

# 11 Geology and Soils

## 11.1 Scope of the Assessment

- 11.1.1 Road schemes are capable of impacting 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. .
- 11.1.2 This chapter describes the assessment undertaken to determine the potential impacts on geology and soils of the Proposed Scheme, considering the aspects above, during the construction and operational phases. The assessment is carried out taking into account the guidelines set out in Volume 11 of the DMRB.
- 11.1.3 It should be noted that this chapter does not discuss the impact on the hydrogeology of the area as this is discussed in Chapter 16 Road Drainage and the Water Environment, while the value of the soil resources in terms of agriculture or other potential land uses is covered in Chapter 15 Community and Private Assets.

### Study Area

- 11.1.4 The study area encapsulates the proposed road alignment and also the adjacent surrounding area. The study area for designated sites, contamination and mine workings focuses on the Proposed Scheme and a radius up to 1km away. It is recognised that the affects of the road construction and use on the underlying geology would not be restricted to the road corridor itself.

## 11.2 Legislative, Regulatory and Planning Context

- 11.2.1 The following key legislation and guidance documents have been used to inform the assessment:
- Planning Advice Note 33: Development of Contaminated Land, published by the Scottish Government October 2000: provides guidance relating to the development of contaminated land and implications for planning applications.
  - Environmental Protection Act 1990: Part 2A, Contaminated Land, published by Department for Environment Food and Rural Affairs (DEFRA), 1990: provides guidance on the definition of contaminated land.
  - The Contaminated Land (Scotland) Regulations 2005, published by the Scottish Government, 2005: contains amendments made to the Environmental Protection Act 1990: Part 2A with specific reference to Scotland.

## 11.3 Methods of Assessment

### Baseline Methods

- 11.3.1 A number of sources of baseline information have been used to assess the sensitivity of the geology and soils within the study area. A desk-based study was undertaken by Mouchel Fairhurst Joint Venture in June 2008 as part of the DMRB Stage 2 assessment. At this stage the final route had not been chosen and so the report focussed on a general study area that encapsulated all of the potential route options being considered at the time. This made use of available information to develop a

conceptual ground model for the site. The following information was collated to produce the desk study report:

Table 11.1 Sources of Geological Information

British Geological Survey Maps			
British Geological Survey	NS 24 NE	Solid	1:10,000
British Geological Survey	NS 24 NE	Drift	1:10,560
British Geological Survey	NS 34 NW	Solid	1:10,000
British Geological Survey	NS 34 NW	Drift	1:10,560
British Geological Survey	NS 35 SW	Solid	1:10,000
British Geological Survey	NS 34 SW	Drift	1:10,560
British Geological Survey	Hydrogeological Map of Scotland (1988)		1:625,000
Mining Records			
British Geological Survey, Sheet Memoir 22W and 21E, The Geology of Irvine District, 1999			
British Geological Survey, Economic Geology of Ayrshire Coalfields Area 1, 1925			
British Geological Survey, Various Non-Coal Abandonment Plans			
Coal Authority Report, Coal Mining Report – New Proposed Route For, A737 Dalry Bypass, Dalry, North Ayrshire. Ref: 00117400-07, November 2007.			
Coal Authority Report, Coal Mining Report – New Proposed Route For, A737 Dalry Bypass, Dalry, North Ayrshire. Ref: 00106244-07, October 2007.			
Coal Authority Report, Coal Mining Report – New Proposed Route For, A737 Dalry Bypass, Dalry, North Ayrshire. Ref: 00119372-07, December 2007.			
Coal Authority and British Geological Survey, Ground Stability Report – Dalry Bypass, Dalry, North Ayrshire. Ref: 00099734-07, September 2007.			
Other Information			
Landmark Envirocheck Report			

- 11.3.2 A Stage 2 ground investigation was undertaken by White Young Green Environmental Limited between July and September 2008. This investigation also focussed on a general study area that encapsulated all of the Stage 2 potential route options.
- 11.3.3 From April 2012 to August 2012 a desk study was undertaken that focussed on a review of the available mining records for the area. Underground seam levels and conditions encountered within the previous mine workings, as shown on the mine plans, in conjunction with details recorded during the sinking of old pit shafts in the area. Information was also obtained both from historic boreholes and recent borehole mineral investigations. All this information was used to develop a composite mining plan (Figures 11.1 and 11.2) and a geological section along the route (Figure 11.3).
- 11.3.4 An updated Envirocheck report was obtained in June 2012 to determine if any additional sources of contamination could be identified that were not present when the 2008 desk study was carried out. The information from the 2012 Envirocheck report has been used to produce a Desk Study Addendum Report that highlights any changes from the initial 2008 Desk Study Report. This highlights potential sources of

contamination that the scheme may encounter. A copy of the Desk Study Addendum is provided in Appendix 11.1.

- 11.3.5 A detailed ground investigation for the Proposed Scheme alignment was undertaken by Ian Farmer Associates between December 2012 and April 2013. This focussed on obtaining data that can be used for geotechnical and geo-environmental design. The locations of trial pits and boreholes from the Stage 2 and Stage 3 ground investigations are shown in Appendix 11.2.
- 11.3.6 Preliminary consultations were held with SEPA and the Contaminated Land Officer (North Ayrshire Council) on 5<sup>th</sup> December 2012, with particular focus on groundwater quality and ground contamination. North Ayrshire Council agreed that any contaminated soil issues arising during the construction phase would be dealt with under waste management and contaminated land regulations.
- 11.3.7 All of the above information has been used to predict the ground conditions beneath the proposed alignment and to establish the baseline conditions relating to the geology and soils in the study area.

### **Impact Assessment Methods**

#### *Guidance Documents*

- 11.3.8 The impact of the proposed road scheme on the geology and soils of the area has been considered in accordance with the Design Manual for Roads and Bridges (DMRB), (1998); Volume 11; Environmental Assessment, Section 3; Part 11; Geology and Soils.

#### *Impact Assessment Criteria*

- 11.3.9 In order to determine the impact that the scheme would have on areas of geological value, a hierarchy of site importance (or value) and impact magnitude has been devised. Geological sites may be classified into those of national importance/value, regional importance/value and those not considered worthy of protection as shown in Table 11.2. Table 11.2 also outlines the criteria by which the potential for ground contamination has been assessed. It should be noted that the impact of the scheme on the Water Environment (including surface and groundwater) is discussed in Chapter 16. Impacts discussed in this chapter are restricted to those on the road itself (concrete and any other road construction materials) and construction workers.

*Table 11.2 Criteria to Assess the Geology and Soils Sensitivity*

<b>Sensitivity</b>	<b>Criteria</b>
<b>High</b>	Areas containing geological or geomorphological features considered to be of a national interest, for example, Sites of Special Scientific Interest. Presence of extensive areas of economically important minerals valuable as a national resource. Presence of source-pathway-receptor contamination linkage with a high risk of the possibility of causing significant harm to the scheme, site workers and/or end users. Possible presence of high-quality topsoil.
<b>Medium</b>	Areas containing geological features of designated regional importance, for example Regionally Important Geological Sites (RIGS), considered worthy of protection for their educational, research, historic or aesthetic importance. Presence of areas of economically important minerals of regional value. Presence of source-pathway-receptor contamination linkage with moderate risk of

Sensitivity	Criteria
	causing significant harm to the scheme, site workers and/or end users. Possible presence of medium-quality topsoil.
<b>Low</b>	Geological features not currently protected and not considered worthy of protection. Absence of mineral areas or minimal areas of local economical value only. Presence of source-pathway-receptor contamination linkage with a low risk of causing significant harm to the scheme, site workers and/or end users. Possible presence of low-quality topsoil.

11.3.10 The magnitude of the impact has been determined by predicting the extent of the change in baseline condition resulting from the scheme as shown in Table 11.3 below.

*Table 11.3 Criteria to Assess the Magnitude of the Predicted Impact on Geology and Soils*

Magnitude of Impact	Criteria
<b>Major</b>	Partial (greater than 50%) or total loss of a geological site, or where there would be complete severance of a site such as to affect the value of the site. Existing resource use is irreparably impacted upon. Changes to quality or water table level would impact upon local ecology. Contamination levels encountered in excess of human health and property assessment criteria requiring significant remediation works. Destruction or loss of high-quality topsoil (more than 50% volume).
<b>Moderate</b>	Loss of part (between approximately 15% to 50%) of a geological 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 degree. Contamination levels marginally above human health and property generic assessment criteria requiring minor remediation action . Destruction or loss of high-quality topsoil (between 15% and 50% volume). Destruction or loss of medium-quality topsoil (more than 50% volume).
<b>Slight</b>	Minimal effect on the geological 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. Contamination levels below human health generic assessment criteria but minor remediation works required as a result of impact to property. Destruction or loss of less than 15% volume high-quality topsoil. Destruction or loss of medium-quality topsoil (between 15% and 50% volume). Destruction or loss of low-quality topsoil (more than 50% volume).
<b>Negligible</b>	Very slight change from baseline condition. Change hardly discernible, approximating to a 'no change' condition. Contamination levels below human health and property assessment criteria and no remediation required

11.3.11 Each potential impact is assessed in order to establish its overall significance by drawing a comparison of the magnitude of impact against the importance/value of the affected site as shown in Table 11.4 below.

Table 11.4 Criteria to Assess the Significance of the Predicted Effect on Geology and Soils

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

- 11.3.12 For the purpose of this assessment major or moderate effects are deemed to be significant and would require mitigation to reduce the significance of the effect.
- 11.3.13 Potentially contaminated sites have been assessed based on the type and extent of contaminants which might typically be associated with the historical use of the study area. Consideration has then been given to the relationship of the Proposed Scheme to the areas that would be disturbed during construction. Where potentially contaminated sites are located within areas that would be disturbed by construction, these have been assessed. For each site, where potential contaminants could be mobilised a risk assessment, has been undertaken using a source-pathway-receptor model.
- 11.3.14 Contamination data has been assessed in accordance with BRE Special Digest 1 "Concrete in Aggressive Ground" (3<sup>rd</sup> Ed 2005).

## 11.4 Baseline Conditions

### Sensitive Land Uses / Designated Sites

- 11.4.1 Lynn Spout is a Site of Special Scientific Interest (SSSI) of geological interest and is located approximately 900m west of the southern part of the Proposed Scheme. Its location is shown on Figure 9.3a. The SSSI is a protected outcrop of Lower Carboniferous Limestone located in a gorge of the Caaf Water.
- 11.4.2 As the Lynn Spout is a SSSI it is classed as a high sensitivity feature.

### Topography and Geomorphology

- 11.4.3 Topographic or geomorphological features may be important due to their rarity or educational value. No topographical or geomorphological features that are considered worthy of protection were identified within the study area.
- 11.4.4 The ground investigations have provided a significant volume of data that has been incorporated into the ground model and has been used to more accurately define ground conditions generally. During this process no sites of geomorphological interest have been identified.
- 11.4.5 Topographical and geomorphological resources are concluded to be of low sensitivity.

### Geology and Soils

- 11.4.6 The drift and solid geology of the area are summarised on Figures 11.4 and 11.5, which are based on the British Geological Survey mapping.

- 11.4.7 The geology and historic mining underlying the site can be seen on Figures 11.1 to 11.2 – Illustrative Composite Mine Plans and on Figure 11.3 – Illustrative Geological Section. These figures have been compiled using historic mining records together with borehole records.

#### *Solid Geology*

- 11.4.8 The bedrock underlying the site is of Carboniferous age and comprises the Dalry Sandstone Formation belonging to the Limestone Coal Formation beneath the northern section of the study area and the Caaf Water Limestone Formation belonging to the Upper Limestone Formation beneath the central and southern sections of the study area.
- 11.4.9 The Dalry Sandstone Formation (Limestone Coal Formation) typically comprises sandstone, siltstone, mudstone, economic seams of ironstone and limestone and a few thin coals, some of which may have been mined in the past. The Caaf Water Limestone (Upper Limestone Formation) typically comprises sandstone, siltstone, mudstone and economic seams of limestone.
- 11.4.10 Bedrock deposits encountered during the ground investigations were noted to be variable, although generally comprising two distinct zones. In the northern part of the study area, from around Peesweep Mount (Ch1600 on Figure 11.6b) to the north of the route at Easter Highfield, bedrock deposits predominantly comprise slightly weathered Sandstone with Mudstone, Siltstone and Coal encountered locally. The strength of the deposits is variable and ranges from very weak to strong.
- 11.4.11 In the south of the study area, from Peesweep Mount (Ch1600 on Figure 11.6b) to the south of the route at Hillend, bedrock deposits generally comprise moderately strong to very strong fresh Limestone, with Sandstone, Siltstone and Mudstone encountered locally.
- 11.4.12 With the exception of the Lynn Spout SSSI (see Section 11.4.1) and potential mineral reserves (see Section 11.4.45) there are no sensitive/important sites associated with solid geology identified within the study area. This baseline condition is therefore considered to be low sensitivity.

#### *Drift Geology*

- 11.4.13 Alluvial deposits were encountered within the floodplain of the River Garnock and in an isolated locality to the east of the Blairland Housing Estate. The material ranged in thickness from 1.8m up to 15m. The material comprises peat, soft clays, loose and medium dense sand and gravel and uncompacted silts. Peat is also present at the northern part of the Proposed Scheme from Pasturehill Cottages to the northern most part of the route. The locations of peat and Alluvium can be seen on Figures 11.6a to 11.6e.
- 11.4.14 Glacial Till is found throughout the study area and generally comprises clay with varying amounts of sand and gravel. The shallower horizons are generally soft to firm with the material becoming stiff to very stiff at depths greater than 1.5m below existing ground level (begl). The thickness of the Glacial Till varies from 1m to around 20m with the thicker areas located in the central and south western parts of the site. During the ground investigation numerous boulders and cobbles were noted throughout the material with some recorded to over 1m diameter.



- 11.4.15 The ground investigations indicate that there are no economically important superficial deposits underlying the site. This baseline condition is therefore classified as low sensitivity with regard to drift geology.

#### *Soils*

- 11.4.16 Topsoil within the corridor is derived from the underlying glacial deposits and is therefore likely to be largely mineral based and exhibit poor drainage characteristics. Data from the ground investigations indicates the topsoil is generally thin with a large proportion of clay and therefore is not likely to be of high quality.
- 11.4.17 The baseline condition is classified as low sensitivity with regard to soils.

#### **Ground Surface Stability**

- 11.4.18 The mining desk study sourced a number of mine plans showing extensive past underground operations in various seams and minerals below and in the vicinity of the Proposed Scheme, amongst which were the Index or Highfield Limestone, Wee Coal, Smithy Coal, Borestone Coal, Dalry Blackband Ironstone and Dalry Clayband Ironstone.
- 11.4.19 The mining researches enabled an illustrative composite mine plan to be produced showing the general extent of old workings in the locality of the route (Figures 11.1 and 11.2).
- 11.4.20 An illustrative geological section along the Proposed Scheme (Figure 11.3) was prepared from information recorded on the old mining records, in particular seam levels, pit shaft details and conditions encountered during the course of working together with mineral borehole records.
- 11.4.21 The typical thickness and separation of the various seams is given in Table 11.5 below.

*Table 11.5 Summary of Mine Workings*

<b>Seam</b>	<b>Typical Thickness (m)</b>	<b>Typical Separation (m)</b>
Upper Linn Limestone	9.5	
		30.0
Lower Linn Limestone	5.5	
		18.0
Third Post Limestone	1.6	
		34.0
Index Limestone	2.5	
		8.0
Wee Coal	0.8	
		10.0
Smithy Coal	1.2	
		5.0
Main Coal	0.9	
		5.0

Seam	Typical Thickness (m)	Typical Separation (m)
Stone Coal	0.8	
		8.0
Borestone Coal	1.3	
		47.0
Dalry Blackband Ironstone	0.5	
		55
Dalry Clayband Ironstone	0.5	

- 11.4.22 Figure 11.3 illustrates that the depth of the mine seams increases from north to south along the Proposed Scheme. Towards the northern end of the Scheme the depth to the seams becomes shallower such that there is a risk of ground stability issues for the Scheme in this area.
- 11.4.23 The ground investigations were targeted at obtaining information so as to assess the potential for mining instability along the Proposed Scheme.
- 11.4.24 There are 13 No recorded abandoned mine entries within or adjacent to the study area. Mine Entry Data Sheets obtained from the Coal Authority show no indication that any of these features have been treated in the past. Attempts to locate the various mine openings during the Stage 2 ground investigation have been successful in only one case. This was a shaft that was encountered in the Highfield area in the north of the site. Given the proposed route, it is considered that none of the mine entries are within influencing distance of the Proposed Scheme.
- 11.4.25 The two phases of Ground Investigation included deep boreholes along the entire route and it is considered that any unrecorded workings would have been picked up by the investigation. However in view of the long history of the mining in the area the possible presence of further unrecorded mines will always remain.
- 11.4.26 The results indicate that there is a risk of shallow mining instability in the area of the Highfield Roundabout toward the northern end of the route as shown on Figure 11.8.
- 11.4.27 Stable ground is of extreme importance for the scheme development and for the purpose of this assessment ground stability is classified as high sensitivity for the area at Highfield Roundabout. The rest of the route alignment is classed as low sensitivity due to the increased depth of the seams or where seams are present they have not been mined.

### Contamination

- 11.4.28 The 2008 Desk Study Report and 2012 Desk Study Addendum highlighted several on-site and off-site potential sources of contamination. Whilst these may not specifically be within the Scheme construction corridor they have the potential to impact on the soil.
- 11.4.29 The desk study identified potential sources of contamination are shown in Table 11.6 with Department of the Environment (DOE) Industry Profiles used to identify the associated contaminants.



Table 11.6 Potential Contamination Sources

Reference Number on Figure 11.7	Source	Location	Associated Contaminants
1	Railway land (including sidings and turntable)	On site and off site	PAH, metals, fuel, oils, sulphate, VOCs, SVOCs
2	Gas house	On site	TPH, BTEX, PAH, Phenols, VOCs, SVOCs, ammoniacal nitrogen, sulphates, pH, sulphides, cyanide, sulphur, cadmium, chromium, copper, iron, lead, nickel, manganese, mercury, molybdenum, vanadium, zinc, asbestos
3	Tank house (may simply be water tank but unknown)	On site	Unknown, but should include TPH, BTEX, PAH, Phenols, VOCs, SVOCs, ammoniacal nitrogen, sulphates, pH, sulphides, cyanide, sulphur, cadmium, chromium, copper, iron, lead, nickel, manganese, mercury, molybdenum, vanadium, zinc, asbestos
4	Engine house	On site and off site	Fuel, oils, asbestos, metals
5	Limekiln	On site	Fuel, oils, asbestos, metals
6	Foundry	On site	Metals, asbestos, high calorific materials, fuels, oils, PCB, PAH, cyanide, sulphates
7	Quarries (infilled)	On site and off site	TPH, BTEX, PAH, Phenols, VOCs, SVOCs, sulphates, pH, sulphides, cyanide, sulphur, metals, asbestos
8	Agriculture	On site and off site	Pesticides
9	Brickworks	Off site	Metals (mainly iron, aluminium, magnesium), fuels, oils, asbestos, high calorific value, PAH
10	Ironworks	Off site	Metals, asbestos, high calorific materials, fuels, oils, PCB, PAH, cyanide, sulphates
11	Shafts	Off site	Metals, pH
12	Colliery	Off site	Metals, pH, high calorific materials, PAH
13	Colliery heaps	On site	metals, pH, high calorific materials, PAH
14	Slag/refuse heaps	Off site	Metals, pH, high calorific materials, PAH
15	Pits (coal)/mining	On site	Fuel, oils, asbestos, metals

Reference Number on Figure 11.7	Source	Location	Associated Contaminants
16	Pits (limestone, freestone, sandstone, coal)	Off site	TPH, BTEX, PAH, Phenols, VOCs, SVOCs, sulphates, pH, sulphides, cyanide, sulphur, metals, asbestos
17	Fireclay works	Off site	Metals (especially iron, aluminium, magnesium), fuels, oils, asbestos, high calorific value, PAH
18	Laundry	Off site	VOCs, SVOCs, TPH, PCB
19	Slaughter House	Off site	pH

- 11.4.30 A plan showing the potential sources of contamination along the Proposed Scheme route can be seen in Figure 11.7. This plan also identifies contamination issues highlighted later in this chapter.
- 11.4.31 Within the 2008 Desk Study Report a number of potential source-pathway-receptor linkages were identified. The key receptors were noted as being human health, property and the water environment.
- 11.4.32 Previous discussions with North Ayrshire Council Contaminated Land Department, confirmed that contamination aspects would be addressed by the contractor during the construction stage and that risks to users of the site (motorists) once the scheme is operational would be discounted on the basis that no significant pathway exist. Potential pollutant linkages were therefore defined as those between contamination sources and the following receptors:
- Surfacewaters (River Garnock and local burns and ditches).
  - Groundwater.
  - The road fabric (buried concrete structures).
  - Construction and maintenance workers.
- 11.4.33 The ground investigations included geo-environmental testing of soils and groundwater to assess the levels of any contamination present. These focused on:
- water quality in terms of ascertaining any treatment that would be required for water arisings so as to avoid impact on surfacewaters and groundwater;
  - waste classification of soil arisings to ensure reused soils do not pose a risk to construction/maintenance workers or the environment; and
  - soil quality in terms of potential impact on workers and the road fabric.
- 11.4.34 Groundwater quality issues are discussed in Chapter 16 Road drainage and the Water Environment.
- 11.4.35 The Stage 2 and Stage 3 Ground Investigations both focussed on obtaining soil contamination data. This was based on the results of a desk study so the Ground Investigation could be targeted at obtaining information for specific contaminants.

During the Stage 2 Ground Investigation the following contamination testing was carried out on soil samples:

- 41 No General Suite tests consisting of the following determinands: Arsenic, Cadmium, Chromium (Total), Chromium (Hexavalent), Lead, Mercury, Selenium, Boron, Copper, Nickel, Zinc, Cyanide (Total), Cyanide (Complex), Cyanide (Free), Vanadium, Phenols (Total), Polyaromatic Hydrocarbons (USEPA 16 Speciated), Total Petroleum Hydrocarbons (Texas Band Aliphatic / Aromatic Split), Sulphide, Sulphate (water soluble 2:1 extract), pH;
- 4 No Aluminium tests;
- 4 No Nitrate as NO<sub>3</sub> (2:1 water extract);
- 4 No Ammonia tests;
- 4 No Iron tests;
- 8 No Asbestos screens.

11.4.36 During the Stage 3 Ground Investigation the following contamination testing was carried out on soil samples:

- 14 No Arsenic;
- 23 No Cadmium;
- 23 No Chromium;
- 23 No Lead;
- 14 No Mercury;
- 4 No Selenium;
- 23 No Copper;
- 23 No Nickel;
- 22 No Zinc;
- 7 No Tin;
- 12 No Cyanide (Total);
- 16 No Vanadium;
- 12 No Phenols (Monohydric);
- 23 No Polyaromatic Hydrocarbons (USEPA 16 Speciated);
- 15 No Total Petroleum Hydrocarbons (Aliphatic / Aromatic Split);
- 6 No Sulphide;
- 23 No Total Sulphate as SO<sub>4</sub> (water soluble 2:1 extract);
- 23 No Sulphate (Aqueous Extract as SO<sub>4</sub>);
- 23 No pH;
- 17 No BTEX;
- 18 No Speciated Volatile Organic Compounds (VOC);

- 18 No Speciated Semi-Volatile Organic Compounds (SVOC);
- 8 No Aluminium tests;
- 1 No Nitrate as NO<sub>3</sub> (2:1 water extract);
- 12 No Iron tests;
- 16 No Asbestos screens;
- 4 No Ammoniacal Nitrogen tests;
- 6 No Sulphur (Free) tests;
- 6 No Total Sulphur as S;
- 8 No Molybdenum tests;
- 18 No Calorific Value tests;
- 1 No Electrical Conductivity tests;
- 1 No Calcium tests;
- 11 No Manganese tests;
- 1 No Sodium tests;
- 1 No Total Organic Carbon tests;
- 1 No Organic Matter Content
- 2 No C5-C40 Gasoline Range Organics (GRO)

11.4.37 Site investigation data and soil quality can generally be summarised as containing naturally occurring levels of contamination associated with typical coal bearing rocks. This is reflected in high levels of iron, aluminium and manganese, though not at levels that would pose a risk of harm to human health. However there are isolated elevated levels of soil contamination as detailed in Table 11.7. The locations of trial pits are shown in Figures 11.6a to 11.6e.

Table 11.7 Soil Contamination

Trial Pit Location	Contaminant	Recorded Level (mg/kg)	Assessment criteria (mg/kg)	Assessment criteria source
2TP011	Vanadium	79	75	LQM Ed2 <sup>1</sup>
2TP020	Arsenic	56	32	EA SGV <sup>2</sup>
2TP020	Lead	1600	450	EA SGV <sup>3</sup> (withdrawn)
2TP022	Vanadium	150	75	LQM Ed2
2TP022	Lead	940	450	EA SGV (withdrawn)
2TP036	Benzene	0.1	0.08	EA SGV

1. LQM(2009) Generic Assessment Criteria for Human Health Risk Assessment, Ed.2
2. Current SGVs (produced using the latest version of the CLEA model by the EA)
3. Old SGVs (produced using the previous, now withdrawn version of the CLEA model by the EA)

- 11.4.38 It should be noted that there are no specific criteria for assessing the risk of harm to health of construction and maintenance works from soil contaminants. The criteria highlighted above are very conservative and are derived for assessing the risk to young females (most sensitive human receptor) over a continuous period of years.
- 11.4.39 Soil in the vicinity of TP36 would be encapsulated beneath an embankment structure and those around TP20 would remain undisturbed by the works. Also, likely receptors (construction workers, typically 18 – 65 year old men) would be exposed to contaminants over much shorter time frames (during periods of work in vicinity of source) and are physiologically less sensitive to contaminants than the receptor used in derivation of the criteria and may not be exposed at all if remaining in the cab of construction vehicles/plant.
- 11.4.40 Buried concrete structures are likely to comprise the viaduct foundations, Blair Road overbridge structures and lighting column foundations. Aggressive contaminants can potentially inhibit or reverse the pozzolanic reaction which binds the constituents of concrete together. There are three locations (indicated Table 11.8 below) where contaminants have been found at levels which may require concrete specification to be amended to mitigate against attack, though none are in locations where significant concrete structures are proposed:

Table 11.8 Potentially Concrete Damaging Contaminants

Location	Total Sulphate as SO <sub>4</sub> (%)	pH	Design Sulphate Class	ACEC Class
2TP020	0.28	6.3	DS2	AC-1s
2TP022	0.48	8.2	DS2	AC - 2
2TP002	0.25	9.6	DS2	AC - 2

- 11.4.41 Contamination testing can be used to undertake a generalised waste classification, with carcinogenicity and eco-toxicity being the most sensitive issues that may indicate a Hazardous (Special) Waste classification. Generally, Hazardous (Special) Wastes cannot be reused on site without a waste management license. Such eventualities are often more costly and time consuming than disposing of the material off site.
- 11.4.42 Contamination levels which would potentially indicate a Hazardous (Special) Waste classification are present on site as described in Table 11.9.

Table 11.9 Hazardous (Special) Waste

Location	Rationale	Comment
2TP020	Potentially ecotoxic lead and zinc at a cumulative total of 0.31%	Associated with infilled quarry. Ecotoxicity Special Waste threshold is 0.25%
2TP022	Potentially ecotoxic copper, lead and zinc at a cumulative total of 0.39%	Associated with another infilled quarry. Ecotoxicity Special Waste threshold is 0.25%

- 11.4.43 SEPA guidance (Land remediation and waste management guidelines, SEPA) confirms that waste management licensing requirements can be relaxed where a remediation plan is in place demonstrating that the following criteria are applicable:

- The use of such soils is a necessary part of the planned works.
- The material is suitable for that use.
- The material does not require any processing or treatment before it is reused.
- No more than the quantity necessary is used.
- The use of the material is not a mere possibility but a certainty.
- The use of the soil would not result in pollution of the environment or harm to human health.

11.4.44 For the purposes of this assessment the sensitivity of the scheme to soil contamination is classed as Low. This is based on the fact that although there are elevated contaminants in five locations on site, pollutant linkages are not present at all of them and the vast majority of the site is unaffected by contamination at all. It should be noted again that the impact of the scheme with regard to the disturbance of contamination on the water environment is discussed in Chapter 16.

### **Economic Deposits**

11.4.45 Mine abandonment plans obtained from the Coal Authority indicate that coal seams have been mined in this area at shallow depth. A number of limestone seams, which may have been worked locally in the past, are indicated to be present beneath the study area and may be of local importance.

11.4.46 It is noted that reserves of coal and limestone still exist in the locality and could be worked in the future, subject to feasibility, licences and planning consents. However, the Proposed Scheme is not within an area where Coal Authority licenses for underground or opencast mining are being sought and it is considered that such deposits are unlikely to be exploited.

11.4.47 It is considered that there is little economic value in any of the drift deposits underlying the study area and in terms of the impact assessment methodology, referred to Table 11.2, these deposits are not considered worthy of protection and the study area is therefore assessed as being of low sensitivity.

### **Summary of Baseline Conditions**

11.4.48 Table 11.10 summarises the sensitivity of the baseline conditions.

*Table 11.10 Summary of Baseline Conditions*

<b>Baseline Condition</b>		<b>Sensitivity of Geological Interest</b>
Sensitive Land Uses / Designated Sites		High
Topography and Geomorphology		Low
Geology	Topsoil	Low
	Drift Geology	Low
	Solid Geology	Low
Ground Surface Stability		High for the area at Highfield Roundabout. Low for the rest of the site.
Contamination		Low

Baseline Condition	Sensitivity of Geological Interest
Economic Deposits	Low

## 11.5 Predicted Impacts

### General

11.5.1 This section discusses the potential impacts on baseline geology and soil conditions that may result from development of the Proposed Scheme without any mitigation measures. Impacts have been assessed for two possible scenarios, described below:

- Do-nothing Scenario – Under the conditions of a “do-nothing” scenario (i.e. the Proposed Scheme did not go ahead) baseline conditions would only be affected by the occurrence of natural geological processes over time and would therefore remain largely unchanged. Other development may occur in the area with potential implications on geological and soil resources, however, no such significant development has been identified as part of this assessment.
- Development of the Proposed Scheme – Under this scenario, baseline conditions would be affected by construction activities and/or from operation of the Proposed Scheme.

### Sensitive Land Uses / Designated Sites

11.5.2 Lynn Spout SSSI is located approximately 900m west of the scheme alignment.

11.5.3 The site is expected to remain largely unchanged under a do-nothing scenario.

11.5.4 The SSSI is at a distance far enough away to not be affected by the construction or operation of the Proposed Scheme. No impact is therefore predicted.

### Topography and Geomorphology

11.5.5 No sites of importance relating to topography or geomorphology have been identified within the study area. The topography and geomorphology of the area would therefore remain largely unchanged under a do-nothing scenario.

11.5.6 The Proposed Scheme involves considerable earthworks (cutting and filling activities), which would have an impact on the current topography. However, there are no sites of importance related to geomorphology or topography within the alignment of the Scheme. Therefore, the magnitude of the impact is considered to be Negligible.

11.5.7 Reference to Table 11.4 indicates that the significance of effect on specifically important features of geomorphology and topography is Negligible.

### Geology and Soils

#### Topsoil

11.5.8 The topsoil deposits which cover the area are not considered to be of significant economic or geological value. Under a do-nothing scenario, these deposits would be unaffected other than by natural erosive and degradation processes.

11.5.9 Using data obtained from the ground investigations and the earthworks detail construction of the Proposed Scheme would result in removal of approximately



60,000m<sup>3</sup> of topsoil within the scheme footprint. Although there would evidently be disturbance of topsoil, it is anticipated that much of the topsoil can potentially be reused as part of the scheme, to dress the earthworks slopes for example. By reference to Table 11.3, the magnitude of the predicted impact on the topsoil is therefore considered to be Slight.

- 11.5.10 Reference to Table 11.4 confirms that the significance of the effect on the topsoil as a consequence of the Proposed Scheme would be Negligible.

#### *Drift*

- 11.5.11 The drift or subsoil deposits underlying the site are considered to be of limited economic value. Under a do-nothing scenario, these deposits would be unaffected other than by natural erosive processes.
- 11.5.12 The Proposed Scheme involves the formation of cuttings and embankments, with the requirement for filling being greater than that generated from cutting. Where possible, materials would be reused on-site to minimise the volume of material being imported and exported to and from site. A review of results from the ground investigations indicates that much of the excavated soil material would be suitable for re-use, including the peat which can be re-used with landscape bunds.
- 11.5.13 Further works are required to demonstrate that exclusion from waste management licensing criteria can be met but this is likely to be the case. The outcome of this further work would be dependant upon the source and destination of the soil material being used for cut and fill.
- 11.5.14 Soils in the vicinity of 2TP020 are not proposed to be disturbed by the works and no waste materials would therefore be encountered.
- 11.5.15 Soils in the vicinity of 2TP022 would be excavated as part of a shallow cutting for the road construction. A small volume of potentially Special waste would be generated but the impact managed by designers and or contractor accordingly.
- 11.5.16 Although there would be some disturbance of drift material and a small volume of potentially Special waste may be generated and would require management, no sites of importance relating to drift geology or subsoils have been identified and therefore the magnitude of the impact is considered to be Slight.
- 11.5.17 Reference to Table 11.4 indicates that the significance of effect on drift geology is Negligible.

#### *Solid*

- 11.5.18 With the exception of Lynn Spout SSSI (see Section 11.5.1) and possible mineral reserves (see Section 11.5.36), no sensitive/important sites relating to solid geology have been identified within the study area. Under a do-nothing scenario, the solid geology of the site would remain largely unaffected.
- 11.5.19 The Proposed Scheme involves the formation of cuttings and embankments. The formation of the embankments would have no impact upon the solid geology of the area. The available ground investigation data indicates that bedrock is generally deep with the exception of the north of the site where the bedrock is present to within 1m of the existing ground surface. With the proposed depth of cuttings and shallow depth to

bedrock in the north of the site it is anticipated that some rock excavation would be required in this area. Although there may be some disturbance to solid strata, no sites of importance relating to solid geology have been identified within the study area and therefore the magnitude of the impact is considered to be Slight.

- 11.5.20 Reference to Table 11.4 indicates that the significance of effect on solid geology is Negligible.

#### **Ground Surface Stability**

- 11.5.21 The mining study and associated plans and sections have identified a risk associated with shallow mine workings, particularly in the north of the site.
- 11.5.22 As shown on Figures 11.1 to 11.3 mineworkings are present at shallow depths in the northern half of the study area but are found at greater depths in the southern half of the study area. The collapse of abandoned workings is usually a result of deterioration of mine supports or mine roof materials. Where this occurs at shallow depth, the void created by the original mineworkings may migrate upwards towards the surface and cause instability at ground level. Similarly, failure of former Pit Shafts or Adits can result in localised settlement or collapse at ground level. The potential impact is unchanged under a do-nothing scenario.
- 11.5.23 Construction of the proposed bypass is unlikely to promote mineworking collapse, as this process is largely influenced by the deterioration of mine supports and not the application of surface loadings. However, collapse of mineworkings and subsequent migration of voids beneath a development scheme may cause significant damage to the structure and major disruption to scheme users and the wider environment. In addition any grouting remediation works that are carried out may impact upon groundwater flow. However it is noted that all of the proposed mine consolidation areas are unsaturated and therefore the impact upon groundwater flow is considered to be negligible. As the mine workings are unsaturated there is a risk associated with ground gas during consolidation of the workings. With the construction of the scheme, the magnitude of this impact may therefore be considered as Major for the area at Highfield Roundabout identified as high risk and Negligible for the rest of the site.
- 11.5.24 Reference to Table 11.4 indicates that the significance of effect of potential ground instability for the high risk area is classed as Major. However along the rest of the Scheme route the potential the significance is classed as Negligible.

#### **Contamination**

- 11.5.25 Following the most recent ground investigation, the potential presence and extent of contamination and / or pollutants associated with former or present land uses has been established. The investigation aimed to determine whether the presence of contaminants would pose a risk to the Proposed Scheme, or whether construction works would pose a risk to wider environmental receptors.
- 11.5.26 The risk of contamination is based on the source-pathway-receptor linkage. A risk is created where there is a linked combination of a contaminant to a potential receptor via an exposure pathway i.e. a pollutant linkage. This can be defined as follows:
- Source contaminant – a substance that is in, on or under the land and has the potential to cause harm or to cause pollution of controlled waters.

- Receptor – something that could be adversely affected by a contaminant, such as people, an ecological system, property or a water body. For example soil, vegetation, groundwater, construction workers, and members of the public.
- Pathway – a route by which a receptor can be exposed to, or affected by, a contaminant. For example ingestion or inhalation of potentially contaminated material.

- 11.5.27 Should Source-Pathway-Receptor linkages be identified, then there is a requirement to determine whether they pose a potentially unacceptable risk.
- 11.5.28 The risks associated with leaving contaminated material in-situ and untreated require site specific assessment with consideration of the mobility of the material and the potential linkages to sensitive receptors. The most likely impact associated with a do-nothing scenario is that contaminants may be mobilised by wind or surface water or by leaching into groundwater and subsequent transferral to underlying aquifers or surface waters.
- 11.5.29 Where contamination is encountered, disturbance of the material during construction works may increase the mobility of contaminants and thus the impact could potentially be major if receptors such as humans, the water environment or property come into contact with harmful substances.
- 11.5.30 Historical land uses were reviewed during the desk study report and sites of potential contamination were established. The ground investigations included a contamination testing programme to provide an indication of contamination levels across the site. This has concluded that contamination levels in soils present a low risk to construction and maintenance workers though this risk would still need to be managed.
- 11.5.31 Impact of contamination on buried concrete structures is confirmed to be slight as a minor increase in sulphate resistance would only be required in 3 isolated locations if any concrete structures are proposed in these areas. At present no significant concrete structures are proposed in these locations.
- 11.5.32 Should the soils from these locations be relocated elsewhere on the site (as is likely to be the case for soils represented by 2TP022 and these subsequently coincide with significant concrete structures, there may prove to be an impact on buried concrete local to this soil.
- 11.5.33 Following completion of the Proposed Scheme hard cover would occupy previously soft ground. This would reduce surface water infiltration and would therefore lower the risk of contaminants being mobilised beneath the carriageway. The new road hard cover would also prevent members of the general public from coming into contact with any potentially contaminated soil. It is considered that in this way the impact on groundwater or underlying soils and other adjacent receptors would be Slight.
- 11.5.34 The construction of a new road adjacent to contaminated material would introduce a potential impact on construction and maintenance workers as they may come into contact with the contaminated material. This impact is considered to be Slight.
- 11.5.35 The significance of Proposed Scheme on the risk of contamination is therefore assessed to Negligible.

### Loss of Economic Deposits

- 11.5.36 Minerals have been extensively exploited beneath the site in the past. Significant quantities may remain beneath the site and commercial extraction of these might be considered at some time in the future, although the Coal Authority indicates that the Proposed Scheme is not within an area of planned opencast or underground mining. Given that much of the more-easily won coal has been extracted historically, it is considered unlikely that deep or shallow mining of the residual coal would be financially viable in the foreseeable future. Additionally, extraction is unlikely to be considered viable given the various landownerships and the very restrictive linear nature of this scheme, i.e. opencast methods are typically only economically viable when mining large areas and volumes of minerals.
- 11.5.37 Construction of the Proposed Scheme across undeveloped land and junctions with existing roads would reduce the area available for future opencast mining following development of the bypass. The magnitude of the impact may therefore be classed as Slight.
- 11.5.38 Reference to Table 11.4 indicates that the significance of effect on the loss of economic deposits is Negligible.

### Summary of Significance of Predicted Impacts without Mitigation

- 11.5.39 Table 11.11 below provides a summary of pre-mitigation impacts on geology and soils resources.

Table 11.11: Summary of Significance of Predicted Impacts on Geological Resources without Mitigation

Baseline Condition	Sensitivity of Geological Interest	Magnitude of Impact	Significance of Impact
Sensitive Land Uses / Designated Sites	High	No Impact	No Impact
Topography and Geomorphology	Low	Negligible	Negligible
Topsoil	Low	Slight	Negligible
Drift Geology	Low	Slight	Negligible
Solid Geology	Low	Slight	Negligible
Ground Surface Stability	High - Highfield Low – rest of study area	Major in the area at Highfield Roundabout and Negligible for the rest of the site	Major in the area at Highfield Roundabout and Negligible for the rest of the site
Contamination	Low	Slight	Negligible
Loss of Economic Deposits	Low	Slight	Negligible

## 11.6 Mitigation

- 11.6.1 The only significant impact predicted in relation to geology and soils is potential ground surface instability due to mine workings collapse.

- 11.6.2 The most practical mitigation measure to address potential mine workings collapse is consolidation of mine workings by grouting. This involves the drilling of a grid of closely spaced boreholes into the mine working void and inserting grout down the holes into the void. This forms a curtain/perimeter wall and creates a barrier preventing grout material from escaping from the proposed grout zone. Consolidation by drilling and grouting of disused Mine Entries within influencing distance of the Proposed Scheme is undertaken by drilling boreholes to the base of the mine entry or a pre-determined depth and injecting grout throughout the extent of shaft or adit to be treated. The indicative areas of potential mine working consolidation can be seen on Figure 11.7. A suitable method statement, including a detailed monitoring strategy, for grouting work would be prepared and implemented by the contractor to minimise the risk of damage and/or disruption to surrounding land, vegetation and natural features. This would be included within a Construction Environmental Management Plan (CEMP) prepared by the main contractor.
- 11.6.3 Although contamination issues have been assessed as not significant (based on the conclusion that contaminants are not present at concentrations that may pose a risk of significant harm to human health, nor that there is any significant possibility of the presence of "Contaminated Land", (as defined in Part IIA of the Environmental Protection Act 1990)), a range of good practice measures would be implemented to ensure any risk is minimised.
- 11.6.4 However a small volume of Hazardous (Special) waste may be generated in the vicinity of 2TP022. Further assessment would be required once the cut/fill balance is finalised and the Site Waste Management Plan for the works, completed. The SWMP would include further assessment of the suitability of waste soils for reuse within the fabric of the road construction materials.
- 11.6.5 Mitigation measures would be applied to protect construction and maintenance workers and to ensure that any possible migration of contaminants is avoided. These would be implemented through standard health and safety procedures via the CEMP including:
- An appropriate safe system of work and, if necessary, Personal Protective Equipment in line with best practice for working with the contaminants identified through the targeted ground investigation.
  - Clearly defined working areas and access routes.
  - Plans to carefully strip, handle and separately store soils prior to construction.
  - The storage of all oil, chemical and hydrocarbon sources in accordance with legal requirements and best practice.
  - Method statements for dealing with the presence and unforeseen occurrences of hazardous substances.
- 11.6.6 The three locations where extraordinary concrete specification may be required can be mitigated by specifying the appropriate level of sulphate resistant concrete for buried structures, particularly those in contact with groundwater.
- 11.6.7 Provided that potentially contaminated material is excavated and handled in a responsible manner to prevent migration to other receptors, the risks and associated impacts would be reduced to acceptable levels, as defined by local authorities and SEPA, and are considered to be Negligible.

## 11.7 Residual Effects

- 11.7.1 The significance of effects of the Proposed Scheme on geology and soils, following the incorporation of the mitigation set out above, is summarised in Table 11.12.

*Table 11.12 – Summary of Significance of Predicted Impacts Post-Mitigation*

Baseline Condition	Baseline Sensitivity	Significance of Effect without Mitigation	Significance of Effect with Mitigation
Sensitive land uses / designated sites	High	No Impact	No Impact
Topography and Geomorphology	Low	Negligible	Negligible
Topsoil	Low	Negligible	Negligible
Drift Geology	Low	Negligible	Negligible
Solid Geology	Low	Negligible	Negligible
Ground Surface Stability	High - Highfield Low – rest of study area	Major in the area at Highfield Roundabout. Negligible for the rest of the site.	Slight in the area at Highfield Roundabout. Negligible for the rest of the site.
Contamination	Low	Negligible	Negligible
Loss of Economic Deposits	Low	Negligible	Negligible

- 11.7.2 With relevant mitigation measures adopted during the design, construction and operation phases of the Proposed Scheme, no significant effects in terms of geology and soils are predicted.