14 Geology and Soils

14.1 Introduction

This section outlines the geological and geomorphological interests of the area and assesses the impact that the scheme options may have on these interests. An assessment has also been made on the likely impact of the scheme on soils and areas of contaminated land.

It should be noted that this section does not discuss the value of the soil resources in terms of agriculture or other potential land uses as this has already been covered in Chapter 7 (Land Use). Potential impacts upon geology and soils during the construction phase are considered in Chapter 15 (Disruption due to Construction).

14.2 Methods

14.2.1 Baseline Methods

The geological information used within this report was obtained from the following British Geological Survey Maps:

- 1:50,000 Series Solid Edition (Sheet 25W) Published 1983.
- 1:50,000 Series Drift Edition (Sheet 25W) Published 1985.

Copies of these maps are shown in Figures 14.1 and 14.2.

Historical maps were reviewed in order to provide general information regarding past and present activities within the study area, thereby assisting in the evaluation of the geological and geomorphological resources of the area. The historical maps cover different time periods, referred to as epochs. These epochs roughly equate to the first County Series survey, and subsequent revisions, and the first National Grid resurvey. Not all areas have mapping available for each epoch as the number of revisions for each county varies. Maps for Epoch 1 (First County Series survey), Epoch 2 (first revision of the First County Series survey), Epoch 3 (second revision County Series survey) and Epoch a5 (first National Grid resurvey), at a scale of 1:2500, are available for the area affected by the scheme. These historical maps are presented at a scale of 1:10,000 in Figures 14.3 to 14.6 as follows:

- Figure 14.3: Epoch 1 (1843 – 1893);
- Figure 14.4: Epoch 2 (1891 – 1912);
- Figure 14.5: Epoch 3 (1904 – 1939); and
- Figure 14.6: Epoch a5 (1966).

The SBC Environmental Health Officer was consulted with regard to the region's contaminated land register.

Soils information was obtained from The Macaulay Institute for Soil Research, Aberdeen and the Ordnance Survey Soil Survey of Scotland Map (1959 Scale 1:50,000).

14.2.2 Impact Assessment Methods

This assessment has been carried out following the guidelines set out in Volume 11, Section 3, Part 11 of the DMRB (1993 and amendments).

As outlined in Chapter 4 (Approach and Methods), impacts were assessed in terms of both the site value and the magnitude of impact. The site value, or status, of each site was determined as detailed in Table 14.1 below. The severity, or magnitude, of impact was assessed independently of the site value and assigned to one of the categories listed within Table 14.2 based on professional judgment. The significance of predicted impacts was then determined through a combination of value and magnitude as illustrated in Table 14.3.

Table 14.1. Definition of Site Value for Geology and Soils.

Value or Sensitivity	Criteria
High	Any nationally or internationally designated geological site and/or the presence of non-substitutable or highly sensitive geological and soil attributes.
Medium	Any regionally or locally designated sites and/or the presence of geological and soil attributes with limited potential for substitution or moderate sensitivity.
Low	Non-designated sites and/or the presence of geological and soil attributes easily substitutable or with low sensitivity.

Table 14.2. Impact Magnitude Criteria for Geology and Soils.

Criteria	Definition
Major	Partial (greater than 50%) or total loss of a geological or geomorphological site/resource, or where there would be complete severance of a site/resource such as to affect the value of the site/resource. 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 will impact upon local ecology.
Moderate	Loss of part (between approximately 15% to 50%) of a geological or geomorphological site/resource, major severance, major effects to the setting or disturbance such that the value of the site/resource would be affected, but not to a major degree. Changes to the local groundwater regime are predicted to impact slightly on resource use but not rule out any existing supplies. Minor impacts on local ecology may result. ditto
Slight	Minimal effect on the geological site/resource (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/resource would not be affected. Changes to groundwater quality, levels or yields do not represent a risk to existing resource use or ecology. ditto
Negligible	Very slight change from baseline condition. Change hardly discernible, approximating to a 'no change' condition.

Table 14.3. Assessment of Significance Criteria for Geology and Soils.

	Magnitude of Impact			
Site Value	Major	Moderate	Slight	Negligible
High	Major	Major	Moderate	Slight
Medium	Major	Moderate	Slight	Negligible
Low	Moderate	Slight	Negligible	Negligible

14.3 Baseline Conditions

14.3.1 Geology - Solid Strata

Figure 14.1 shows the underlying bedrock of the area between Soutra South and Carfraemill at a scale of 1:10,000 based on the British Geological Survey geological map for the Galashiels area, Scotland Sheet 25W – Solid Edition.

The bedrock consists of mainly sedimentary rocks. Rock of Silurian age from the Gala Group containing mainly grits with greywackes, shales, flags and purple and grey flaggy sandstones is overlain by red and purple conglomerates composed chiefly of rounded greywacke pebbles, thought to be Lower Devonian in age. Just to the north of

the scheme the Silurian rocks are replaced by similar but older rocks of Ordovician age. There is also an igneous dyke just to the north of the scheme. This is composed of basalt and dolerite. This material is known locally as whinstone.

A Geotechnical Investigation (GI) was carried out during the period 19th September to 18th October 2005, in accordance with the guidelines laid down in BS5930 Code of Practice for Site Investigations. Fifteen boreholes were sunk by cable percussion with eight advanced using rotary core drilling methods, thirty nine trial pits were excavated by mechanical means, and fourteen road cores in the A68 carriageway.

The depth to rockhead was established during the GI. As expected the depth to rockhead varies across the proposed scheme, with conglomerates encountered at depths of 4.6 metres to 6.42 metres below existing ground level, between Ch 75 to Ch 1400. Weathered rock, mudstone, siltstone and sandstone were encountered at depths below three metres from existing ground level between Ch 1400 to Ch 2155.

An additional GI covering the area of the proposed new side road between the existing C83 and C84 side roads was carried out during the period 2nd to 5th October 2007. This included the sinking of four boreholes by cable percussion and the excavation of nine trial pits by mechanical means.

The depth to rockhead was established adjacent to proposed new bridge crossing the Headshaw Burn. Rockhead, which was found to be conglomerates, was encountered between 2.2m and 4.0m.

14.3.2 Geology - Drift Strata

Figure 14.2 shows superficial deposits for the area between Soutra South and Carfraemill at a scale of 1:10,000. This figure is based on the British Geological Survey geological map for the Galashiels area, Scotland Sheet 25W – Drift Edition.

From Figure 14.2, the drift deposits shown are only to be found in the valley bottoms and these are limited to boulder clay and alluvium. The alluvium is present in a band approximately 150m wide running from northwest to southeast along the southern boundary of the A68. The alluvium is likely to consist of silts, sands and gravels. The alluvium overlies and is flanked by boulder clay, which in turn overlies the conglomerate. Bedrock outcrops on the higher ground. There is no indication of either glacial meltwater deposits or peat.

However, it was noted from the GI that the Scotland Sheet 25W – Drift Edition differed significantly from what was found during the G.I. Principally, the boulder clay shown on the map from approx Ch 1000 to Ch 1800 was only locally found in thin bands during the ground investigation, with the vast majority of the material being alluvial sands and gravels.

From consultation with landowners it was revealed that there is the possibility of old watercourses having been bypassed and subsequently filled with organic silt or peat,

however, there is no indication of this on any of the historic maps of the area (refer to Figures 14.3 to 14.6) and no peat was encountered during the ground investigations in September / October 2005 or October 2007.

14.3.3 Made Ground

During the GI, made ground / fill associated with the construction of the existing A68 alignment was encountered on the southbound carriageway between Ch 75 to Ch 1700 and Ch 2000 to the tie-in at Ch 2155. The depth of the made ground/fill ranged from 0.5 metres at the southern end of the scheme to up to three metres at the northern tie-in. On the northbound carriageway made ground / fill was encountered between Ch 580 to Ch 1750 and Ch 2000 to the tie-in at Ch 2155. The depth of the made ground / fill ranged from 0.5 metres at the southern end of the scheme to up to three metres at the northern side of Annfield Bridge.

14.3.4 Soil

Brown forest soils and alluvial soils are understood to underlie the A68 through the study area. These soils are of Lauder Association and the parent material can be identified as Till, which is derived from Upper Old Red Sandstone conglomerates and sandstones. These soils are freely drained. The value of these soils in terms of land capability for agriculture is discussed in Chapter 7 (Land Use).

The geotechnical investigation results indicate that the topsoil within the existing A68 road verge ranges from 0.1m to 0.6m in depth and in areas of the proposed widening the depth ranges from 0.1m to 0.35m.

14.3.5 Hydrogeology

The following hydrogeological information has been obtained from SEPA and is based on the British Geological Survey 1:625,000 Hydrogeological Map of Scotland, borehole information from within a 2km radius of the site and on borehole information from GI Works undertaken in September / October 2005 and October 2007 (Figure 14.7).

The lower Devonian conglomerate strata are locally important aquifers where the flow of groundwater is primarily in fissures and other discontinuities. In the Borders area these deposits tend to have a yield of about 1 litre/sec and have water chemistry dominated by calcium and bicarbonate ions.

It is possible that localised perched aquifers capable of supplying small yields to wells and springs or base flow to streams may exist in the boulder clay where there are significant quantities of sands and gravels present. The alluvial deposits may contain significant quantities of water, however due to the localised extent their water resource potential may be limited.

The 1:100,000 scale Groundwater Vulnerability of Scotland (BGS2004) shows that the areas with a cover of till or alluvium are of high vulnerability to surface contamination.

Areas where bedrock outcrop occurs are classified as extremely vulnerable.

A borehole is known to be located at NGR 351100 653500 (Carfraemill Borehole), approximately 450m east north east of the Oxton Junction. The borehole is believed to be in use for water extraction, installed in the Lower Devonian strata and to have a rest water level of 1.25m above ground level (agl). SEPA are not aware of any other boreholes within 2km radius of the site.

During the GI in September / October 2005 and the additional GI in October 2007, standpipes were installed at the locations shown in Figure 14.7 in order to monitor groundwater levels to allow assessment of groundwater conditions.

Table 14.4 below shows that the Groundwater within the vicinity of the scheme is averaging around 2.7m below ground level. This will have little effect on the slope stability for the proposed cut slopes within the scheme, however the standpipes will be monitored throughout the detailed design stage.

Table 14.4. Standpipe – Ground Water Level Monitoring.

Exploratory Hole	Exploratory Hole Level	Depth of Standpipe	Groundwater Measured Depths from Adjacent Ground Level							
			13/10/05	21/10/05	26/10/05	05/12/05	11/01/06	01/08/07	05/12/07	02/04/08
BH02	223.65m	4.8m	3.7m	3.96	3.88	3.6	-	3.95m	3.8m	3.7m
BH03	220.88m	3.3m	1.31m	1.29m	1.25m	1.18m	1.27m	-	-	-
BH04	220.63m	6.0m	5.75m	5.75m	-	3.88m	4.5m	-	-	-
BH05	215.64m	6.0m	5.58m	4.64m	-	2.85m	3.50m	3.4m	3.5m	3.5m
BH06	215.59m	5.0m	4.75m	4.75m	-	2.20m	2.91m	3.7m	3.7m	3.0m
BH12A	218.83m	4.5m	1.10m	1.23m	1.05m	1.02m	-	1.1m	3.7m	-
BH13	222.09m	5.0m	2.14m	-	2.19m	2.12m	2.29m	2.35m	2.35m	2.4m
BH14	208.95m	4.5m	-	0.28m	-	0.00m	-	-	-	-
BHA1	212.87m								0.6m	0.7m
BHA3	214.77m								0.45m	0.5m

There is no specific information on groundwater quality available from SEPA for the area of interest.

14.3.6 Designated Sites

There are no designated SSSI relating to geological or geomorphological features within the scheme area, nor are there any designated Regionally Important Geological Sites (RIGS).

14.3.7 Mineral and Other Resources

There is no indication of any underground mining in the area and it is unlikely that there are any coal deposits.

SBC has a policy of protecting areas of significant mineral deposits from sterilisation by development unless it is unavoidable. The geology of the area limits the scope for mineral extraction to a few sand and gravel deposits and small hard rock deposits.

Ordnance Survey historical mapping of the area for the period 1843 to 1893 (Figure 14.3) shows a number of small whinstone quarries at Headshaw and Kirktonhill. These quarries exploited the intruded igneous dykes but are absent from subsequent maps (Figures 14.4 to 14.6).

Also, a small borrow pit has been used in the past (Figure 14.3**)** for sands and gravels, perhaps by local farmers or during previous road construction. This is still visible today and does not seem to have been infilled with any sort of material.

To the west of the study area, along the line of the Mountmill Burn, is a disused quarry referred to as Mountmill quarry. This utilised the Silurian deposits. The material was transported by the Oxton light railway and quarry probably ceased operation when the railway line was closed in the 1950's.

No areas of current mineral extraction have been identified within the study area.

14.3.8 Contaminated Land

There are no licensed landfill sites within the study area.

The SBC Environmental Health Officer has confirmed that 'at the present time, the Council's Contaminated Land Register does not contain any record relating to this site or to any adjoining or adjacent land'. He goes on to state however, that 'In relation to Part IIA of the Environmental Protection Act 1990, implementation of the contaminated land regime is currently at an early stage and SBC has yet to commence its survey of the area. This survey will proceed in accordance with the strategy that was adopted by the Council in September 2001. The fact that an area of land has not been identified to date gives no indication of its status in relation to the statutory definition of contaminated land.'

The records at present therefore do not provide any useful information with respect to contaminated land within the scheme boundary.

It is known that Henry's Wood was used as a site compound area for construction of the Soutra South climbing lane in the 1980s. The burn was re-aligned, redundant sections of burn infilled and the area for the compound levelled. This area was subsequently topsoiled and planted with trees in 1993. It is thought that no construction spoil was deposited in the area.

The remainder of land within the scheme boundary is used for agriculture with no known contamination. It is therefore unlikely that there is any contaminated land within the scheme boundary.

However, the GI did find (as expected) made ground in the verges, which in some locations included tyres, wire, plastic, china and timber. Although these do not constitute a contamination hazard, they indicate the chance, however small, of the possibility of hazardous substances being locally present in the existing verge fill.

Chemical analysis was not undertaken on samples recovered from the ground given that there was no historical, visible or olfactory evidence of contamination on the site.

14.3.9 Overall Value of Geological/Soil Resource

Overall, the value of the geological and soil resources of the site can be considered of low value / sensitivity, based on the definition provided in Table 14.1.

14.4 Assessment of Impacts

Road schemes have the potential to impact upon the geology and soils of an area through direct and indirect impacts on sites of importance or scientific interest, loss or sterilisation of mineral deposits or soil resources, disturbance of contaminated land or surcharging of ground which may accelerate erosion and subsidence.

The proposed scheme will not impact on any sites of geological interest, mineral extraction locations or any known areas of contaminated land. No impact is predicted in relation to surcharging of ground.

The scheme will require the creation of earthwork embankments and cut slopes to allow a third lane to be created adjacent to the existing carriageway. Material will also be required for the formation of the new side road, realigned D47/5 and the Riggsyde Access. The approximate earthwork quantities for the scheme are as follows:-

	Cut (m^3)	Fill (m^3)
Proposed Scheme	11,400	22,300

The GI Interpretative Report, prepared by SBC, has verified that a high proportion of the cut material will be suitable as fill. The nature of the cut material, predominantly alluvial sands and gravels, is not as weather susceptible as the predicted boulder clays.

Topsoil was encountered across the site with thicknesses varying between 100mm and 600mm and averaging around 200mm to 250mm. It is likely that the majority of topsoil will be suitable for conventional slopes and verges as Class 5A material (acceptable topsoil).

The majority of the earthworks slopes will be 1 in 2 (vertical : horizontal), however this will have to be increased to 1 in 3 in areas of silt for slope stability. Also in order to maintain a suitable distance between the A68 earthworks slope and the bank of the Headshaw Burn, a 1 in 1.5 slope is to be adopted over a 60m length between Ch 420 and 480.

It is not anticipated that any new areas of exposed strata will be created during the earthworks process due to the depth of the solid strata found during the geotechnical investigation, see section 14.3.1.

The proposed earthworks are anticipated to result in a slight adverse impact (magnitude) on the geological and soil conditions of the site (low value) through removal of existing soils and drift deposits and deposition of fill material from out with the site area. In accordance with Table 14.3, the impact significance is assessed as **negligible**.

The only impact upon hydrogeology will be a very slight reduction in ground permeability caused by the construction of embankments on alluvial material. This impact is anticipated to be **negligible** in terms of the overall hydrogeology of the area (Chapter 13 – Road Drainage and the Water Environment).

14.5 Mitigation

As outlined above, the impact of excavated material generated through cutting activities will be reduced through the re-use of material on site and topsoil will be stripped and reused for landscaping purposes. On-site storage of soil will require to be appropriately protected from the weather and should not be stored for prolonged periods and the Contractor on site will undertake best practice to maximise the re-use of materials.

It will not be possible to achieve an earthwork balance for the proposed scheme and the requirement for imported material that may have a slight adverse impact on the geology of the area.

Any imported soil should be from local sources where possible.

14.6 Residual Impacts

Residual impacts for the proposed scheme are assessed as **negligible adverse** significance as mitigation measures will not be able to fully compensate for the imbalances in cut and fill requirements, which will alter the physical geology of the site.

In accordance with Table 14.3, and again using the low site value, the impact significance of the proposed works, with mitigation, is assessed as being **negligible adverse**.