	mild	likely	**Moderate/Low**
PGG-C3	Storage Tanks	PP1 & PP3	medium	likely	**Moderate**
PGG-C5	Disused Quarry	PP1, PP2, PP3 & PP4	medium	likely	**Moderate**
PGG-C6	Disused Quarry	PP1, PP2, PP3 & PP4	medium	likely	**Moderate**
PGG-C7	Sand and Gravel Pit	PP1, PP2, PP3 & PP4	medium	likely	**Moderate**
PGG-C33	Septic Tank	PP1, PP2, PP3 & PP4	mild	likely	**Moderate/Low**
n/a	Made ground removed and temporarily stored, including made ground from the demolition of the Allt Crom Bhruthaich Underbridge and the Allt Geallaidh Underbridge	PP1, PP3, PP5 to PP9	medium	likely	**Moderate**

Construction Phase - Indirect Disturbance

10.4.44 Indirect disturbance may occur where proposed cuttings intercept groundwater, as they could draw contaminated groundwater towards the cutting. Sixty-six 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 Appendix A10.5 (Contaminated Land Indirect Impact Assessment).

10.4.45 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

10.4.46 The same list of potentially contaminated land sources as shown in Table 10.17 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.

10.4.47 Potential impact significance for all sources, other than made ground, is therefore proportional to but one level lower than that shown in Table 10.17. Potential pollutant pathways during the operation include PP12, PP13, PP14 and PP15. The majority of identified potential sources have a potential impact significance ranging from Very low to Low with eight identified potential sources (KP-C15, KP-C17, KP-C21, KP-C25, PGG-C3, PGG-C5, PGG-C6 and PGG-C7) with a potential **Moderate/Low** impact significance**.**

10.4.48 For made ground removed and temporarily stored, including made ground from the demolition of the Allt Crom Bhruthaich Underbridge and the Allt Geallaidh Underbridge, potential pollution pathways PP12, PP14 and PP16 - PP20 are applicable. The potential of an impact occurring has been assessed as being likely and the impact magnitude as medium, resulting in a potential impact of **Moderate** significance.

Operation Phase - Indirect Disturbance

10.4.49 Groundwater intercepted by proposed cuttings will need to be drained and discharged (PP21). The same list of potential contaminant sources as shown in Appendix A10.5 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.

10.4.50 Potential impact significance for all widenings/cuttings and sources is therefore proportional to but one level lower than that shown in Appendix A10.5 (Contaminated Land Indirect Impact Assessment). The majority of widenings/cuttings have a potential impact significance ranging from Very low to Low with twelve (W6, W12, W20, W22, CS2, CS7, CS12, CS15, CS16, CP8, CP12, CP15) identified to have a potential **Moderate/Low** impact significance.

10.4.51 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.

10.5 Mitigation

10.5.1 Mitigation measures for the proposed scheme in relation to geology, contaminated land and groundwater are detailed below and take into account best practice, legislation, guidance and professional experience.

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 ('P05' mitigation item references). Those that specifically relate to geology, soils, contaminated land and groundwater are assigned a 'G' reference.

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

Embedded Mitigation

10.5.4 The slopes within the Glen Garry SSSI/GCR sites affected as part of the proposed scheme have been designed so that no mesh or other slope stabilisation measures will need to be used.

Standard Mitigation

Geology

10.5.5 Although the overall impact significance of removing localised areas of peat is predicted to be Neutral/Slight, the local impact significance will be higher. To ensure there are no localised detrimental effects if peat is encountered during construction, it will be excavated, stored and re-used if possible, taking 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 The Waste Management Licensing (Scotland) Regulations 2011. This will be captured in a Peat Management Plan that will be developed by the Contractor (**Mitigation Item SMC-G10)**.

10.5.6 Risk assessments will be undertaken before explosives can be used on site to reduce 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 reduce 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. 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. Construction staff will be trained to identify asbestos containing material (**Mitigation Item SMC-G4**).

10.5.12 Appropriate training will be provided for personnel involved in earthworks activities to enable implementation of a watching brief to identify 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 of septic tanks and associated infrastructure. Where septic tanks are located within the land made available (LMA) they will be relocated 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 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' (**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 proposed 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 SuDS retention ponds and detention basins, operational SuDS features will be lined (**Mitigation Item SMC-G13**).

10.5.20 Storage of excavated soils and made ground will be minimised on site (spatially and in duration) and 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 both Chapter 11 (Road Drainage and the Water Environment) and Chapter 16 (Air Quality) will offer additional protection.

Specific Mitigation

Geology

10.5.22 A detailed rope access inspection will be required to identify potential mitigation measures for existing rock slopes of concern that will not be reworked. Such measures might include simple maintenance; for example, scaling of the rock slopes to remove rock debris, potential failure blocks and other material from the face, and clearing or widening of existing rock traps. However, in some cases, measures such as the installation of rock dowels or bolts may need to be implemented locally to stabilise specific blocks of concern **(Mitigation Item P05-G16)**.

10.5.23 During construction, the Contractor will liaise with SNH/BGS/Transport Scotland regarding Glen Garry SSSI to refine measures to enhance the Glen Garry SSSI/GCR areas. Proposed enhancement measures have been discussed with SNH and BGS and will include:

- clearing vegetation to refresh Glen Garry SSSI areas as part of the construction works of the proposed scheme;
- ‘signature’ blocks of material to be taken off site and used for educational purposes; and
- SNH/BGS having the opportunity to survey and document the rock exposures during and immediately following construction using photographs of the newly exposed and reworked areas of rocks once completed, for geological mapping update purposes. **(Mitigation Item P05-G17)**.

Contaminated Land

10.5.24 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 P05-G18**).

Groundwater Flow

10.5.25 A number of proposed excavation areas are expected to intercept groundwater. The potential volume of groundwater drainage will be considered in the context of potential need for groundwater

abstraction CAR licences prior to works commencing (**Mitigation Item P05-G19**), taking into account Mitigation Item P05-G18 noted above.

10.5.26 Additional GI is required in vicinity of cuttings W5, W6, W9, W12, W20, CS1, CS4, CS5, CS7, CP14 and CH9 to confirm the conclusions of the initial settlement assessment (**Mitigation item P05-G20**).

Groundwater Quality

10.5.27 Groundwater intercepted by cuttings may need to be treated prior to being discharged, as there was evidence of elevated mercury and speciated hydrocarbons and PAHs in some sampled boreholes. A Groundwater Disposal Strategy will be developed by the Contractor during the construction phase and will form part of submissions to support CAR Licences (**Mitigation Item P05-G21**).

Abstractions

10.5.28 PWS identified as potentially at risk in Table 10.16 and paragraphs 10.4.32-10.4.33 will be monitored. 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 significant 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 P05-G22**).

10.5.29 PWS pipe networks identified as being at potential risk in paragraph 10.4.33 will be protected during construction by the Contractor (**Mitigation Item P05-G23**). This will be achieved by the Contractor confirming the exact location of the pipeline by digging and incorporating protective measures to ensure that the infrastructure does not get damaged during construction and in the long term by the proposed scheme.

Groundwater Effects on Surface Water

10.5.30 Groundwater abstracted via road cuttings and widenings will be returned to the same general catchment during the operational phase. This is expected to compensate the majority of losses at the catchment scale, but may leave residual impacts at the local scale.

10.6 Residual Impacts

10.6.1 Residual impacts on the Glen Garry SSSI/GCR and the Tulach Hill SAC limestone pavement are expected to be of Neutral significance and potentially beneficial as a result of proposed scheme. Residual impacts on peat deposits are assessed as Neutral/Slight. All other residual impacts on geology are expected to be of Neutral significance.

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

10.6.3 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).

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

10.6.5 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.

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

10.6.7 As the impacts on the hydrogeology of ecological receptors TN160-162, TN190-193 and ANF02, are not able to be mitigated, residual impacts on the hydrogeology of these GWDTEs are expected to be **Moderate to Large**. However, as discussed in Chapter 12 (Ecology and Nature Conservation) the habitat at these three sites is not of high quality, being relatively species poor due to the effects of land drainage and existing road infrastructure and therefore no significant ecological losses are expected to result from these impacts.

10.6.8 Residual impacts on surface water receptors from indirect dewatering are assessed to be Neutral to Slight/Moderate.

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 deposits / glacial till and alluvium / River Terrace deposits respectively are anticipated.

10.7.2 Residual impacts of **Moderate** to **Large** are also expected on the hydrogeology of three ecological GWDTE receptors. However, as discussed in Chapter 12 (Ecology and Nature Conservation) the habitat at these three sites is not of high quality, being relatively species poor due to the effects of land drainage and existing road infrastructure and therefore no significant ecological losses are expected to result from these impacts.

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

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