

## **23 Geology, Contaminated Land and Groundwater**

This chapter identifies and describes the existing geology, contaminated land and groundwater within the Southern Leg study corridor. It assesses the impacts of the proposed scheme on these issues and outlines measures for avoiding or mitigating these impacts wherever possible.

Based on a desk based assessment, preliminary ground investigations and consultations, descriptions of drift and solid geology are provided. Data were collected on sites of potential contaminated land, groundwater flow and groundwater resources, including wells and springs, within the study corridor. No sites of geological importance were identified, but Hare Moss represents a site of ecological interest supported by groundwater.

Groundwater flow and quality monitoring, in selected areas, will enable the future development of site-specific mitigation if required. Private water supplies will be replaced if any major impairment is noted during construction and these will be further protected by the lining of drainage pipes during the operational phase. Future mitigation measures to limit disturbance to the water balance and impacts on the groundwater quality at Hare Moss will also be developed, subject to further assessment.

Contaminated material will be treated or removed, if encountered during the earthworks required for construction of the proposed scheme, to avoid risks to construction workers and potential impacts upon groundwater and groundwater quality arising from disturbance to contaminated land will be assessed in further detail at a later stage.

The proposed scheme would result in a Negligible to Slight adverse overall impact for geology and groundwater, a Slight to Moderate adverse impact for Hare Moss and a Slight beneficial impact for contaminated land.

### **23.1 Introduction**

- 23.1.1 This chapter assesses the effects of the proposed scheme on geology within the Southern Leg study corridor, including contaminated land and local groundwater resources. The assessment includes solid (bedrock) geology and drift geological deposits such as peat, sands and gravels. Assessment of the value of local soils is limited to their agricultural capability and this issue is discussed in Chapter 22 (Land Use).
- 23.1.2 Both geology and soils play an important part in determining the environmental characteristics of a region. The underlying geology has a major influence on landform, and rocks provide the parent material from which soils are created. The nature of the rock helps to determine not just the nature and chemistry of the soil, but also the rate at which it forms. This in turn strongly affects the vegetation that will grow naturally and the type of agriculture or horticulture that can be sustained.
- 23.1.3 There are a variety of ways in which road developments can impact on geological resources. Road schemes may sterilise or remove soils associated with prime agricultural land, or sterilise underlying mineral resources. Excavating or masking exposures of rocks or drift geological deposits of scientific interest can represent a serious impact if the features of interest are not reproduced elsewhere in the area. Similarly, removal or modification of geomorphological features can affect their scientific value or the local landscape resource. Impacts can also affect the existing or potential future commercial exploitation of resources and ground conditions may impose constraints on a proposed road scheme, for example, where land has become unstable due to mining or has been contaminated by previous land uses.

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- 23.1.4 Road schemes can have potential impacts on underlying groundwater aquifers both during construction and operation. For example, construction works which involve excavation can lead to dewatering of shallow aquifers. There is also a risk of spillage or leakage of fuel or oil from storage tanks or construction plant. Without suitable mitigation measures, these pollutants can enter the aquifers. Once a new road is opened, runoff from the surface may contain elevated concentrations of pollutants such as oils, suspended solids, metals (e.g. copper and zinc) and, in winter, salt and engine coolants (e.g. ethylene glycol). Consequently, without adequate design measures, highway drainage discharges can cause pollution to aquifers.
- 23.1.5 This chapter presents baseline conditions, predicted impacts and identifies any associated mitigation measures in relation to the solid strata, the covering drift deposits and the associated groundwaters. The assessment also focuses on current and historic mineral extraction and contaminated land and considers impacts occurring both during construction and operation.

## **23.2 Approach and Methods**

### **Baseline Conditions**

- 23.2.1 The study area for the assessment extends to approximately 250m either side of the proposed route. The assessment was undertaken by means of consultation, a desk study and ground investigations.
- 23.2.2 Consultations were undertaken with a number of statutory and non-statutory bodies holding records pertinent to the assessment. These include the following:
- Aberdeenshire and Aberdeen City Council, for records of Regionally Important Geological Sites (RIGS) and information on contaminated sites and private water supplies;
  - British Geological Survey (BGS), for information on local geology and borehole information; and
  - Scottish Environment Protection Agency (SEPA), for contaminated sites, waste disposal sites and industrial processes.
- 23.2.3 The desk-based studies followed the recommended scope of DMRB, Volume 11, Section, Part 11 Chapter 5, Geology and Soils (The Highways Agency, 1993).
- 23.2.4 A programme of additional consultation with landowners commenced in March 2007, following publication of the Environmental Statement in December 2006. This consultation focused on the confirmation of desk study identified private water supplies located partly or fully within the study area (i.e. 250m either side of the proposed scheme). This additional consultation is not complete and further detailed baseline information is yet to be determined.

### **Impact Assessment**

- 23.2.5 As described in Chapter 5 (Overview of Assessment Process), impact significance was determined with respect to the sensitivity of the baseline conditions and the magnitude of potential impact. This is described in detail below.

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Sensitivity/Importance

23.2.6 The importance or sensitivity of the geological and groundwater interest of the study area was determined using the criteria set out in Tables 23.1 and 23.2.

**Table 23.1 – Sensitivity Criteria for Geology**

Sensitivity	Description	Examples of Receptors
<b>High</b>	Areas containing geological or geomorphological features considered to be of national interest.	Sites of Special Scientific Interest (SSSIs).
<b>Medium</b>	Areas containing features of designated regional importance considered worthy of protection for their educational, research, historic or aesthetic importance.	Regionally Important Geological Sites (RIGS).
<b>Low</b>	Features not currently protected and considered not to require specific protection.	n.a.

**Table 23.2 – Sensitivity Criteria for Groundwater**

Sensitivity	Description
<b>High</b>	Local groundwater aquifer(s) constitutes a valuable resource because of its high quality and yield, or extensive exploitation for public, private domestic, agricultural and/or industrial supply. Designated sites of nature conservation dependent on groundwater.
<b>Medium</b>	Local aquifer(s) of limited value because quality does not allow potable or other quality sensitive uses. Exploitation of local groundwater is not extensive. Local areas of nature conservation known to be sensitive to groundwater impacts.
<b>Low</b>	Poor groundwater quality and/or very low permeabilities make exploitation of the aquifer(s) unfeasible. Changes to groundwater not expected to have an impact on local ecology.

23.2.7 Specific criteria are not defined for the assessment of mineral extraction or contaminated land as these aspects primarily represent engineering considerations for the scheme construction and their extent, nature and required mitigation will be assessed by specific ground investigations undertaken by the Contractor prior to detailed design of the development. However, the occurrence and proposed management of these aspects has been considered, assessed qualitatively, and presented as part of this assessment.

Magnitude of Impact

23.2.8 The magnitude of predicted impact on geological and groundwater interests was determined in accordance with the criteria shown in Table 23.3 and 23.4.

**Table 23.3 – Magnitude Criteria for Geology**

Magnitude	Description
<b>High</b>	Where there would be partial (greater than 50%) or total loss of a site, or where there would be complete severance of a site such as to significantly affect the value of the site.
<b>Medium</b>	Where there would be loss of part (between approximately 15% to 50%) of a site, major severance, major effects to the setting, or disturbance such that the value of the site would be affected, but not to a major extent.
<b>Low</b>	Where there would be a minimal effect on a site (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.
<b>Negligible</b>	Very slight change from baseline condition. Change hardly discernible, approximating to a 'no change' conditions.

**Table 23.4 – Magnitude Criteria for Groundwater**

Magnitude	Description
<b>High</b>	Major permanent or long-term change to groundwater quality or available yield. Existing resource use is irreparably impacted upon. Changes to quality or water table level would have an impact upon local ecology.
<b>Medium</b>	Changes to the local groundwater regime are predicted to have an impact slightly on resource use but not rule out any existing supplies. Minor impacts on local ecology may result.
<b>Low</b>	Changes to groundwater quality, levels or yields do not represent a risk to existing resource use or ecology.
<b>Negligible</b>	Very slight change from groundwater baseline conditions approximating to a 'no change' situation.

Significance of Impact

23.2.9 The significance of impacts was then determined by reference to both the sensitivity of the site and the magnitude of impact, according to the matrix shown in Table 23.5.

**Table 23.5 – Significance of Impacts on Geology and Groundwater**

Magnitude	Sensitivity			
	High	Medium	Low	Negligible
<b>High</b>	Substantial	Moderate/Substantial	Moderate	Slight
<b>Medium</b>	Moderate/Substantial	Moderate	Slight/Moderate	Negligible/Slight
<b>Low</b>	Moderate	Slight/Moderate	Negligible/Slight	Negligible
<b>Negligible</b>	Slight	Negligible/Slight	Negligible	Negligible

**Limitations to Assessment**

- 23.2.10 The listing of wells and springs is based on information received from consultation with Aberdeenshire and Aberdeen City Council, from information gathered during hydrological surveys, and from current Ordnance Survey (OS) map data. Further private supplies were identified during landowner consultation and have therefore been included in the assessment. Wells and springs, which are not notified to the Councils, not identified during surveys or landowner discussions undertaken to date and not recorded by OS are therefore not assessed within the ES.
- 23.2.11 Available information obtained through the private water supply survey is presented within this chapter. However, it should be noted that detailed consultation and mitigation development is anticipated to continue as part of the pre-construction activities on the AWPR and as such the exact location of some springs and wells is yet to be determined.
- 23.2.12 Contour maps were produced for groundwater contours, rockhead elevation and drift thickness. These contours are solely based on ground investigation data available to date, which are mainly concentrated along the route of the proposed scheme and not on the wider area.

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#### 23.3 Baseline Conditions

##### Designations

- 23.3.1 No geological Sites of Special Scientific Interest (SSSIs), Regionally Important Geological Sites (RIGS) or other designated sites of geological value have been identified in the area, and no other features of special importance to geology have been identified.

##### Geology

- 23.3.2 The solid geological succession and drift deposits are described below, and provide context to the mineral extraction, contaminated land and groundwater assessments. The local solid geology is shown on Figure 23.4a, with key drift deposits (peat and river alluvium) highlighted on Figures 23.2a-h.

##### Solid Geological Succession

- 23.3.3 BGS geological maps indicate that along the route scheme, the bedrock is mainly composed of granite. The granite bedrock is a foliated muscovite-biotite granite of the Aberdeen. Metasediments comprising psammities, semipelites and subsidiary pelites with very scarce calc-silicate ribs are also present. A major fault trending southwest-northeast is indicated to run along the northern limit of the River Dee and is crossed by the proposed Southern Leg scheme.
- 23.3.4 To complement BGS published information, a preliminary ground investigation was carried out in May/June 2006. The dominant geological units encountered during ground investigation are shown on Figure 23.4a and are summarised below.
- 23.3.5 According to the preliminary ground investigation, the Southern Leg is characterised by the presence of schists at the northern end up to West Hatton (ch108780) but also at Hare Moss between ch204000 and ch206400. The remaining part of the Southern Leg would appear to be underlain by granite.
- 23.3.6 As there are no geological designations and the local geological strata are extensively represented elsewhere throughout the area, solid geology is considered to be of low sensitivity.

##### Rockhead Elevation

- 23.3.7 Based on the preliminary ground investigation, rockhead elevation contours have been produced (Figures 23.3a-h) indicating a variable rockhead surface.
- 23.3.8 The area around River Dee (ch102850) is characterised by a low rockhead elevation point of 0mAOD from which rockhead rises to the north up to 180mAOD at Brimmond Hill (ch111210) and to the south up to 80mAOD at Cleanhill Junction (ch100000). Rockhead elevation continues to rise towards the east up to a maximum of 120mAOD at Merchants Croft (ch201200).
- 23.3.9 This data indicates that rock generally follows the landform/topography.

##### Drift (Superficial) Deposits

- 23.3.10 Published geological maps indicate that the Southern Leg is mostly underlain by glacial till deposits with significant areas of glacial meltwater deposits, which is consistent with the results of the ground investigations.

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##### *Drift Composition*

- 23.3.11 The ground investigation uncovered the presence of peat, river alluvium and both cohesive (clay/silt-rich) and granular (sand and gravel) glacial deposits, as described in Table 23.6 below.

**Table 23.6 – Drift Composition Present**

Drift Material	Description
Glacial Deposits	Cohesive glacial (boulder clay) deposits – characterised by stiff, stony, sandy, clayey, diamicton with metamorphic and igneous clasts, typically massive, but stratified and more sandy locally.
	Granular glacial (meltwater) deposits – described as unsorted, generally unstratified, clay, sandy clay, or sand, usually containing many pebbles and boulders but locally almost stoneless.
River Alluvium	Loose to very dense deposits ranging from silty sands to coarse gravels.
Peat	Plastic, slightly sandy and fibrous.

- 23.3.12 The alluvial deposits along the River Dee are extensive and are flanked by meltwater deposits. River alluvium deposits are also encountered around Ord Burn (ch106100, to the south of Silver Burn). These areas are shown on BGS maps to represent a potential resource for sand and gravel. However, these alluvial deposits are not designated as sites of geological value and are considered to be of low to medium sensitivity.
- 23.3.13 Immediately east from Cleanhill Junction (ch100000), the drift map identifies a small section of alluvium followed by an outcrop of granite although this was not confirmed by the ground investigation.
- 23.3.14 Granular and cohesive glacial deposits are often interbedded and where this occurs these are referred to in the ES collectively as glacial deposits, being mixtures of sandy gravels, gravelly clay, cobbles and boulders. Glacial deposits are the most abundant drift material in the area, underlying the majority of the route. These are considered to be of low sensitivity.
- 23.3.15 The extensive logging undertaken during the preliminary ground investigation identified the following areas of the Southern Leg underlain by glacial deposits:
- from Denhead of Cloghill (ch109100) to Nether Beanshill (ch104000);
  - alluvium deposits on either site of the River Dee, extending from Milltimber (ch103000) to South Deeside Road (ch1019100); and
  - from Cleanhill Junction (ch100000) south to Greens of Crynoch (ch10450).
- 23.3.16 The ground investigation also uncovered the presence of peat cover extending farther into the proposed route than would be interpreted from the BGS drift map of the Hare Moss area (ch204500). The suspected extent of peat deposits at Hare Moss is shown on Figures 23.2a-b. Two walkovers inspections were undertaken at Hare Moss in November 2005 and July 2006. Hare Moss represents a degraded peat bog that appears to act as a seasonal wetland; very wet and water logged in winter times and significantly drier in summer times. A full description of the ecology and habitats is given in Chapter 25 (Ecology and Nature Conservation). Further details on the hydrogeology of Hare Moss are in paragraphs 23.3.39 to 23.3.40.
- 23.3.17 No made ground was encountered during the preliminary site investigation.

##### *Drift Thickness*

- 23.3.18 Drift thicknesses have been plotted using the preliminary ground investigation results and are presented on Figures 23.1a-h.

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23.3.19 The Southern Leg study area begins with drift thickness fluctuating between 3 and 5m from Brimmond Hill (ch111210) to Upper Beanshill (ch104200), except for a thinning to 2m at Gairnlea (ch107000). The deposits then thicken from Upper Beanshill to become 16m deep at the Dee (ch102850). From the River Dee, there is a gradual thinning from 16m to 6m by Cleanhill Junction (ch100000). The drift deposits then constantly reduce in depth to 2m at Merchant's Croft (ch201200), reducing to around 1m farther east, except in the vicinity of Charleston (ch206000) where it increases to 2m.

#### **Mineral Extractions**

23.3.20 No mineworkings or shaft locations were identified along the route alignment during the desk study. An absence of mining is consistent with the geological strata in the area.

23.3.21 Sand and gravel quarries have been identified and these are features of interest in relation to potential past landfilling and associated contamination (identified in the following section) and to potential future sand and gravel exploitations.

#### **Contaminated Land**

23.3.22 Information relevant to contaminated land is based on a desk study review of historical maps and consultations. Potential contaminated areas are indicated on Figures 23.5a-c and summarised in Table 23.7.

23.3.23 The main evidence of potential contamination along the Southern Leg is the former Brodaich Quarry adjacent to the proposed scheme, which has been backfilled with material of unknown origin and composition. The preliminary ground investigation trial pits, which were limited to the land take for the proposed scheme, did not confirm the presence of potential contaminated land features in the vicinity, described below.

23.3.24 The Quarry known as Quarry 1, at Whistlebrae, is represented by two ponds on the current OS map and it is therefore unlikely to have been fully backfilled. The presence of the pond prevented any ground investigation at this site.

23.3.25 Beyond the land-take required directly for the proposed scheme, but within the study area, the Bankhead landfill is noted to have been licensed for inert waste in 1998 and then for domestic and commercial waste in 2004. 'North of Fairley Quarry' and Gairnhill Quarry, both potentially backfilled with material of unknown nature and are also considered as potential significant contaminated land sites.

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**Table 23.7 – Potentially Contaminated Sites**

Potential contaminated land & location	Chainage	Desk study evidence	Ground investigation and laboratory testing
North of Fairley Quarry	Northwest of ch110900	Quarry indicated on 1901 historical map and no longer shown on current OS. May have been backfilled.	Not investigated
Derbeth Smithie	East of ch110680	The smithie was indicated in an 1856 map only.	Not investigated
Brodiach Quarry	Edge of ch108810	Marked in a 1900 map. Infilled by 1963.	Not investigated
Kingswells South	ch108500	None	Slightly acid pH (5.8)
East Kingsford Smithie	West of ch108500	Marked in a 1900 map not indicated in 1963 map.	Not investigated
Five Mile Garage	East of ch108500	Authorised in 1998. Still present	Not investigated
Gairnhill Quarry	West ch107800	Quarry indicated on 1963 historical map and no longer shown on current OS. May have been backfilled.	Not investigated
East Silverburn Mill	West of ch106430	Saw mill Marked in a 1900 map. Still present	Not investigated
Beans Hill	ch106000	None	Acid pH (5.0)
Hill of Milltimber	ch105700	None	Slightly acid pH (5.8)
Milltimber Telex Substation	Northeast of ch103100	Electrical substation (part of telephone exchange) labelled as such on historical maps between 1963 and 1971. The building is still present.	Not investigated
Deeside Old Railway Line	ch102905	Marked in maps from 1901 – 1963. No longer present.	Not investigated
Milltimber Station	East ch102820	Railway station labelled on historical maps from 1901 up to 1963. The building is still present.	Not investigated
Camphill	ch102200	None	Slightly basic pH (8.0)
River Dee	ch102600	None	Slightly basic pH (8.4)
Kingcausie Quarry 2	East of ch101860	Marked in maps from 1900 – 1963. No longer present	Not investigated
Kingcausie Infilled Cistern	East of ch101640	Marked in an 1880 map. No longer present	Not investigated
Millbank Corn Mill	West of ch101630	The Corn Mill is still indicated on OS maps.	Not investigated
Cleanhill Saw Mill and Pond	East of ch100880	Marked in maps from 1900. No longer present	Not investigated
Cleanhill Junction	ch100000	None	Slightly acid pH (5.7)
Burnhead Smithie	ch200550	Marked in a 1900 map. Still present	Not investigated
Quarry 1 – Whistlebrae	ch205740	This quarry was labelled as old since the second Ordnance Survey Edition. By 1962, two ponds only remained. Those ponds are still evident on the current OS.  This quarry is unlikely to be fully backfilled. The presence of the pond prevented any ground investigation at this site.	Not investigated



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Potential contaminated land & location	Chainage	Desk study evidence	Ground investigation and laboratory testing
Bankhead Landfill	South of ch205520	Domestic commercial industrial waste License No. WML/N/20164 issued in 1998. Inert waste License No. WML/N/20143/97 Issued in 1997. Register of PPC part B processes, 31 May 2004	Not investigated

- 23.3.26 Uranium is naturally occurring in the Aberdeenshire granite. A BGS search indicated that sediment samples had levels of uranium range from 5 to 34ppm in the Milltimber area. Sediment samples taken from the Crynoch Burn, approximately 0.4km west of the proposed scheme, exhibit a level of 8ppm of uranium. Burnhead Burn, which lies within the AWPR scheme boundary, shows levels of 12ppm. Approximately 5km west of the AWPR, sediment from a tributary to the River Dee, running through Moss-side plantation, exhibits uranium levels of 22ppm. The highest recorded level of 34ppm in this area shown on BGS plans is located further upstream of the tributary flowing through Moss-side plantation, approximately 4.7km to the west of the AWPR. These levels are not considered to present a risk to human health during construction of the proposed scheme, based upon the accepted levels of 30ppm for safe drinking water (US EPA 2006) and the USEPA PRG (Preliminary Remediation Goals which combine exposure information assumptions with EPA toxicity data) data which suggests that a maximum level of 204ppm is acceptable for undertaking industrial works. This naturally uranium-enriched material is not subject to the Radioactive Substance Act 1993 (RSA) and will therefore be treated in the same way as any other soil, which is considered to be harmless unless proven otherwise.

#### Groundwater

- 23.3.27 The crystalline igneous and metamorphic rocks present beneath the Southern Leg study area do not have the capacity to store or transmit large volumes of water, although some limited potential may exist in cracks and joints opened by weathering close to rockhead.
- 23.3.28 The alluvial deposits present around the major watercourses crossed by the proposed scheme and significant deposits of glacial sand and gravel deposits may represent shallow aquifers capable of producing small scale private supplies. Groundwater in local drift deposits may also support important ecological resources, such as areas of peat.

#### Groundwater Resources

- 23.3.29 Historical maps show that numerous wells were present along the route and many of them remain in use today. Figures 23.2a-h show the wells currently in use, based on information collected by means of consultation with the local authority, consultation with landowners and information gathered during hydrological walkovers (Chapter 24: Water Environment). These are for domestic water supply and/or agricultural use as identified in Table 23.9 and Appendix A23.1. Although the study area for the assessment extends to approximately 250m either side of the proposed route, the wells have been listed within a distance of 1km to identify potential areas of high well density. This list is given in Table 23.9.
- 23.3.30 Several areas of high well density have been identified at the following locations and are defined on Figures 23.2a-h.
- Derbeth, between ch110902 and ch111000;
  - Moss of Auchlea and Blacktop, between ch108000 and ch16100;
  - Along the River Dee, to the west of the proposed scheme;
  - Kingcausie, between ch10200 and ch10100;
  - Hill of Blairs, between ch201300 and ch202400; and
  - Bishopton, between ch202800 and ch203500.

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- 23.3.31 Two natural springs are evident within the Southern Leg study area in the vicinity of the proposed route. One of them is adjacent to the River Dee near Kincairn House (ch101980) located at 930m from the proposed route. The second spring is located near the Moss of Auchlea (ch107500) and located some 350m from the proposed route.
- 23.3.32 To the west of the proposed route (ch104200), near the A93 Millitimer Junction, an unknown number of springs were identified through landowner consultation in the field around Nether Beanshill house. These springs are not currently used for water supply.
- 23.3.33 A walkover inspection was undertaken on 19th July 2006 around Moss of Auchlea. Located in a topographical low-point, this site remains wet despite the surrounding agricultural fields and drainage features and is expected to be extremely wet during winter. It supports a wetland and scrub woodland habitat. Properties around the Moss of Auchlea generally rely on springs and wells for their private water supply, with spring lines occurring along the slopes of Kingshill Wood intercepted and canalised for private water supply purposes.
- 23.3.34 Groundwater in many areas of the Southern Leg is considered to be of medium to high sensitivity due to the presence of wells/springs. Sensitivities are listed in Table 23.9 of Section 23.4 (Potential Impacts).
- 23.3.35 Private water supply questionnaires completed in April/May 2007 as part of the ongoing landowner consultation and incorporated within this assessment are provided in Appendix A23.1.

#### Groundwater Pattern

- 23.3.36 Approximately 45 boreholes were installed for groundwater monitoring during the preliminary ground investigations. Groundwater levels recorded in these boreholes have allowed groundwater level contour plans to be produced (Figures 23.2a-h).
- 23.3.37 Groundwater flow is mostly influenced by the topography, with flow from high to low areas. Groundwater levels fluctuate between 150mAOD and 20mAOD along the Southern Leg study area.
- 23.3.38 The general direction of groundwater flow is southwards from Brimmond Hill (ch111210) and northwards from Cleanhill Junction (ch100000) towards the River Dee with occasional interaction with smaller watercourses. Between Cleanhill Junction and Charleston, the elevation of the Hill of Blairs constitutes a groundwater flow divide and localised artesian conditions were encountered in the vicinity of Burnhead and Cleanhill Wood.

#### Groundwater Supporting Sensitive Habitats

- 23.3.39 Hare Moss is indicated in paragraph 23.3.16 to be a degraded peat bog site with groundwater level and quality considered to be key parameters to the functioning of this peat bog. An airfield for model aeroplanes is present in the northwestern part of Hare Moss. The walkover surveys (November 2005 and July 2006) indicated that Hare Moss relies on direct rainfall and from surface water inflow from ditches to the south. The site is also bordered by a ditch (Jameston ditch) along the northern boundary and the Burn of Ardoe along the eastern boundary. Although groundwater flow towards Jameston ditch is limited by the presence of a peat bund, it is still believed to take place during the summer months, because of the hydraulic gradient difference between water on the site and in the Jameston ditch. In addition, the peat bund is locally interrupted to the east of the airfield and a significant amount of water was noted to drain from Hare Moss to this ditch. The southern ditches drain from agricultural fields and bring nutrient-rich water into the moss. Further information on the ditches surrounding Hare Moss is given in Chapter 24 (Water Environment).
- 23.3.40 Although groundwater levels at Hare Moss appear to have declined due to long term agricultural drainage, which is confirmed by the presence of well established trees within the centre of the site, this site has been informally recognised as a site to be protected and restored. For these reasons, Hare Moss is of high sensitivity.

Groundwater Sensitivity

23.3.41 Groundwater is generally considered to be of low sensitivity in this region. However, where wells and ecological areas of interest supported by groundwater are in the vicinity of the route, sensitivity is considered to be moderate to high. Wells are listed in Table 23.9.

**23.4 Potential Impacts**

**Geology**

Solid Geological Succession

23.4.1 Table 23.8 below details the excavations required for the proposed Southern Leg scheme. This table indicates that several excavations are likely to reach the solid geology.

**Table 23.8 – Excavated Areas**

Road cuttings	Chainage	Maximum Excavation Depth (mbgl)	Average Drift Thickness (mbgl)	Excavation Reaches Solid Geology
Charleston	ch206050-206550	9.3	1-2	Yes
Hare Moss	ch205250-205500	6.1	2	Yes
Hill of Blairs	ch201300-202750	14.7	1.5-3	Yes
Blaikiewell	ch200450-200800	4.9	6-5	No
Cleanhill Wood	ch100350-100850	14.5	8-10	Yes
Crynoch	ch101400-101600	1.27	13	No
Milltimber	ch102850-105900	14.6	4-10	Yes
Gairnhill Wood	ch106750-107150	6.2	4-5.5	Yes
South Kingswells	ch107650-108350	3.5	2-4	Yes
South Kingswells 2	ch108800-109100	6.0	4	Yes
Coghill	ch109350-109900	16.3	3	Yes
Derbeth	ch110300-111300	18.5	3	Yes

23.4.2 The solid geology is considered to be of low sensitivity. The impact magnitude, given the extent of the same strata types across the area, is negligible, and the overall significance of impacts on solid geology is therefore assessed as Negligible.

*Impact of Blasting*

23.4.3 It is anticipated that rock blasting may be required where cuttings extend into bedrock. Although no areas of geological interest have been identified, blasting may impact on the hydrogeological characteristics of the rock mass. The potential impacts from blasting in terms of disruption are addressed in Chapter 33 (Disruption due to Construction).

23.4.4 There are three major mechanisms whereby 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 along unfavourably oriented joints and fracture surfaces.

23.4.5 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 promotions of slippage along unfavourably oriented joints can occur several hundreds of metres from the blast (termed 'far-field' effects).

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- 23.4.6 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 accrue if the contractor opts for the use of explosives in the excavation of the cuttings where there are sensitive receptors and potentially significantly contaminated sites in relatively close proximity. There are two locations at potential risk in the Southern Leg; at Crynoch and Gairnhill Wood cuts where the water table (groundwater) will be above the final base of the cuttings, several private water supplies are present, and Kingcausie Quarry 2 and Gairnhill Quarry are respectively located adjacent to the two cuttings as shown on Figures 23.2d, 23.2f and 23.5b, 23.5c. Consequently, this area is considered of medium to high sensitivity and the blasting magnitude of impact is considered as medium. The overall significance of impact is Moderate. In all other areas, the significance of impact of blasting on the rock mass is expected to be Slight to Negligible.
- 23.4.7 Utilities/services such as gas and water mains, power cables, and pylons may be subject to vibration impacts from blasting. Allowable vibration limits set by service providers/utility companies will be relatively low, typically 10-15mm/sec.
- 23.4.8 Further detail and identification of further studies required in the next phase of the development are described in Appendix A8.2 (Blasting Assessment).

#### Drift (Superficial) Deposits

- 23.4.9 Table 23.8 above indicates that excavations are likely to affect the drift deposits, in some cases extensively. The sensitivity of drift deposits (dependant on the nature of the drift), and the magnitude of predicted impact (dependant on the depth of cutting and the drift deposit thickness) vary from one cutting to another and are considered further below.
- 23.4.10 Glacial deposits underlie the majority of the route and are of low sensitivity. The impact magnitude of excavating through glacial deposits is estimated to be negligible to low. The overall significance of impact is therefore assessed to be Negligible to Negligible/Slight.
- 23.4.11 River alluvium occurs along the River Dee and Ord Burn and is considered to be of low to medium sensitivity since those deposits are classified by the BGS as potential sand and gravel resources. The magnitude of impact is estimated to be negligible to low, as the impact will be very localised, and the overall significance of impact is therefore assessed as Slight.

#### **Mineral Extraction**

- 23.4.12 The only mineral extraction areas identified were past and potential future sand and gravel quarries.
- 23.4.13 Impacts associated with former quarries and quarries used for infilling or landfill with potentially contaminated material are discussed in the following section.
- 23.4.14 Impacts related to potential future sand and gravel quarries (river alluvium) have been discussed in the previous section and were found to be Slight.

#### **Contaminated Land**

- 23.4.15 Areas of contaminated land are not environmentally sensitive receptors. However, there is potential for contaminated land to impact on human health and other environmental receptors, particularly during the construction phase, and this is dependant on the type of contamination present.

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- 23.4.16 The proposed road scheme is not expected to have any direct interaction with the areas of contaminated land located away from the road, therefore assessment of direct human interaction with contaminated land focuses on areas of potential contamination encountered on or immediately adjacent to the proposed Southern Leg scheme. Gross contamination (significant levels of contamination likely to cause harm to the environment and human health) was not identified during the preliminary ground investigation.
- 23.4.17 Historical evidence suggests the presence of Brodiach Quarry located on the western edge of the route and Quarry 1 along the route. The nature of backfilled material is unknown at this stage.
- 23.4.18 As explained in paragraph 23.3.26, the levels of uranium, in naturally enriched material, are low and no impact is expected on human health.

#### **Groundwater**

- 23.4.19 The impacts on groundwater are considered in relation to the presence of private groundwater supplies and/or ecological receptors supported by groundwater, and their proximity to the proposed road scheme.

#### Groundwater Quality

- 23.4.20 In the event of an accidental road spillage, particularly during construction, contamination may either migrate through the unsaturated zone or discharge directly into groundwater in cuttings, and impair groundwater quality. The magnitude of impacts on groundwater quality is determined as moderate where embankments or grade sections are proposed, and determined as high in areas of proposed road cuttings.
- 23.4.21 As a result, impacts of Substantial to Moderate significance have been identified in several locations, if no appropriate mitigation measures are taken. These areas include wells and springs present in the vicinity of Bishopton, Hill of Blairs cutting, to the south of River Dee, Nether Beanshill, Blacktop, the Moss of Auchlea, Derbeth, Burnhead and Ferniebrae. In addition, the proposed road junction near Derbeth may impact on well S52.
- 23.4.22 Springs along the River Dee are distant from the proposed scheme and as a consequence a negligible significance of impact is predicted. The spring located in the vicinity of Moss of Auchlea is located near to wells S44, to S49 (ch107500). The comments made on wells S44 to S49 in Table 23.9 are thus also relevant for this spring. Springs located in proximity of the Phillips Cottage and used as private water supplies are assessed in Table 23.9 and a Negligible significance of impact is predicted in relation to groundwater quality.
- 23.4.23 Shallow groundwater, mainly in areas covered by sand and gravel or peat deposits, is at risk from the same contaminated run-off and spillages as surface waters, as covered in detail in Chapter 24 (Water Environment). However, the potential impact is reduced because groundwater does not take direct discharge from the road, unlike watercourses, and would only be impacted upon if the road drainage design was inadequate to collect all run-off and overspill onto adjacent land occurred. Any potential groundwater quality impacts are therefore predicted to be temporary and of low magnitude. Given the low sensitivity of groundwater in the study area, the overall impact has been assessed to be Negligible to Slight significance.
- 23.4.24 Table 23.9 provides a list of wells and springs, including those identified during results of the private water supply consultation obtained during April and May 2007, and a summary of the potential impacts on the groundwater quality in the absence of mitigation measures.

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**Table 23.9 – Potential Impacts on Wells/Springs**

Well/ Spring No	Well/Spring Location	Well/Spring Distance from AWPR (m)	Well/ Spring Sensitivity	Borehole/ Spring Elevation (mAOD)	Existing Elevation at Proposed Road (mAOD)/direction of land gradient fall from AWPR	Proposed Elevation of Road/ Cutting – Embankment	Significance of impact	Comments from landowners consultation
S1	Woodside Farm	909m to the North	Negligible	125	107/South	111/Embankment	Negligible/Slight	N/A
S2	Little Bishopton	0m	High	115	115/Northeast	116/Embankment	Moderate/ Substantial	Bishopton Farm uses 1 single well of about 15 feet (4.6 m) deep. Usually the well does not run out during dry periods, but the water level is quite low. It used for both cattle and domestic use. Water quality analysis is undertaken each year and the results can be seen.
S3	Bishopton	149m to the South	High	118	117/Northeast	117/Cutting	Substantial	Included in comment for S2
S4	Bishopton Cottage	248m to the South	Medium	120	117/Northeast	117/Cutting	Moderate/ Substantial	Included in comment for S2
S5	Sunnyside	810m to the South	Negligible	131	115/Northeast	116/Embankment	Negligible/Slight	N/A
S6	Greenloaning	116m to the North	High	122	126/Northeast	118/Cutting	Substantial	No further data is available at this stage. A letter was sent and the consultation is on going.
S7	Merchants Croft/ Birkenbraes	231m to the South	Medium	124	129/Southwest	116/Cutting	Moderate/ Substantial	No further data is available at this stage. A letter was sent and the consultation is on going.
S8	Mains of Potenlow	743m to the South	Negligible	120	130/West	115/Cutting	Slight	N/A
S9	Ferniebrae	17m to the South	High	115	112/West	108/Cutting	Substantial	No further data is available at this stage. A letter was sent and the consultation is on going.
S10	Craigend School	397m to the North	Negligible because the well is no longer used	95	88/West	90/Embankment	Slight	There is evidence of a former well, a possible spring and a wet area.

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Well/ Spring No	Well/Spring Location	Well/Spring Distance from AWPR (m)	Well/ Spring Sensitivity	Borehole/ Spring Elevation (mAOD)	Existing Elevation at Proposed Road (mAOD)/direction of land gradient fall from AWPR	Proposed Elevation of Road/ Cutting – Embankment	Significance of impact	Comments from landowners consultation
S11	Eastland Cottage	363m to the East	Low	68	59/Northwest	65/Embankment	Slight/ Moderate	Several springs and 1 abandoned well are present, in addition to springs and a wet- boggy area. Substantial details have been given regarding this property and these details are given in appendix A23.1
S12	Glenburnie	578m to the West	Negligible	62	53/East	58/Embankment	Negligible/ Slight	N/A
S13	Parkhead Cottage	1272m to the West	Negligible	63	50/North	51/Embankment	Negligible/ Slight	N/A
S14	Parkhead Farm	1322m to the West	Negligible	63	47/North	46/Cutting	Slight	N/A
S15	Philips Cottage Kingcausie	413m to the East	Low	73	51/West	53/Embankment	Slight/Moderate	N/A
S16	Collie Vallach Kingcausie	413m to the East	Low	75	48/West	48/Embankment	Slight/Moderate	N/A
S17	Rumlin Fauld Kingcausie	413m to the East	Low	75	48/West	48/Embankment	Slight/Moderate	N/A
S18	Kingcausie Maryculter	165m to the East	High	18	43/Northwest	41/Cutting	Substantial	Comments included in S11
S19	Milton Bridge/Corbie Park	83m to the West	High	19	26/Northwest	30/Embankment	Moderate/ Substantial	Comments included in S11
S20	Templars Park	1553m to the West	Negligible	38	13/North	25/Embankment	Negligible/Slight	N/A
S21	Kincairn House	363m to the East	Low	21	26/Northwest	30/Embankment	Slight/Moderate	N/A
S22	Inchferry House	958m to the West	Negligible	14	19/Northeast	21/Embankment	Negligible/Slight	N/A
S23	Boathouse Inchferry	876m to the West	Negligible	14	37/Northeast	26/Cutting	Slight	N/A
S24	Broomvale Inchferry	694m to the West	Negligible	14	17/Northeast	21/Embankment	Negligible/Slight	N/A

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Well/ Spring No	Well/Spring Location	Well/Spring Distance from AWPR (m)	Well/ Spring Sensitivity	Borehole/ Spring Elevation (mAOD)	Existing Elevation at Proposed Road (mAOD)/direction of land gradient fall from AWPR	Proposed Elevation of Road/ Cutting – Embankment	Significance of impact	Comments from landowners consultation
S25	Kintewline	1272m to the East	Negligible	42	25/North	28/Embankment	Negligible/Slight	N/A
S26	Nether Lands	1371m to the East	Negligible	30	13/North	25/Embankment	Negligible/Slight	N/A
S27	Culter House	529m to the West	Negligible	80	79/Southeast	71/Cutting	Slight	N/A
S28	Nether Beanshill	83m to the East	Negligible	86	94/Southeast	87/Cutting	Slight	The property is on mains supply. There is a well but this is no longer used. There are also a number of springs to the west of the proposed route, in the field around the farmhouse. These springs are not used.
S29	Woodend 1	1652m to the West	Negligible	85	94/Southwest	85/Cutting	Slight	N/A
S30	Woodend 2	1504m to the West	Negligible	85	89/Southwest	79/Cutting	Slight	N/A
S31	Benview	1636m to the West	Negligible	90	88/Southwest	16/Cutting	Slight	N/A
S32	Binghill Farm Cottage	876m to the East	Negligible	138	107/Southeast	102/Cutting	Slight	N/A
S33	Westfield Lodge	694m to the East	Negligible	88	109/Southeast	108/Cutting	Slight	N/A
S34	Hilton / Foggieton	1520m to the East	Negligible	100	104/Southeast	103/Cutting	Slight	N/A
S35	East Brotherfield	710m to the West	Negligible	85	89/South	101/Embankment	Negligible/Slight	N/A
S36	Broomfold	1520m to the West	Negligible	105	124/South	125/Embankment	Negligible/Slight	N/A
S37	Silverburn	727m to the West	Negligible	105	115/South	178/Embankment	Negligible/Slight	N/A
S38	East Silverburn	198m to the West	Medium	92	109/South	115/Embankment	Moderate	MA requested that the land owner be not contacted.



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Well/ Spring No	Well/Spring Location	Well/Spring Distance from AWPR (m)	Well/ Spring Sensitivity	Borehole/ Spring Elevation (mAOD)	Existing Elevation at Proposed Road (mAOD)/direction of land gradient fall from AWPR	Proposed Elevation of Road/ Cutting – Embankment	Significance of impact	Comments from landowners consultation
S39	Broomwood	17m to the West	High	100	109/Southwest	115/Embankment	Moderate/ Substantial	Water supply is taken from a well. The water quality is checked every 2 years and is considered to be slightly acidic due to pipe material, limestone sometimes added to neutralise it. The water never run out even through severe drought a few years ago.
S40	Broomwood Farm	150m to the East	High	114	98/Southwest	111/Embankment	Moderate/ Substantial	One well is used as domestic water supply and for cattle. The water never runs out.
S41	Gairnlea Blacktop	33m to the East	High	120	121/Southwest	123/Embankment	Moderate/ Substantial	Comments included in S39.
S42	Broomhill, Blacktop	83m to the East	Negligible	150	135/Southwest	131/Embankment	Negligible	No well is recorded on this property. A septic tank and soakaway are recorded in the north west corner. A watermain is recorded directly west of tank and soakaway.
S43	Loracin, Upper Fifeshill	876m to the East	Negligible	185	139/Southwest	146/Embankment	Negligible/Slight	N/A
S44	Craigluig	182m to the East	Medium	~150	141/Southwest	147/Embankment	Moderate	No further data is available at this stage. A letter was sent and the consultation is on going.
S45	Byways	116m to the East	High	~150	147/Southwest	149/Embankment	Moderate/ Substantial	No further data is available at this stage. A letter was sent and the consultation is on going.
S46	Invermoriston	132m to the East	High	~150	151/Southwest	150/Embankment	Moderate/ Substantial	No further data is available at this stage. A letter was sent and the consultation is on going
S47	West Auchlea	1090m to the West	Negligible	128	139/South	146/Embankment	Negligible/Slight	N/A
S48	Auchlea	595m to the West	Negligible	140	142/South	148/Embankment	Negligible/Slight	N/A

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Well/ Spring No	Well/Spring Location	Well/Spring Distance from AWPR (m)	Well/ Spring Sensitivity	Borehole/ Spring Elevation (mAOD)	Existing Elevation at Proposed Road (mAOD)/direction of land gradient fall from AWPR	Proposed Elevation of Road/ Cutting – Embankment	Significance of impact	Comments from landowners consultation
S49	Moss Side Of Auchlea	264m to the West	Low	140	150/South	150/Cutting	Moderate	No further data is available at this stage. A letter was sent and the consultation is on going.
S50	Upper Kingshill	1685m to the East	Negligible	150	154/East	150/Cutting	Slight	N/A
S51	Woodcote	710m to the West	Negligible	124	154/North	150/Cutting	Slight	N/A
S52	Fairley Home Farm	181m to the East	Medium	160	180/East	176/Cutting	Moderate/ Substantial	No further data is available at this stage. A letter was sent and the consultation is on going.
S53	Derbeth Farm	330m to the East	Low	163	186/East	176/Cutting	Moderate	No further data is available at this stage. A letter was sent and the consultation is on going.
S54	West Brimmondside	793m to the West	Negligible	175	173/Southeast	175/Embankment	Negligible/Slight	N/A
S55	Dykeside	215m to the East	Medium	153	175/East	171/Cutting	Moderate/ Substantial	No further data is available at this stage. A letter was sent and the consultation is on going.
S56	Milltimber	Exact location unknown – possibly adjacent to the proposed road	High	unknown	47/South	38/Cutting	Moderate	A well or spring is present in the land owned by the International School in Aberdeen, but the water supply itself is owned by Milltimber Farm.
S57 2 wells	Burnhead	75m to the south	Negligible	80	63/South	66/Cutting	Negligible/Slight	Included in comments for S10.
S58	Charleston	100m to the north	High	90	98/North East	103/Embankment	Moderate/ Substantial	Private water supply is taken from a well of 107 feet deep. The water level is approximately 60 feet below ground level.
S59	Hare Moss	100m to the north	High	110	104/North	110/Embankment	Moderate/ Substantial	A well is used as private water supply. The water never runs out and supplies only this property - Water is used for cattle and potentially for domestic supply.

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Well/ Spring No	Well/Spring Location	Well/Spring Distance from AWPR (m)	Well/ Spring Sensitivity	Borehole/ Spring Elevation (mAOD)	Existing Elevation at Proposed Road (mAOD)/direction of land gradient fall from AWPR	Proposed Elevation of Road/ Cutting – Embankment	Significance of impact	Comments from landowners consultation
S60	Ferniebrae	150m to the north	High	100	108/North East	105/Cutting	Substantial	No further data is available at this stage. A letter was sent and the consultation is on going.
S61	Invermoriston	180m to the East	Medium	175	156/East	151/Cutting	Moderate/ Substantial	No further data is available at this stage. A letter was sent and the consultation is on going.
S62	Cleanhill Wood	400m to the Northeast	Negligible	98	74/South	80/Embankment	Negligible/Slight	Included in comments for S11
S63	Phillips Cottage Kingcausie	530m to the Northeast	Negligible	95	59/Northwest	64/Embankment	Negligible	Included in comments for S11

N/A: No landowner consultation was carried out for these properties because wells are distant from the proposed route scheme and will not be affected

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#### Groundwater Flow

- 23.4.25 Local groundwater flows and levels can be affected in areas of deep road cutting that extend below local groundwater levels. The resultant dewatering of the groundwater bodies into the road drainage and locally reduced groundwater levels can affect habitats sustained by groundwater (e.g. wetlands), groundwater abstractions and in extreme cases can significantly reduce low flows in watercourses.
- 23.4.26 Table 23.10 indicates that several cuttings along the Southern Leg are likely to affect groundwater flow. Within areas of cutting, the potential impact on local groundwater level is considered to be of medium magnitude, due to possible localised dewatering. The highest potential impacts are expected at the Hill of Blairs, Burnhead, Milltimber, Gairnhill Wood and Derbeth cuttings, with impact significances ranging from Slight/Moderate to Moderate/Substantial.

**Table 23.10 – Potential Impact of Cuttings on Groundwater Flow**

Cuttings	Groundwater Parameters			Groundwater Affected by Cutting/ Impact Magnitude	Receptor(s) Sensitivity	Significance
	Max depth (mbgl) of cutting	Local monitoring	Estimated elevation of groundwater mAOD/mbgl			
Charleston	9.3	Yes	110-115/3-7.0	Yes: The excavation intercepts groundwater/ medium.	Low	Slight/Moderate
Hare Moss	6.1	No	105-115/1-2.5	Yes: Estimated groundwater level likely to be intercepted by excavation/ medium.	High: S59 near the cutting	Moderate/ Substantial
Hill of Blairs	14.7	Yes	110-120/ 2-4	Yes: Most of the excavation intercepts groundwater/ medium.	High: Four wells (wells S6, S7, S9 and S60) in the vicinity of the cutting	Moderate/ Substantial
Burnhead	4.9	No	80-90/2.2-3	Yes: Estimated groundwater level likely to be intercepted by excavation/ medium.	High: Two adjacent wells (S57) in the vicinity of the cutting	Moderate/ Substantial
Cleanhill Wood	14.5	No	15-30/0-1.5	Yes: Deep cutting likely to intercept groundwater/ medium.	Medium: two distant springs (S11 and S63)	Moderate
Crynoch	1.27	No	15/1.5	Yes/no: Based on the information currently available, it is uncertain whether the cutting will intercept groundwater level/ low to medium.	Medium: one distant well (S19).	Moderate

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Cuttings	Groundwater Parameters			Groundwater Affected by Cutting/ Impact Magnitude	Receptor(s) Sensitivity	Significance
	Max depth (mbgl) of cutting	Local monitoring	Estimated elevation of groundwater mAOD/mbgl			
Milltimber	14.6	Yes	40-120 / 3-4	Yes: Most of the excavation intercepts groundwater/ medium.	High: one well is potentially adjacent to the proposed scheme (S56) Three distant wells (S27, S32 and S33)	Moderate/ Substantial
Gairnhill Wood	6.2	Yes	135-140/ 1.0-1.5	Yes: Most of the excavation intercepts groundwater/ medium.	High: well S42 in the vicinity One distant well from the cutting although adjacent to the route (S41).	Moderate/ Substantial
South Kingswells	3.5	Yes	140-145/ 4.0-6.0	No: groundwater level should not be intercepted by the cutting/ low.	Medium: wells in the vicinity of the beginning of the cutting where groundwater is not intercepted (S45, S46 and S49) and one potential spring/well (South +1) 200m to the east of the cutting.	Moderate
South Kingswells 2	6.0	Yes	130-140/ 4.5-5.5	Yes: The cutting is expected to intercept locally groundwater level/ medium.	Low	Slight/Moderate
Cloghill	16.3	Yes	150/6.0	Yes: Most of the excavation intercepts groundwater/ medium.	Low	Slight/Moderate
Derbeth	18.5	No	150/5.0	Yes: Estimated groundwater level likely to be intercepted by excavation/ medium.	High: one well in the vicinity (S55). One distant well (S53)	Moderate/ Substantial

Groundwater Supporting Sensitive Habitats

23.4.27 The Southern Leg will pass along the southern edge of Hare Moss, which was defined in paragraph 23.3.39 as being of high sensitivity. The proposed scheme passes to the south of Hare Moss, between the moss and its inflowing surface water features. Consequently, there is a potential for the road to alter the water balance in the moss. The magnitude of impact on the water balance is considered to be low to medium and the impact assessed as moderate to Substantial significance. Significance of impact on the ecology of Hare Moss is assessed in Chapter 25 (Ecology and Nature Conservation).

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- 23.4.28 In addition, road drainage is designed to outfall in Jameston Ditch. There is a hydraulic link between Hare Moss and Jameston Ditch and the road drainage outfall has consequently been located downstream of the Moss. The hydraulic link between Hare Moss and Jameston Ditch may require further investigation to establish its precise nature. Potential impacts on water quality and quantity on Hare Moss are anticipated to be low to moderate. Significance of impacts is therefore defined as Moderate/Substantial. Further investigation of the hydrological functioning of the moss will be required to input to the detailed design of the proposed scheme at this location.

#### Groundwater Flow and Potential Contaminated Land

- 23.4.29 There are areas along the Southern Leg study area where the groundwater zone of influence of road cutting (i.e. disturbance of groundwater flow caused by dewatering) may reach areas of potentially significant contaminated land (i.e. landfills or backfilled quarries), which could result in contamination flowing towards groundwater receptors, namely private water supplies, but also towards human receptors (construction workers operating during the construction phase). Where this occurs, there is potential for humans to come into direct contact with contamination transported by groundwater and issuing from contaminated land located away from the proposed road. Those areas are discussed below.

#### *Bankhead Landfill*

- 23.4.30 Bankhead Landfill is located approximately 150m to the south of Hare Moss cutting. At present, local groundwater flow is likely to be southwards, away from the proposed route. The material buried at Bankhead Landfill includes domestic and industrial wastes and the groundwater could be significantly contaminated (high magnitude of impact). Hare Moss cutting has been assessed as intercepting groundwater level and in consequence the direction of groundwater may be changed, potentially draining contaminated groundwater towards the cutting. However there are no private water supply wells or sensitive ecological receptors recorded within the immediate area (the nearest groundwater supply is located on the other side of the proposed scheme) and for that reason groundwater is of low sensitivity. The resulting significance of impact is therefore assessed as Moderate on groundwater. Humans are also at risk from contact with potentially contaminated groundwater.

#### *Brodaich Quarry*

- 23.4.31 Brodaich Quarry (backfilled with unknown material) is located approximately 20m to the east of the South Kingswells 2 cutting. Based on Table 23.10, groundwater is likely to be intercepted by the cutting. At present, groundwater flow is likely to be towards the proposed route and consequently groundwater flow direction will not be modified. There are no private water supply wells or sensitive ecological receptors recorded within the immediate area so groundwater is low in sensitivity. The fact that groundwater flow direction will not be changed implies that the magnitude of impact on groundwater will be low, resulting in an overall Slight significance of impact for groundwater. However, there is potential risk of contact with contaminated groundwater by construction workers.

#### *Kingcausie Quarry 2 and Kingcausie cistern*

- 23.4.32 Kingcausie Quarry 2 and the Kingcausie infilled cistern are located some 100m and 260m to the northeast of Crynoch cutting respectively. At present, groundwater generally flows to the north-northwest, towards the River Dee. Based on the findings detailed in Table 23.10, it is uncertain whether the cutting will slightly intercept the resting groundwater level or not. The groundwater flow disturbance is therefore likely to be localised (low magnitude of impact). Several private water supply wells are present within the immediate area (high sensitivity) and contaminant migration from the infilled cistern via groundwater towards some of these wells is possible. Impacts upon groundwater flow associated with the use of blasting in relatively close proximity to contaminated sites are discussed in 23.4.8. The resulting significance of impact is assessed as Moderate on groundwater. Humans are also at risk of contact with potentially contaminated groundwater.

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##### *Gairnhill Quarry*

- 23.4.33 Gairnhill Quarry is located approximately 120m to the east of Gairnhill Wood cutting. At present, localised groundwater flow is likely to be west to the proposed route and is likely to be intercepted by the cutting. A private water supply well is present between the proposed route and Gairnhill Quarry (high sensitivity). Although the groundwater flow direction is not anticipated to change (low magnitude), the gradient may be increased by the cutting and potential contamination issuing from Gairnhill quarry may migrate closer to the private well and the road cutting. Impacts upon groundwater flow associated with the use of blasting in relatively close proximity to contaminated sites are discussed in 23.4.8. The resulting significance of impact is assessed as Moderate on groundwater. Construction workers are also at risk from contact with potentially contaminated groundwater.

##### *'North of Fairley' Quarry*

- 23.4.34 'North of Fairley' Quarry is located approximately 260m to the northwest of the Derbeth cutting. Groundwater flow is likely to be towards the east, towards the proposed route, and groundwater is likely to be intercepted by the cutting. No change in groundwater direction is anticipated (low magnitude). There is a private water supply well on the opposite side of the proposed route to the quarry (low sensitivity). Contamination will therefore be prevented from migrating to the well. Significance of impact on groundwater is assessed as Slight. However, humans are at risk from contact with potentially contaminated groundwater.

## 23.5 Mitigation

- 23.5.1 The mitigation measures described below are proposed to minimise or eliminate the potential impacts on geology, contaminated land and groundwater arising from the Southern Leg.

### **Solid Geology**

- 23.5.2 The assessment indicates potentially Negligible impacts with respect to the local solid geology and therefore no mitigation measures are required.
- 23.5.3 However, as noted in Section 23.4 (Potential Impacts), rock blasting has the potential to impact on the hydrogeology by creating or changing groundwater pathways, and on utilities/services due to vibration. In Crynoch and Gairnhill Wood cuts, identified potentially at risk in paragraph 23.4.8, mitigation measures during construction, should blasting be undertaken, will include the use of technical methodologies such as use of low-explosive loading densities, following current British Standards and regulations. These technical considerations are provided in Appendix A8.2 (Blasting Assessment).

### **Drift Deposits**

- 23.5.4 As Negligible to Negligible/Slight impact significance is predicted for the drift deposits, no mitigation measures are required.
- 23.5.5 Mitigation measures relating to Hare Moss are discussed in Chapter 24 (Water Environment).

### **Contaminated Land**

- 23.5.6 Any hazardous contaminated made ground/backfill encountered during the earthworks required for construction of the proposed scheme will be treated or removed to avoid risks to site construction workers. This material is generally unsuitable for construction for geotechnical reasons. Areas where further investigation will be needed as part of the mitigation strategy are identified below.

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- 23.5.7 The proposed scheme may cross a number of areas of suspected contaminated ground, as discussed in the previous sections. Although no areas of gross contamination, which may present significant human health or environmental risks, were identified during the preliminary ground investigation, additional investigation will be required in the areas of potential contamination prior to construction, to further define the contamination and to allow the design of any required remedial measures. These areas should include the Brodaich Quarry and Quarry 1.
- 23.5.8 Although considered to be unlikely, further potentially contaminated ground, which is not currently identified, may be encountered during the earthworks required for construction of the proposed scheme. Should this occur, treatment and/or removal will be required as part of the Employer's Requirements for Construction.
- 23.5.9 For all contaminated areas, the Contractor will be required to prepare Method Statements, which will be submitted to the appropriate regulatory authorities for approval, with compliance monitored by the Employer's Representative. Potentially contaminated materials will be tested and removed if necessary in a controlled manner in accordance with the Duty of Care Regulations (The Environmental Protection (Duty of Care) Amendment (Scotland) Regulations, 2003).
- 23.5.10 The Employer's Requirements will include measures, as detailed in Table 23.11, to prevent contaminated run-off or contaminated groundwater produced by the works from entering and polluting the local drainage system. Any contaminated waters produced will be removed for off-site disposal at an appropriate facility in accordance with waste management regulations, or treated on-site and discharged in compliance with a Consent to Discharge issued by SEPA. Further details on measures to avoid contamination of watercourses during construction are provided in Chapter 33 (Disruption due to Construction).
- 23.5.11 Since the level of uranium, in naturally enriched material, is harmless for humans (see 25.3.26) no mitigation measure is required during construction.

**Table 23.11 – Mitigation Measures for Contaminated Land**

Type of Measure	Description
<b>Prevent</b>	The adoption of procedures to deal with any hazardous ground and gas being encountered and the removal of potentially contaminated materials to prevent the release of contaminated materials into the environment. Removal and disposal off-site of any contaminated waters to prevent contaminated run-off or groundwater produced by the Works, from entering and polluting the drainage system.
<b>Reduce</b>	Adoption of soil handling procedures during construction to contain contaminated soil and reduce potentially adverse impacts on soil quality and the potential for spread of contamination to impact construction workers, the public and adjacent land or controlled water.
<b>Offset</b>	Only remove contaminated soil from the development where there is a demonstrable need via environmental risk assessment for risk management, Otherwise, where suitable, made ground or moderately contaminated soil may be contained within the construction.
<b>Enhance</b>	None

#### **Mineral Extraction**

- 23.5.12 No mitigation is required.

#### **Groundwater**

- 23.5.13 As the exact location of some springs and wells is still not known, a walkover survey will take place during June-July 2007 to confirm the locations of all supplies at risk (based on Table 23.9); this will provide a better understanding of the nature of the springs and additional information about total depth and groundwater level in wells. Groundwater (from both springs and wells) will be sampled and analysed to allow preliminary groundwater quality background conditions to be defined for these water supplies.



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##### Groundwater Quality

- 23.5.14 To prevent potential for contamination of private wells/springs used for water supply or pollution impacts in the areas of high well density identified in the baseline, by accidental spillage, the following sections of the AWPR road drainage system will be lined:
- Derbeth, between ch110902 and ch111000;
  - Moss of Auchlea and Blacktop, between ch108000 and ch106100;
  - Kingcausie, between ch10200 and ch10100;
  - Hill of Blairs, between ch201300 and ch202400; and
  - Bishopton and Hare Moss, between ch202800 and ch205200.
- 23.5.15 In addition, the areas around Milltimber (ch103200), around Duff's Hill (ch20500), around Burnhead (ch200550), Eastland Cottage (ch101200), Milltimber (ch103300), Nether Beanshill (ch104000) and the eastern branch of the proposed roads junction at ch101000 will also be lined because of the presence of isolated private water supplies. These lined areas correspond to all areas where impacts on private groundwater features had been identified as substantial to moderate.
- 23.5.16 Mitigation measures to prevent or minimise the potential for contamination of local groundwaters elsewhere during construction or operation are the same as those required for surface water protection and are detailed in Chapter 24 (Water Environment) and Chapter 33 (Disruption due to Construction).

##### Groundwater Flow

- 23.5.17 The local impacts on groundwater levels associated with a number of proposed road cuttings within the Southern Leg can be reduced slightly by optimising the drainage design. However, intercepting groundwater that would otherwise flood the road necessitates the reduction of the immediate groundwater level to the level of the road.
- 23.5.18 The data currently available, which includes private water supplies identified during the consultation undertaken in April and May 2007, suggest that impacts would be likely on groundwater levels adjacent to cuts, which may affect nearby groundwater supplies. A more extensive groundwater monitoring network will be installed in areas identified in Table 23.10 and groundwater testing (both qualitative and quantitative) will be carried out, prior to construction, to clarify the level of impact and provide a better understanding of groundwater flow and groundwater quality. This will enable the potential impact on private groundwater supplies to be determined with more accuracy, and mitigation developed as appropriate.
- 23.5.19 Based on the groundwater monitoring and assessment, further mitigation measures may be proposed in relation to specific groundwater supplies. It may be necessary to undertake monitoring of selected groundwater supply sources during construction and into the start of the operational phase to assess whether there has been any discernible effect on the supply. If yields of water supplies are shown to be reduced, mitigation measures would be likely to include an alternative or replacement supply.

##### Groundwater Supporting Sensitive Habitats

- 23.5.20 The road embankment (ch203300-204600) running along Hare Moss will be constructed using permeable materials in order to allow shallow groundwater to flow towards Hare Moss and ensure that the road does not act as a barrier. Drains and surface water features flowing towards Hare Moss should be culverted beneath the Southern Leg to minimise disturbances to the water balance of the moss.

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- 23.5.21 Mitigation measures at Hare Moss will also include the reinforcement of the peat bund running along the Jameston ditch, in particular where breaches were noted during the walkover. The reinforcement of the peat bund should consist of:
- ensuring that the peat bund is not interrupted; and
  - compacting the bund to reduce its permeability.
- 23.5.22 It is also important that the northern ditch is not deepened further.
- 23.5.23 Monitoring piezometers (groundwater level and quality) will be installed in Hare Moss along the road line and adjacent areas of the moss, prior to construction. The piezometers will be monitored before, during and after the construction of the proposed road scheme to define a baseline hydrogeological condition for the moss, and to assess any change in moss water levels.
- 23.5.24 In addition, it is believed that the condition of Hare Moss as a bog could be improved by raising and managing the sub-surface water level independent of the road construction. A detailed survey could be carried out to better understand the functioning of the site and engineering solutions aimed at increasing residence time of water in Hare Moss. The monitoring points would also be used to design and monitor any restoration scheme of the moss. Potential restoration of the moss is not discussed further here.

#### Groundwater Flow and Potential Contaminated Land

- 23.5.25 Changes in groundwater flow conditions and potential migration of contaminants towards cuttings may potentially impact on private water supplies around Hare Moss, Crynoch and Derbeth cuttings, and on construction workers at all cuttings listed in paragraphs 23.4.31 to 23.4.36.
- 23.5.26 The measures proposed in paragraph 23.5.18 are also applicable here (monitoring network). The groundwater flow and quality monitoring data will provide the background information to determine the zone of influence of each cutting. If potentially contaminated land is within the zone of influence, sampling and testing will be required to determine the exact nature of any contamination. If required, a risk assessment will be carried out and further measures will be proposed, as appropriate.
- 23.5.27 If groundwater becomes contaminated and is then intercepted by the road drainage, treatment will be required before the drainage can be discharged.

## 23.6 Residual Impacts

- 23.6.1 Residual impacts are the impacts that remain once the mitigation measures described in section 23.5 have been implemented.

### **Solid Geology**

#### Solid Geological Succession

- 23.6.2 The residual impact on local solid geology is anticipated to be Negligible.

#### *Blasting*

- 23.6.3 Mitigation measures are proposed in paragraph 23.5.3 to reduce blasting impacts on the rock mass. If these measures are implemented, the residual impact at Crynoch and Gairnhill Wood cuts is assessed as Slight.

#### Drift (Superficial) Deposits

- 23.6.4 There are Negligible to Negligible/Slight anticipated residual impacts on local drift deposits.

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##### **Contaminated Land**

- 23.6.5 The mitigation measures for the management of known or encountered occurrences of contaminated ground during construction will ensure that any human or environmental risks are appropriately addressed. At the same time, those mitigations may tackle in-situ ground contamination and may consequently improve the condition of those sites. The residual impacts may therefore be considered as Slight (beneficial) where any existing contaminated ground is treated or removed.
- 23.6.6 No residual impact is predicted upon human health from uranium levels in the Milltimber area.

##### **Mineral Extraction**

- 23.6.7 Future quarries in drift deposits have been assessed in paragraph 23.6.4 and past landfill issues discussed in paragraph 23.6.5 and these result in Negligible to Negligible/Slight adverse and Slight beneficial residual impacts respectively.

##### **Groundwater**

###### Groundwater Quality

- 23.6.8 All drainage features in areas of high well density and where groundwater supports sites of ecological interest will require to be lined and in consequence residual impacts are considered Slight.
- 23.6.9 Potential impacts on shallow groundwater quality in sand and gravel aquifers are mitigated by the same management procedures as proposed for protection of surface waters. It is predicted that these measures will result in Negligible residual impacts.

###### Groundwater Flow

- 23.6.10 Groundwater levels will be lowered in the vicinity of road cuttings which extend below the water table. The only potential impact of significance associated with this effect is the impact on private groundwater supplies yields in the cutting areas. It is anticipated that the characterisation of the local groundwater conditions and supply details, followed by provision of alternative or replacement supplies, if necessary, will appropriately mitigate impacts on private groundwater supplies. This will result in Negligible residual impacts.

###### Groundwater Supporting Sensitive Habitats

- 23.6.11 The residual impact at Hare Moss is considered to be Slight to Moderate. In addition, monitoring of the site will be conducted pre, post and during construction to ensure the effectiveness of mitigation and to provide further information regarding the hydrological and groundwater connectivity of the moss. Further information on the hydrological functioning of the moss can be found in Appendix A24.1 Surface Water Hydrology.

###### Groundwater Flow and Potential Contaminated Land

- 23.6.12 Once monitoring, ground investigations, risk assessments and any other measures considered necessary have been undertaken, it is anticipated that residual impacts on both humans and private water supplies will be Negligible.

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**23.7 References**

BGS – British Geological Survey. Drift and Solid maps – Aberdeen – Sheets 77 & 67.

BGS – NJ80NE, NJ80SE, NO89NE, NO89SE and NO88NE drift & solid maps and associated borehole logs descriptions.

Norwest Holts Reports (2004 and 2006)

Historical maps of the area (First edition until current Ordnance Survey) at 1:10,000 and 1:2,500 scale.

Mouchel Parkman (2003) Western Peripheral Route (western leg) – Stage 2 Addendum Environmental Assessment/ Mouchel Parkman.