

## 16. Geology and Soils

This chapter considers the potential effects of the Proposed Scheme on the existing geology and soils, hydrogeology and contaminated land of the study area. Desk study assessment, consultation and site survey, including intrusive ground investigation have been used to establish the baseline conditions for the existing geology and soils receptors. Superficial deposits are predominantly glacial till and glacial fluvial deposits: made ground is present associated with man-made features (such as existing roads) and alluvium is found along the Dean Burn. The underlying bedrock comprises the Scottish Middle Coal Measures Formation and Scottish Lower Coal Measures Formation, comprising cycles of sandstone, mudstone, siltstone and coal seams. The main mineral resource is coal, but extraction of this has now ceased and no other economically viable mineral resources will be sterilised by the Proposed Scheme. A number of the coal seams have been worked at shallow depth beneath the scheme and mine entries are present across the site. There are no designated or non-designated geological sites within the study area. Surface agricultural soils are Class 1, 2 and 3.1 in terms of land capability for agriculture. The land and groundwater contamination assessment indicates that the risk from potential contamination to sensitive receptors is low and limited to localised sources in made ground, the water environment and ground gases.

Assessment has been undertaken to establish the significance of effects (direct and indirect) from the Proposed Scheme on the geology and soils receptors, during construction and during operation and considering implementation of the proposed mitigation measures. A neutral significance of effect was assessed for mineral resources, geomorphology and designated sites. The effect on superficial deposits, solid geology and mineral resources was assessed as neutral/slight, but on agricultural soils was assessed as large / very large due to the loss of prime agricultural land. A slight significance of effect was assessed for superficial and bedrock aquifer flow and quality, with the effect on bedrock quality reducing to neutral during operation. The effect on potentially contaminated ground and groundwater during construction was assessed as slight significance and neutral/slight for the operation phase.

The Proposed Scheme is therefore assessed to predominantly have a 'neutral' to 'slight' rating of residual significant effects after mitigation measures are employed, except on soils where the residual effect is 'large/very large'.

### 16.1 Introduction

16.1.1 This chapter considers the potential effects of the proposed A720 Sheriffhall Roundabout ('the Proposed Scheme') on the defined geology and soils of the study area and has been carried out in accordance with Design Manual for Roads and Bridges (DMRB), Volume 11, Section 3, Part 11 'Geology & Soils' for the Stage 3 Environmental Assessment (Highways Agency et al. 1993) as updated.

16.1.2 This chapter considers the potential impacts on:

- the underlying superficial deposits and solid geology;
- geological or geomorphological features which are of specific interest or importance;
- soils through loss and destruction of agricultural soils; and,
- contaminated land.

16.1.3 This chapter should be read in conjunction with the following chapters:

- Chapter 11 – Road Drainage and the Water Environment, which provides an assessment of the water quality and drainage impacts of the Proposed Scheme on groundwater, surface water, flooding areas and designated sites. Appendix 11.5 – Hydrogeological Assessment Technical Note presents detail on hydrogeology which is relevant to Geology and Soils.

- Chapter 15 – People and Communities – Community and Private Assets, and Human Health, which considers the impacts of agricultural land take.
  - Chapter 17 – Material Assets and Waste, which describes the use of material resources and management of waste during construction of the Scheme and proposes mitigation to minimise material use and maximise re-use.
- 16.1.4 New guidance covering the 'Geology and Soil' topics was published on 31 October 2019 under the heading LA 109 – Geology and Soil. This guidance aligns the DMRB assessment process more closely with the 2017 EIA Regulations.
- 16.1.5 The Geology and Soil assessment had been completed prior to the publication of this guidance. However, a review of the new guidance, LA 109, has been undertaken and it is not anticipated that the application of the guidance would substantially alter the assessment results.
- 16.1.6 Reference to DMRB, Volume 11, Section 3, Part 11 'Geology & Soils' within this chapter should be taken to refer to the 1993 guidance as discussed in paragraph 16.1.1 and not the new LA 109 guidance.
- 16.1.7 This chapter of the ES has been prepared by competent experts with relevant and appropriate experience. The technical lead for the Geology and Soils has over 15 years of relevant work experience and is a chartered member of the Institute of Civil Engineers. The technical lead for Contamination has over 30 years of relevant work experience and is a Chartered Geologist, Chartered Scientist, a Fellow of the Geological Society and a member of the European Federation of Geologists. Further details are provided in Appendix 1.2 – Table of Expert Competencies.

## 16.2 Approach and Methodology

### Study Area

- 16.2.1 The study area for this assessment includes the Proposed Scheme Extents and the wider immediate area of associated soils and geology that may be impacted by the Proposed Scheme. The study area boundaries are further defined in Section 16.5 below. Chapter 5 – The Proposed Scheme provides detail of the scheme.

### Stages of Assessment

- 16.2.2 The assessment was carried out in the following stages:
- Consultation with the relevant statutory and non-statutory bodies to establish geological receptors within the study area;
  - Review and assessment of desk study information and intrusive ground investigation data to establish baseline conditions within the study area;
  - Identification of potential effects and consideration of the interactions between the Proposed Scheme and current site conditions;
  - Assessment of the significance of effect by taking into account the sensitivity of the receiving environment and the potential magnitude of each impact; and
  - Mitigation measures devised to avoid or reduce any significant adverse effects.

### Information Gathering

#### **Consultation**

- 16.2.3 Consultations related to Geology and Soils were carried out with statutory and non-statutory bodies, including Animal Health and Veterinary Laboratories Agency (AHVLA), British Geological Survey (BGS), Buccleuch Estates, The City of Edinburgh Council (CEC), The Coal Authority, East Lothian Council, Midlothian Council (MLC), Scottish

Environment Protection Agency (SEPA), Scottish Government Rural Payments Inspections Directorate (SGRIPD), Scottish Natural Heritage (SNH), The Valuation Office Agency, Scottish Mining Museum, and road operators BEAR Scotland and Amey. Further details on consultation are provided in Chapter 7 - Consultation and Scoping.

### **Review of Available Sources**

16.2.4 A review of available sources of information has been undertaken to characterise the geology and soils of the study area. Sources comprised:

- Ordnance Survey (OS) data including current topographical maps, historical maps and information;
- British Geological Survey (BGS) data including mapping, online data, BGS aquifer maps and accompanying reports, previous ground investigations & historical borehole records, including factual reports for the city bypass;
- Edinburgh City Bypass Gilmerton Section, Site and Mineral Investigation (Norwest Holst, 1985)
- Edinburgh City Bypass Millerhill Section, Report on Site Investigation (Wimpey Laboratories, 1985)
- 'As Built' plans and design drawings provided by Transport Scotland for the Millerhill and Gilmerton sections of the A720 Edinburgh City Bypass ('the A720') construction;
- Design drawings from the A7 Dalkeith Western Bypass and ground investigation factual reports (Whatlings (Foundations) Ltd, 1988 and Norwest Holst, 1986);
- Aerial photography (obtained from Historic Environment Scotland within their National Collection of Aerial Photography (NCAP));
- Scotland and Northern Ireland Forum for Environmental Research (SNIFFER);
- SEPA Water Environment Hub Interactive map;
- Coal Authority Reports and Mine Abandonment Plans;
- Landmark Information Group Envirocheck Reports;
- Published papers and articles in various industry journals;
- Geotechnical data and ground investigation factual reports relating to the construction of the Borders Railway;
- Ground Investigation Factual Reports: A720 Sheriffhall Roundabout Improvements - Soil Engineering Geoservices Ltd. (SEGL), 2018 and 2019;
- Macaulay Land Use Research Institute (MLURI) for Land Use Capability and Agricultural Land quality maps.

16.2.5 Environmental Information was obtained from the above sources and from within the Landmark Information Group Envirocheck Report, which included:

- Location and details of discharge consents;
- River quality information;
- Details of groundwater vulnerability;
- Flood data;
- Locations of registered landfills;
- Potentially contaminative land uses;
- Locations of environmentally sensitive areas such as Sites of Special Scientific Interest (SSSI); ancient monuments, and areas of archaeological interest; and

- Information obtained from SEPA, SNH and the BGS.

- 16.2.6 The location of geological SSSIs, Regionally Important Geological Sites (RIGS) and potentially contaminated land sites have also been determined by consultation with Scottish Natural Heritage, SEPA, BGS and Midlothian, East Lothian and the City of Edinburgh Councils.
- 16.2.7 An assessment of mining and quarrying at, and in proximity to the site was undertaken from review and assessment of the Coal Authority Interactive Map Viewer, Coal Authority Mining Reports, Coal Authority mine abandonment plans, BGS Mining Plans Portal, BGS GeoIndex, and the Valuation Office Agency, in conjunction with a review of the recent and historic ground investigation data.
- 16.2.8 A Preliminary Sources Study Report (PSSR) has been produced separately by URS (now AECOM) (Ref 47067662/DOC/C/002, dated July 2014).
- 16.2.9 The Ground Investigation Final Factual Report: A720 Sheriffhall Roundabout Improvements - Soil Engineering Geoservices Ltd (TC8086) provides details of the extensive 2018 ground investigation. Ground Investigation Final Factual Report: A720 Sheriffhall Roundabout Improvements - Soil Engineering Geoservices Ltd (TC8086A) provides details of the 2019 ground investigation. In combination, and in conjunction with all historic ground investigation information, the reports provide sufficient information for the purposes of this assessment.

#### ***Field Survey***

- 16.2.10 A site walkover survey was undertaken by URS (now AECOM) personnel on 14 January 2014. During this walkover, personnel were granted access to the Borders Railway site and were therefore able to observe the on-going construction works at the underpass for the railway beneath the A720. The findings and observations from this site walkover are reported fully in the PSSR.
- 16.2.11 Further site walkover surveys were undertaken by AECOM personnel in July and October 2017. During these surveys it was noted that, other than the completion of the Borders Railway, there were no significant changes to the condition of the study area from what was previously reported in the PSSR.

#### ***Intrusive Ground Investigation***

- 16.2.12 Intrusive Ground Investigations, to inform the design of the Proposed Scheme, were undertaken by Soil Engineering Geoservices Limited (SEGL) between February and October 2018 and March to May 2019. The exploratory work included soil and rock drilling, trial pit excavations, soil and rock sampling, mine entry investigation (by geophysics, trenching and drilling), rock drilling to determine potential underground workings and establish stratigraphy and levels of the coal measures bedrock, road pavement cores, surface water sampling, in-situ testing, including soil permeability tests. Gas and groundwater monitoring instrumentation was installed in selected boreholes to allow sampling of groundwater for analysis and on-going monitoring of concentrations and flow rates of ground gases and groundwater levels. A programme of laboratory contamination testing was undertaken on selected samples of soil and groundwater recovered from the exploratory holes.
- 16.2.13 The findings of the investigations are reported in the Ground Investigation Factual Reports and will also be summarised in a Ground Investigation Report (GIR) by AECOM.
- 16.2.14 Several other intrusive investigations have previously been undertaken at the site, including work to inform the design of the Edinburgh City Bypass (1985) and Borders Railway (2013). The findings of these investigations are also considered in the reporting and assessment work for this chapter.

## Assessment of Impacts

16.2.15 The significance of the potential effects of the Proposed Scheme have been categorised considering the sensitivity of the receiving environment and the potential magnitude of impacts. This assessment methodology is based on experience of carrying out such assessments for a range of major infrastructure projects including knowledge of geology and soil characteristics in Scotland and cognisance of best practice and guidance. The assessment is in accordance with DMRB Volume 11, Section 3, Part 11 'Geology and Soils' but, as it does not define the sensitivity and magnitude criteria, the assessment relies on DMRB Volume 11, Section 2, Part 4 'Environmental Assessment and monitoring' (LA 104) (Highways England, et al., 2019), and the definitions of sensitivity, magnitude and significance are based on Tables 3.2N, 3.4N and 3.8.1, respectively, in LA 104.

### Sensitivity/Importance

16.2.16 The sensitivity and importance of the receiving environment has been categorised by taking into account the following range of criteria, as defined in Table 16-1 'Sensitivity Criteria – Geology Soils'.

**Table 16-1 Sensitivity Criteria – Geology and Soils**

Importance	Criteria	Examples
Very high	Attribute with a high quality and rarity, regional or national scale	Geological Site of Special Scientific Interest (SSSI) Regionally important Geological Site (RIGS); or aquifer within the zone of influence of a public water supply borehole; or supplying an SSSI. Areas containing geological or geomorphological features considered to be of a national interest such as Sites of Special Scientific Interest (SSSI), candidate SSSI or Geological Conservation Review (GCR) sites. Presence of extensive areas of economically important minerals valuable as a national resource. Areas of peatland within designated sites such as SSSI, Special Area Conservation (SAC) or Special Protection Area (SPA) with national or European importance and/or SNH priority peatland. SNH priority peatland Class 1 (nationally important carbon-rich and peaty soils, deep peat and priority peatland habitat likely to be of high conservation value)
High	Attribute with a high quality and rarity, local scale	Other exposed geological features of major or educational value; or mineral reserve allocated on Local Minerals Plan. SNH priority peatland Class 2 (nationally important carbon-rich and peaty soils, deep peat and priority peatland habitat likely to be of potentially high conservation value and restoration potential). Prime agricultural land (Class 1, 2 and 3.1) according to the Macaulay Institute for Soil Research, Aberdeen
Medium	Attribute with medium quality and rarity, local scale.	Areas containing geological features of designated regional importance considered worthy of protection for their educational, research, historic or aesthetic importance, such as Local Geodiversity Sites (LGS)/Regionally Important Geological Sites (RIGS). Presence of areas of economically important minerals of regional value. SNH priority peatland Class 3 (dominant vegetation cover is not priority peatland habitat but is associated with wet and acidic type. Occasional peatland habitats can be found. Most soils are carbon-rich and peaty soils, with some areas of deep peat). Agricultural land capable of producing an average to narrow range of crops (Class 3.2 to 4.2) according to the Macaulay Institute for Soil Research, Aberdeen
Low	Attribute with a low quality and rarity, local scale.	Sites and geological features not currently identified as SSSI, GCR or LGS/RIGS but that may require protection in the future. Presence of mineral areas or resource of local importance only. SNH priority peatland Class 5 (soil information takes precedence over vegetation data and there is no peatland habitat recorded, but all soils are carbon-rich and peaty soil and deep peat). Agricultural land capable of use as improved grassland or rough grazings (Class 5.1 to 6.3) according to the Macaulay Institute for Soil Research, Aberdeen
Negligible	Attribute with negligible quality and rarity, local scale.	Geological features not currently protected and unlikely to require protection in the future. No exploitable minerals or geological resources. SNH priority peatland Class 4 (areas unlikely to be associated with peatland habitats or wet and acidic type, and unlikely to include carbon-rich or peat soils), Class 0 (mineral

Importance Criteria	Examples
	soils where peatland habitats are not typically found), Class -1 (unknown soil types) and Class -2 (non-soil (i.e. loch, built up area, rock and scree)). Agricultural land of very limited agricultural value (Class 7) according to the Macaulay Institute for Soil Research, Aberdeen

### **Magnitude of Impact**

16.2.17 The magnitude is influenced by the timing, scale, size and duration of the potential effect. For the purposes of this assessment the magnitude is defined in Table 16-2 'Magnitudes of Impact'. The level of magnitude can be difficult to quantify, and professional judgement is often necessary to make an objective assessment.

**Table 16-2 Magnitudes of Impact**

Scale of Impact	Description of Degree of Effect
<b>Major</b>	Loss or partial loss (>50%) of a designated geological site, or where there could be complete severance at a site such as to fundamentally affect the integrity of the site (Adverse). Major permanent or long-term change. Existing resource use is irreparably affected, e.g. Loss of a designated geological feature (Adverse). Large scale or major improvement; extensive restoration or enhancement e.g. extensive stabilisation of valuable exposed rock slopes or undermined ground, reinstatement of open cast sites to match surrounding geomorphology (Beneficial). Major or total loss of topsoil, soils or peatland, or where the value of the area would be severely affected (Adverse). Large scale or major improvement; extensive restoration or enhancement e.g. extensive stabilisation of valuable exposed rock slopes or undermined ground, reinstatement of open cast sites to match surrounding geomorphology (Beneficial).
<b>Moderate</b>	Loss of part (approximately 15-50%) of a geological site or unit, major severance, major effects to its integrity as a feature, or disturbance such that the value of the site would be affected, but not to a major degree, e.g. quarrying of rock for imported fill, or substantial changes due to cuttings (Adverse). Partial loss of topsoil, soils or peatland, or where the value of the area would be affected, but not to a major degree (Adverse). Benefit or addition to key characteristics, features or elements; improvements of quality e.g. stabilisation of slopes or undermined ground, remediation of contaminated land (Beneficial).
<b>Minor</b>	Detectable but non-material effect on the geological site (up to 15%) or a medium effect on its integrity as a feature or where there would be a minor severance or disturbance such that the value of the site would not be affected, e.g. superficial disturbance to geology (Adverse). Partial loss of topsoil, soils or peatland, or where soils will be disturbed but the value of the area would not be affected (Adverse). minor benefit or addition to key characteristics, features or elements e.g. local rock slope improvements, local reinstatement of soils (Beneficial) or removal of contaminated soils (Beneficial).
<b>Negligible</b>	Very minor change from baseline condition. Change hardly discernible e.g. local changes to made ground deposits (Adverse) or local removal of contaminated soils (Beneficial). Very slight change of soil baseline conditions.
<b>No Change</b>	No loss or alteration or observable adverse or beneficial impact.

### **Significance of Effect**

16.2.18 The sensitivity of the receiving environment together with the magnitude of the effect defines the significance of the effect as outlined in

16.2.19 Table 16-3 'Matrix for Determination of Significance of Effect'.

**Table 16-3 Matrix for Determination of Significance of Effect**

Sensitivity of Receptor	Magnitude of Impact				
	Major	Moderate	Minor	Negligible	No Change
<b>Very High</b>	Very Large	Large/Very Large	Moderate/Large	Slight	Neutral
<b>High</b>	Large/Very Large	Moderate/Large	Slight/Moderate	Slight	Neutral

Sensitivity of Receptor	Magnitude of Impact				
	Major	Moderate	Minor	Negligible	No Change
Medium	Moderate/Large	Moderate	Slight	Neutral/Slight	Neutral
Low	Slight/Moderate	Slight	Neutral/Slight	Neutral/Slight	Neutral
Negligible	Slight	Neutral/Slight	Neutral/Slight	Neutral	Neutral

Source: Table 3.8.1, DMRB, Volume 11, Section 2, Part 4 'Environmental Assessment and monitoring' (LA104) (Highways England, 2019)

16.2.20 The significance of effect is assessed initially before the consideration of the effectiveness of the mitigation design and committed mitigation measures. Further assessment is thereafter completed to assign residual significance of effect once appropriate mitigation measures have been implemented. It is reiterated that this assessment relies on professional judgement. Significant effects typically comprise residual effects that are within the moderate, large or very large categories.

### Assessment of Potential Contamination Impacts

16.2.21 The assessment of potential contamination impacts is based on the potential source-pathway-receptor linkages as defined in the current DEFRA (Guidelines for Environmental Risk Assessment and Management) and CIRIA (Construction Industry Research and Information Association) C552 Contaminated Land Risk Assessment. A Guide to Good Practice 2001. The guidance document describes a method for the classification of the severity and likelihood of identified risks. This assessment is based on consideration of both:

- The likelihood of an event (probability – takes into account both the presence of the hazard and receptor and the integrity of the pathway); and
- The severity of the potential consequence (takes into account both the potential severity of the hazard and the sensitivity of the receptor).

16.2.22 The methodology adopted relies on the development of a site-specific conceptual site model (CSM) which summarises the potentially viable contaminant linkages with the assigned risk ratings.

16.2.23 The following tables indicate the categorization of risk with respect to land contamination used to assess the qualitative risk of contamination. The likelihood of an event (probability – takes into account both the presence of the hazard and receptor and the integrity of the pathway) using Table 16-4 'Classification of Likelihood of Risk'.

**Table 16-4 Classification of Likelihood of Risk**

Classification	Definition
High likelihood	Pollution linkage identified and an event that either appears very likely in the short term and almost inevitable over the long term; There is evidence at the receptor of harm or pollution.
Likely	Pollution linkage identified and it is probable that an event will occur. Event is not inevitable but possible in the short term and likely over the long term.
Low Likelihood	Pollution linkage identified and circumstances possible under which an event could occur. No certainty that event would take place even in the long term and is less likely in the shorter term.
Unlikely	Pollution linkage identified but it is improbable that an event would occur even in the very long term.

16.2.24 The severity of the potential consequence (takes into account both the potential severity of the hazard and the sensitivity of the receptor using Table 16-5 'Classification of Severity of Risk'.

**Table 16-5 Classification of Severity of Risk**

Classification	Definition
Severe	Short-term (acute) risk likely to result in significant harm. Short-term risk of pollution of sensitive water resource. Catastrophic damage to buildings/property. A short-term risk to a particular ecosystem, or organism forming part of such ecosystem.
Medium	Chronic damage to human health (non-fatal). Pollution of sensitive water resources. A significant change in a particular ecosystem, or organism forming part of such ecosystem.
Mild	Pollution of non-sensitive water resources. Significant damage to crops, buildings, structures and services. Damage to sensitive buildings/structures/services or the environment.
Minor	Harm (not necessarily significant harm) which may result in financial loss or expenditure to resolve. Non-permanent health effects to human health (can be easily prevented by PPE). Easily repairable effects of damage to buildings, structures and services.

- 16.2.25 The comparison of severity and likelihood will allow a risk to be determined as defined in Table 16-6 'Matrix to Ascertain Qualitative Risk Ranking' and Table 16-7 'Summary Description of the Classified Risk' below.

**Table 16-6 Matrix to Ascertain Qualitative Risk Ranking**

Likelihood	Severity			
	Severe	Medium	Mild	Minor
High	Very High Risk	High Risk	Moderate Risk	Moderate/Low Risk
Likely	High Risk	Moderate Risk	Moderate/Low Risk	Low Risk
Low	Moderate Risk	Moderate/Low Risk	Low Risk	Very Low Risk
Unlikely	Moderate/Low Risk	Low Risk	Very Low Risk	Very Low Risk

- 16.2.26 Risk ratings at moderate/low risk or above are considered to be potentially significant and require consideration of mitigation controls.

**Table 16-7 Summary Description of the Classified Risk**

Classification	Description
<b>Very High Risk</b>	There is a high probability that severe harm could arise to a receptor from an identified hazard; or There is evidence that severe harm to a designated receptor is currently happening.
<b>High Risk</b>	Harm is likely to arise to a designated receptor from an identified risk.
<b>Moderate Risk</b>	It is possible that harm could arise to a designated receptor from an identified hazard. Harm is unlikely to be severe or would be relatively mild.
<b>Low Risk</b>	It is possible that harm could arise to a designated receptor from an identified hazard. Harm would be mild.
<b>Very Low Risk</b>	There is a low possibility that harm could arise to a receptor. Harm is not likely to be severe.

### Limitations to the Assessment

- 16.2.1 It is likely that the Proposed Scheme will be procured by means of a Design and Build (D&B) type contract. Under the terms of this contract type, the Contractor will undertake both the detailed design and construction of the Proposed Scheme
- 16.2.2 It is expected that the construction work would take place within the Scheme Extents as shown on Figure 1.2 'The Proposed Scheme'. The Scheme Extents have informed the land take calculations undertaken for assessment purposes in this ES. The land within the Scheme Extents will be purchased under a CPO.



- 16.2.3 It is possible that the Contractor may require construction compounds to be located out with land identified in the CPO. Should construction compounds be located out with the Scheme Extents it will be the responsibility of the Contractor to assess the environmental impacts of the construction compounds and seek to mitigate these where possible.
- 16.2.4 The construction assessment is based on the construction information that is currently available, with advice being provided by the Highway Design Team. As with all construction assessments, the exact details of construction activities would not be fully known before a specific contractor is appointed to complete the works who would determine their exact construction methods and programme during the detailed design stage.
- 16.2.5 As the Proposed Scheme is developed at detailed design any refinements to the design should be subject to environmental review to ensure that the residual effects would not be greater (or significantly different) than those reported in this ES. The findings of any such review should be subject to approval by Transport Scotland (TS) and where necessary opinions should be sought from the statutory bodies.
- 16.2.1 Although the design will be required to be within the acquired land and comply with the Employers Requirements, the exact scheme extents (i.e. earthworks) may differ from the Proposed Scheme. This may alter the proposed extents of mine workings treatment (both in plan and depth) and/or the proposed mine entry treatment however, this is not likely to result in a change in impact ranking.
- 16.2.2 As the appointed contractor will be responsible for determining the working methods (including temporary works) and selection of materials, the assessment of associated impacts are subject to inherent limitations. Nevertheless, compliance with the mitigation measures, such as those defined in Section 16.7, will allow these impacts to be controlled and mitigated.
- 16.2.3 This assessment has been undertaken in accordance with DMRB guidance for a Stage 3 Assessment, and the above limitations are typical. The assessment is therefore considered robust and the level of investigation and detail is appropriate for the purposes of a DMRB Stage 3 Assessment.

## 16.3 Legislative and Policy Framework

- 16.3.1 The DMRB Stage 3 Environmental Assessment for upgrading Sheriffhall roundabout will consider two different council administrative boundaries:
- The City of Edinburgh Council, and;
  - Midlothian Council.
- 16.3.2 The planning context for Sheriffhall must take a number of policy documents into consideration along with a high number of development designations in existing and forthcoming local plans/local development plans (LDPs).
- 16.3.3 The planning policies which are identified as relevant to the A720 scheme with respect to geology and soils are listed below.

### National Policy

#### ***National Planning Framework 3 (Scottish Government, 2014b)***

- 16.3.4 Scotland's Third National Planning Framework (NPF3) document outlines the Scottish Government's strategy for Scotland: economic strategy and plans for infrastructure investment. NPF3 subject policies which are relevant to geology and soils are listed below:

**Table 16-8 NPF3 Policies relevant to the Geology and Soils Assessment**

Policy	Relevance
Natural Resilient Place	Respect, enhance and make responsible use of natural assets. Mentions coal bed methane as an energy resource Agricultural land noted as an important resource. Need to actively address impacts of past land uses, including mineral extraction

**Scottish Planning Policy (Scottish Government, 2014a)**

- 16.3.5 The Scottish Planning Policy (SPP) document is a statement of the Scottish Government's policy on nationally important land use matters. SPP subject policies which are relevant to geology and soils are listed below.

**Table 16-9 SPP Policies relevant to the Geology and Soils Assessment**

Policy	Relevance
A Low Carbon Place	A new development should minimise unnecessary use of primary materials and support zero waste targets. Relates to re-use of site won material and SWMP.
Valuing the Natural Environment	Considers impact on RIGS and peat land. Specifies protection of soils from damage and compaction. Considers impact on agricultural soils. Promotes protection of water environment including groundwater.
Promoting Responsible Extraction of Resources	Requirement to minimise sterilisation of mineral resources. Relates to use of site won fill and recycled aggregates where possible. Development of marginal land is relevant to stabilisation of (and potential improvement to) currently un-used land by mine workings treatment.

**Scottish Soil Framework (Scottish Government, 2009)**

- 16.3.6 The Scottish Soil Framework aims to raise awareness of services soils provide to society and the pressures they face, and to instigate a process by which key stakeholders work together to achieve better soil protection. It will promote the sustainable management and protection of soils consistent with the economic social and environmental needs of Scotland. The Framework identifies activities that will contribute to thirteen soil 'outcomes', those particularly relevant to geology and soils on this scheme are listed below:

**Table 16-10 Scottish Soil Framework Policies relevant to the Geology and Soils Assessment**

Policy	Relevance
SO9	Soil contamination reduced
SO10	Reduced pressure on soils by using brownfield sites in preference to greenfield

**Scotland's Geodiversity Charter 2018 – 2023 (Scottish Geodiversity Forum, 2018)**

- 16.3.7 The Charter encourages the promotion and management of Scotland's geodiversity to help protect a crucial aspect natural heritage and deliver more sustainable management of Scotland's natural resources. The charter has four main areas of activity and those relevant to geology and soils on this scheme are listed below:

**Table 16-11 Scottish Geodiversity Charter Policies relevant to the Geology and Soils Assessment**

Policy	Relevance
Raise awareness	Encourage public awareness of geodiversity
Integrate Geodiversity	Incorporate geodiversity to encourage sustainable management of natural heritage. Encouraged to work with natural processes as far as possible.
Conserve and Enhance	No designated sites on the scheme

Undertake Research      Make available records and samples as part of local and national geological record keeping.

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### **Planning Advice Notes (PANs) and Other Guidance**

16.3.8 PANs provide national guidance on various topics and SEPA has produced a number of guidance documents covering a range of environmental issues. Those documents relevant to Geology and Soils are listed below:

- PAN33 - Development of Contaminated Land (2000)
- SEPA Policy No. 19 - Groundwater Protection Policy for Scotland (2009);
- PPG 1 – Understanding Your Environmental Responsibilities (document is withdrawn but is still considered good practise);
- GPP5 – Works and Maintenance in or Near Water (February 2019);
- PPG 6 – Working at Construction and Demolition Sites (document is withdrawn but is still considered good practise); and
- GPP 22 – Dealing with spills (October 2018).

*Note: SEPA Pollution Prevention Guidelines are currently out of date. A review plan for the PPGs is currently underway, replacing them with a replacement guidance series, Guidance for Pollution Prevention (GPPs). However, the PPGs are still considered good practise guidance.*

## Regional Policy

### **South East Scotland Strategic Development Plan (SDP) (SESplan, 2013)**

16.3.9 The South East Scotland Strategic Development Plan (SESplan) (June 2013) sets out a spatial strategy which recognises existing development commitments and promotes a sustainable pattern of growth across the City of Edinburgh, East Lothian, Fife, Midlothian, Scottish Borders and West Lothian Council areas. Policies relevant to geology and soils are listed below:

**Table 16-12 SESplan SDP Policies relevant to the Geology and Soils Assessment**

Policy	Relevance
<b>Policy 4 - Minerals</b>	
Policy 4a	Requirement to safeguard mineral resources from sterilisation.
Policy 4d	Supports and encourages use of secondary and recycled aggregates.
Sub-clause 103	Requirement to minimise transportation of aggregate minerals
Sub-clause 104	Supports extraction of onshore gas or coal bed methane resources
<b>Policy 15 – Water and Flooding</b>	
Policy 15a	Make provision to prevent deterioration of the water environment, which relates to grouting of mine workings and piling work
<b>Policy 12 – Green Belt</b>	
Sub-clause130	Effort to minimise loss of land and minimise impact of scheme relates to loss of agricultural land

### **Proposed South East Scotland Strategic Development Plan (SDP2) (SESplan, 2016)**

16.3.10 SESplan is currently being updated and a new proposed plan was published in October 2016. The following strategic level cross boundary planning policies which are relevant to geology and soils are discussed below.

16.3.11 Minerals are addressed under 'Responsible Resource Extraction' which recognises that the region has a legacy of sites where minerals were formerly extracted. It also recognises the need for a sufficient supply of construction aggregates and states that a working group will be established to address this.

- 16.3.12 As discussed in Chapter 2 - Need for the Scheme, the Proposed SDP was rejected by the Scottish Ministers on 16 May 2019, however the proposed plan has still been considered within this ES as a draft plan.

## Local Policy

### ***Edinburgh Local Development Plan (City of Edinburgh Council, 2016)***

- 16.3.13 CEC's Local Development Plan (LDP) (Adopted November 2016) policies which are relevant to geology and soils are listed below.

**Table 16-13 City of Edinburgh Council LDP Policies relevant to the Geology and Soils Assessment**

Policy	Relevance
<b>Caring for the Environment – Natural Resources</b>	
Policy Env 22 - Pollution and Air, Water and Soil Quality	Considers impact on agricultural soils. Considers impact on ground stability – which relates to potential mine workings stabilisation works. Relevant to contaminated land Considers impact on the water environment, which relates to mine workings treatment and hydrogeology
<b>Minerals</b>	
Policy RS 5 - Minerals	Requirement to minimise sterilisation of mineral resources.

### ***Midlothian Local Development Plan (Midlothian Council, 2017)***

- 16.3.14 Policies from the MLC's Local Development Plan which are relevant to geology and soils are listed in Table 16-14 below.

**Table 16-14 Midlothian Council's LDP Policies relevant to the Geology and Soils Assessment**

Policy	Relevance
<b>Heritage Protection Policies - Safeguarding and Managing Our Natural Environment</b>	
Policy ENV 4 - Prime Agricultural Land	Considers impact on prime agricultural land and whether the benefits outweigh the loss.
Policy ENV 5 - Peat and Carbon Rich Soils	Considers impact on deposits of peat or carbon rich soils.
Policy ENV 10 - Water Environment	Relates to pollution of water from areas of contaminated land. Also relates to the disruption and pollution of the water environment from mine workings treatment.
Policy ENV 16 - Vacant, Derelict and Contaminated Land	Encourages development of vacant land that could be considered marginal. Development of marginal land is relevant to stabilisation of (and potential improvement to) currently un-used land by mine workings treatment.
<b>Economic Growth Policies - Resource Extraction</b>	
Policy MIN 1 - Areas of Search for Surface Mineral Extraction	Considers hard rock quarrying. Requirement to minimise sterilisation of mineral resources.

## 16.4 Consultation

- 16.4.1 Table 16-15 'Summary of Consultations Undertaken' below provided a summary of the consultations carried out with relation to geology and soils during the Stage 3 assessment.

**Table 16-15 Summary of Relevant Consultations**

Consultee	Response
BGS	No known RIGS are situated within the study area.

Consultee	Response
	<p>Data from the British Geological Survey has shown low levels and rare occurrences of seismic activity along the Sheriffhall Fault.</p> <p>BGS were further consulted for information about the differences in geology mapped on Sheet 32E compared with the older 10,560 County Series map. They stated that rock features exposed during the construction of the A720 Edinburgh City Bypass may have been examined which may subsequently have led to re-interpretation of the solid geology as presented on the more recent geological map for this area.</p> <p>BGS provided report SL79/3 entitled Geological Report on the Edinburgh City Bypass: Gilmerton to Millerhill Section (July 1979).</p>
The Valuation Office Agency	<p>Consultation with the mining, minerals, waste management and contaminated land specialists of the Valuation Agency confirmed that coal mining is the main mineral activity affecting the study area. They noted that oil shale and limestone minerals may have been worked to the west, but any such workings lie outwith the study area and do not affect the proposed scheme.</p>
Scottish Government Rural Payments and Inspections Directorate (SGRPID)	<p>Consultation with SGRPID provided details on agricultural land quality. However, although referring to the Macauley mapping in their response the SGRPID description of the land classifications differed to the Soil Survey maps. SGRPID response was: "The land in and around Sheriffhall roundabout is considered to be very good quality land and is mapped as land classification 2. The land extending east along the leg of your highlighted area towards Millerhill Junction is considered even higher and is mapped as land classification 1. You will thus gather that almost all of the land in your highlighted area is very capable land from an agricultural point of view. The only exception would be a very thin sliver on the south east of the area highlighted running in the general direction of the Millerhill Junction. This is confined to the edge of the River Esk and part of the wooded area. This thin sliver is considered to be in land classification 5.2 due to the natural water run-off to the lower area near the river".</p> <p>[NOTE - For the purposes of this assessment the published mapping data has been used which agrees with the SGRPID commentary]</p>
Midlothian Council (MLC) (Environmental Health Officer)	<p>MLC's Environmental Health Officer stated they had checked their GIS and there was no information regarding potential contaminants on the site in question. There are a number of areas around Sheriffhall and the Gilmerton Junction where Giant Hogweed has been reported.</p>
City of Edinburgh Council	<p>CEC's Contaminated Land officer consulted on potential contamination within the Council boundary where it is within the scheme extents. Their reply noted potential for mine entries within the study area and a number of features outside the study area namely: Gilmerton Colliery bing, now a scrap yard (350m beyond study area), two former landfill sites (within 1km of the study area). They had no record of private groundwater or surface water abstractions.</p>
Animal Health and Veterinary Laboratories Agency (AHVLA)	<p>The AHVLA were consulted about animal burial sites associated with disease. They confirmed there are no animal burial sites associated with disease in the area.</p>
Road Operators (BEAR Scotland and Amey)	<p>BEAR Scotland were consulted to determine if there had been any unusual road maintenance during their tenure as term maintenance contractor (as this may have been attributable to fault movement). BEAR confirmed there had been no unusual road maintenance required. Amey had previously been consulted (by others in earlier stages of the scheme) and also recorded no unusual road maintenance.</p>
Buccleuch Estates	<p>AECOM visited Buccleuch Estate offices to view their historic maps and plans and note evidence of historic shallow mine workings in the land to the west of the roundabout.</p>
Scottish Environment Protection Agency (SEPA)	<p>Consultation at Stage 3 specific to consolidation grouting of mine workings and mine entries. SEPA's response comprised: "SEPA Planning Standard Response – Stabilisation of mine workings with PFA grouts", which noted <i>The pouring of grout below the water table is a controlled activity under General Binding Rule (GBR) 16 of the Water Environment (Controlled Activities) (Scotland) Regulations 20011 (CAR). GBR 16 includes a requirement that no material coming into contact with groundwater shall cause pollution of the water environment. SEPA considers that an assessment should be undertaken to assess whether the use of PFA grout will meet the requirements of GBR 16. If the activity causes pollution, SEPA may take enforcement action in accordance with these regulations.</i> The response also recommended that works be undertaken in line with BRE Report 509. The covering email also noted: <i>We would like to know, however, of any likelihood that the grouting of shallow mine workings might affect surface water. SEPA's local team * should be notified when these works start, what works are involved and what watercourse/ditches they may affect and what mitigation is in place. SUDS should be in place prior to any soil removal for the construction phase. Should you need any more specific advice we would need more specific detail of the nature of the works, the proximity of these works to watercourses or ditches, etc.</i></p>
The Coal Authority	<p>Response to Stage 3 DMRB assessment consultation received:</p> <p><i>Construction over mine shafts:</i></p> <p>CA Policy is that development should avoid mine entries and their zones of influence wherever possible (formal policy document provided with response). CA planning responses therefore normally object to any proposed development over a mine entry or within its zone of influence, and recommend that layouts are adjusted accordingly. In exceptional cases, and only if there is clear justification that the proposed layout cannot be practically altered to avoid such features, such development may be acceptable, but CA will</p>

Consultee	Response
	<p>also require evidence that a suitable engineering design has been developed to take account of all the relevant safety and environmental risk factors including gas and mine-water.</p> <p><i>Mine shaft indemnity and future liability:</i> Liability will remain with the parties involved in the works (i.e. landowner, contractor, consultant): however, the ownership of coal mine entries usually rests with CA. Developers wishing to treat them must apply for a permit to treat from CA permissions department. The treatment specification and method will be considered as part of this process and permission to build over them will only be assented to if the proposal is considered safe. As part of the permit to treat, the developer will be required to sign a disclaimer indemnifying CA from claims in connection with said mine entries for a twelve year period.</p> <p><i>Mine water and Mine water Treatment:</i> No groundwater pumping from Monktonhall colliery, which was pumping until 2009. Records from Coal Authority boreholes show groundwater levels have recovered since the cessation of pumping. A number of parties are interested in heat from mine water projects. As these would be closed loop injection systems a net reduction in mine water levels is not expected. Mine water treatment sites are located to the south of River Esk so these will not affect mine water beneath Sheriffhall.</p>

## 16.5 Baseline Conditions

### Baseline Study Area

- 16.5.1 The baseline conditions for this chapter have been considered within a study area defined by the plan extent of the Proposed Scheme plus a 500m margin around this. A wider study area was adopted where appropriate, for instance for larger scale features such as seismic events along the Sheriffhall fault and potential contamination sources which may exist outside the 500m buffer. The wider study area extends up to 2.0km in all directions from the centre of the roundabout.

### Topography and Land Use

- 16.5.2 The topography of the study area mainly consists of gently undulating terrain with typical natural slope angles of around 5° to 10°. The land tends to fall towards the A720 from the south and west. The elevation at Sheriffhall roundabout is approx. 61mOD. To the south and west the land rises to 71mOD. Immediately north and southwest of the roundabout an esker forms a local area of higher ground, up to 65mOD but the beyond the esker the ground levels fall to 58mOD. Around the Dean Burn and extending to the south-east Sustainable Drainage System (SuDS) pond, ground level falls to around 57mOD. The Dean Burn flows west to east to the south of the A720 across the scheme and is considered further in Chapter 11 – Road Drainage and Water Environment).
- 16.5.3 The land surrounding the Proposed Scheme consists of large areas of arable farm land with occasional residential properties, and local woodland copses and rough ground immediately adjacent to the A720. A disused railway line runs in a north-south orientation to the east of the Sheriffhall Roundabout, as does the new Borders Railway which runs through a tunnel under the A720. Localised bunds are present to the south-west of the A720 near an irrigation pond. The A720 road infrastructure is in cutting and low fill to the west of Sheriffhall Roundabout. To the east of the roundabout the existing A720 alignment rises resulting in an embankment up to 6m in height. The A7 and A6106 roads also tie-in to the roundabout.

### Geology

- 16.5.4 The published drift and solid geological information within the study area is reproduced on the following Figures:
- Figure 16.1 – Solid and Drift Geology (From 1:10,560 Geology Map)
  - Figure 16.2 – Solid and Drift Geology (From BGS Sheet 32E)
  - Figure 16.3 – Solid Geology (From BGS Sheet 32E)

16.5.5 Full geological details can be found in the Geotechnical Preliminary Sources Study Report prepared by AECOM (then URS). Further details relating to the superficial and bedrock geology encountered during recent intrusive ground investigation works can be found in the Ground Investigation factual reports (by Soil Engineering) and the GIR, prepared by AECOM. A summary of the geology based on all the sources of information is presented below

## Superficial Geology

### **Thickness of Superficial Deposits**

16.5.6 Indicative thicknesses of superficial deposits in the study area are shown on the BGS Environmental Geology Map, South East Edinburgh, 1981; 'Thicknesses of Unconsolidated Deposits'. These are indicated to be around 5m at Gilmerton, increasing to between 10m and 15m immediately west of Sheriffhall Roundabout. East of Sheriffhall Roundabout, drift thickness is shown to be between 5m and 10m. In the Lugton Bogs area to the south, and east to the A6106 (South) the thickness appears to increase up to 30m, with the thicker deposits shown to occur at the A7 (South) in the vicinity of Melville Gate.

16.5.7 The actual thickness of superficial deposits encountered during intrusive Ground Investigation broadly aligns with those shown on the BGS Environmental Geology Map; with the thinnest deposits (approximately 3.0m below ground level) occurring in the west of the study area, towards Gilmerton, and the thickest deposits (approximately 23.0m below ground level) occurring to the south, near the A6106 South and the A7 South.

### **Made Ground**

16.5.8 Made ground is present at the location of all man-made development and engineering infrastructure. Made ground is present as infill to, and possibly surrounding, old mineral extraction pits, abandoned mines and mine shafts. In some instances, the made ground comprises reworked natural soils, similar in composition to surrounding soils, but evidently disturbed or reworked by man. In other cases, the made ground also contains variable quantities of man-made material including tarmac, blaes, brick, sandstone masonry and natural organic materials such as branches and logs. Instances of made ground at the Sheriffhall site are:

- Two bunds to the south of the existing A720 towards the west end of the proposed scheme;
- Mound of material in the centre of the roundabout;
- Reworked and made ground to the north and south of the A720 associated with Borders Rail and the A720 temporary diversion to the north of the existing road alignment;
- Former A7 road alignment currently forming the cycle path west of the A7 North and A6106 South; and
- Minor and localised fly tipping;

16.5.9 Made ground is considered further in the 'Potential Contamination Assessment' Section of this chapter and Figure 16.4 'Potential Contamination Sources' shows areas of recorded made ground which may be potential contamination sources.

### **Engineering Fill**

16.5.10 The embankments of the existing A720 are up to 6m high and are formed of engineered fill. The A720 embankment fill temporarily exposed during Borders Rail construction was seen to comprise red blaes (either well burnt colliery spoil or spent oil-shale waste) at the base of the embankment lying underneath black/grey unburnt colliery spoil occasionally interbedded with thinner layers of sand fill and cohesive fill derived from natural soil deposits. Recent boreholes drilled through the embankments describe the embankment fill as dense to very dense black sandy clayey gravel, with bands of sandy gravelly clay.

- 16.5.11 The A7 South embankment is up to 3m high and is also formed of engineering fill, comprising sandy clayey gravel. It was constructed in 1990.
- 16.5.12 Beneath the A7 North/A720 junction and A6106 South/A720 junction at the roundabout engineering fill is recorded to be present in the form of a reinforced soil "raft". Design drawings record the raft to comprise engineering fill and galvanised steel reinforcing strips.

#### ***Topsoil***

- 16.5.13 Topsoil was encountered across the extent of the study area; excluding areas of existing development, road carriageway, railway, access tracks or other areas of recent made ground. Typically described as slightly sandy slightly gravelly clay with occasional rootlets, it was found to range in thickness from approximately 0.1m to 0.5m.

#### ***Alluvial Deposits***

- 16.5.14 Published geological mapping does not indicate that alluvial deposits are present beneath the study area. However, such deposits would reasonably be expected to be present along the watercourse (the Dean Burn) which passes through the study area in a west to east orientation and within the areas that are susceptible to flooding in the vicinity of this watercourse. During the intrusive Ground Investigation, isolated alluvial deposits (in the form of silty sediments) were encountered at the base of the pond at Lugton Bogs to the west of the study area and in a borehole on the south bank of the Dean Burn, where the alluvial soils were described as firm slightly sandy slightly gravelly clay.

#### ***Glaciofluvial Deposits***

- 16.5.15 Published geological mapping indicates that an esker (comprising glaciofluvial deposits of sand and gravel), runs in a north-westerly direction through the centre of the study area, from Sheriffhall Mains in the south to beyond Campend in the north.
- 16.5.16 Ground Investigation exploratory holes have generally found the extents of glaciofluvial deposits to be as indicated by the published geological mapping, and where encountered, these deposits were typically described as 'loose to medium dense sand' and locally 'sand & gravel', with varying (sometimes substantial) proportions of clay and silt.

#### ***Glacial Till***

- 16.5.17 The superficial geology underlying the study area predominantly comprises glacial till of varying thickness and depth. Weathered glacial till is encountered across the site and is typically described as soft to firm sandy gravelly clay with occasional cobbles and boulders. Where present the weathered glacial till was underlain by fresh glacial till which was typically described as stiff becoming very stiff with depth, sandy gravelly clay, with occasional cobbles and boulders.
- 16.5.18 In some cases, the weathered zone is absent, for instance under existing structures.

### **Solid Geology**

#### ***Bedrock***

- 16.5.19 The solid geology underlying the study area is predominantly recorded to comprise the Carboniferous strata of the Scottish Middle Coal Measures Formation and Scottish Lower Coal Measures Formation. The Scottish Middle and Lower Coal Measures contains seams of coal and other minerals which are known to have been commercially exploited in the past. A number of coal seams are recorded to outcrop within the study area, as discussed in the 'Mining and Quarrying' section of this chapter.



16.5.20 The Scottish Middle and Lower Coal Measures Coal Measures comprise cycles of coal, seatearths, sandstone, grey siltstone, grey/brown often micaceous and carbonaceous mudstone and black coals. The sandstones and siltstones are typically weak to moderately strong. The mudstones and coal are typically weak.

### ***Structural Geology***

16.5.21 The ground within the vicinity of the study area is significantly faulted, with a series of east-west and north-south trending faults. The most persistent of these faults, the major Sheriffhall Fault, is recorded to trend broadly east-west through the centre of the study area downthrowing the strata to the north by approximately 175m. The position of this fault has been proven underground within mine workings within the vicinity of the study area. The geological memoir indicates that the Sheriffhall Fault is an oblique normal fault, with components of dip-slip (vertical) and strike-slip (lateral) movement. From this information it has been inferred that the fault is inclined to the north by around 50° from the horizontal. The strata in the vicinity of the fault are likely to be shattered. Mine abandonment plans indicate that there is a zone of “troubled” or shattered strata around 40m wide. Several smaller southeast-northwest trending faults are also recorded within the study area, primarily to the north of the Sheriffhall Fault and generally terminating against this feature.

16.5.22 The geological maps indicate that the strata beneath the study area are generally inclined towards the east by around 10°, although local variations associated with folding and faulting are to be anticipated.

### ***Seismicity***

16.5.23 Seismic activity has been recorded in the past in and around the study area, although the magnitudes of the seismic events were weak to very weak. The BGS database indicates seismic events with magnitude 1.6 ML to 1.8 ML (ML = Richter local magnitude scale) were recorded in the 1970’s some 2km to the north and south of the study area. Most of the recorded locations of seismic activity in close proximity to Sheriffhall Roundabout correlate with the postulated location of the Sheriffhall Fault. These minor seismic events are attributed to deep mining activity which has since ceased. The most recent activity to be recorded by the BGS is from 1991. This had a magnitude of 0.5 ML (recorded at Lasswade, 2.3km south of the roundabout).

## **Mining and Quarrying**

### ***Mineral Extraction - Coal Mining***

#### Recorded Mining

16.5.24 The geology maps record evidence of underground mining within the study area, with several of the coal seams of the Scottish Middle and Lower Coal Measures recorded to have been worked extensively to the north and south of the Sheriffhall Fault. Information from the Coal Authority records workings in fourteen seams of coal beneath the site, from shallow (<30m below ground surface) to 900m depth (below ground surface). Reference to the Coal Authority’s interactive map viewer indicates recorded shallow (<30m below ground surface) workings are present beneath a small area of the A720 to the west of Sheriffhall Roundabout. This data source also indicates there is potential for unrecorded shallow workings to exist beneath the majority of the site.

16.5.25 Available mine record plans relating to the study area were reviewed, confirming the presence of abandoned workings beneath the site in eleven coal seams (from shallowest to deepest): these seams are named Diamond, Musselburgh Jewel, Little Splint, Cowpits Five Foot, Salters (Whitehall Rough), Nine Foot (Whitehill Splint), Fifteen Foot (combined Pinkie Three Foot and Six Foot), Six Foot (Whitehill Jewel), Great Seam, Stairhead and Parrot Seam. The names in parenthesis denote alternative names given to coals south of the Sheriffhall Fault).

- 16.5.26 Of the above-named seams, the recorded workings in the Little Splint, Cowpits Five Foot, Salters, Nine Foot, Fifteen Foot, Great Seam, Stairhead and Parrot Coals were mined using relatively modern total extraction techniques (workings date from 1948 to 1979) at significant depth and are not considered to pose an ongoing risk to surface stability.
- 16.5.27 However, the extraction methods associated with the older workings in the Diamond, Musselburgh Jewel and Jewel of Whitehill Coals is not recorded. Given the age of the workings (pre-1850) and seam thicknesses (approx. 1.0m) it is considered possible they were worked using the 'stoop and room' partial extraction method. This method can leave the underground passages ("rooms") open long after abandonment and, where present at shallow depths of less than 30 metres, will pose an ongoing risk to surface stability.
- 16.5.28 A table summarising the stratigraphic sequence is presented below. The reader should note that alternative names were given to many of the coal seams to the south of the Sheriffhall Fault and where this is the case the alternative name is given in parentheses.

**Table 16-16 Recorded Mining Stratigraphy**

Seam Name	Recorded Thickness (m)	Approximate Separation between Named Seams(m)	Anticipated Occurrence: North/ South of Sheriffhall Fault
Clayknowes Coal	0.6		North
		52	
Splint Coal	0.3 - 1.6		North
		11	
Rough Coal	0.1 – 0.9		North
		12	
Beefie Coal	0.6 - 1.1		North
		14	
Diamond Coal	0.3 – 1.4		North
		7	
Musselburgh Jewel Coal	1.2		North
		8	
Golden Coal	0.8		Uncertain
		48	
Little Splint Coal (or Dalkeith Upper Coal)	0.8		North and South
		28	
Cowpits Five Foot Coal (Dalkeith Under Coal)	1.1		North and South
		5	
Quarry Coal	0.5		Uncertain
		27	
Glass Coal (or Whitehill Great Seam Coal)	0.2 – 2		North and South
		17	
Salters Coal (or Whitehill Rough Coal)	0.2 – 1.6		North and South
		7	

Seam Name	Recorded Thickness (m)	Approximate Separation between Named Seams(m)	Anticipated Occurrence: North/South of Sheriffhall Fault
Nine Foot Coal (Whitehill Splint Coal)	0.1 – 1.7		North and South
		3	
Pinkie Three Foot Coal (or Parrot Rough Coal)*	0.4 – 1.7		North and South
		4	
Six Foot Coal (or Whitehill Jewel)*	0.1 – 1		North and South
		15	
Pinkie Four Foot Coal	0.9		North
		16	
Seven Foot Coal	1.5		North

#### Potential Unrecorded Mining

16.5.29 Prior to 1872 there was no legal requirement for mine operators to submit records of underground mining and only four mine plans pre-dating this are available for the site. Based on the information reviewed, it is likely that additional unrecorded underground mine workings exist beneath the site, for which no records exist. The geological memoir and map suggest that the following coals have all been worked to some extent within the Proposed Scheme extent and wider study area:

- To the north of the Sheriffhall Fault: the Rough, Beefie, Little Splint and Seven Foot coals;
- To the south of the Sheriffhall Fault: the Whitehill Rough, Whitehill Splint, Whitehill Great, Dalkeith Upper, Dalkeith Under and Parrot Rough coals.

16.5.30 On this basis, there is considered to be a high likelihood of unrecorded workings beneath the site, some of which may be at shallow depth and pose an ongoing risk to surface stability.

16.5.31 During the 2018 and 2019 ground investigations a number of boreholes were sunk into the coal measures bedrock and the borehole data was reviewed to determine the extent and depths of coal seams under the Proposed Scheme extents. Evidence of shallow workings beneath the scheme which would pose a risk to the long-term ground stability was found to the west and south of the existing roundabout. Figure 16.5 'Potential Shallow Mine Workings and Mine Entry Locations' shows the zones of potential shallow mine workings beneath the Proposed Scheme.

#### Mine Entries

16.5.32 The Coal Authority (CA) Coal Mining Report, included in the 2014 PSSR, records a total of forty mine entries within the immediate vicinity of the study area. A further two mine entries, not recorded by the Coal Authority, are shown on the BGS Environmental Geology Map - South East Edinburgh, 1981. The Coal Authority do not know the current condition of these shafts.

16.5.33 Mine entry investigation works, in a total of 12 separate locations, were undertaken in the recent ground investigation. These exploratory works, which comprised trenching and/or surface geophysics, resulted in the positive identification of one mine shaft in the north-east of the study area (suspected to be Pit No. 10 CA Ref 331668-008 accessing the Musselburgh Jewel seam at 42 fathoms (75.6m)). Further evidence of mining activity (i.e. colliery spoil) was also encountered during trenching works directly to the north-east of the existing roundabout (targeted at Pit No. 34 CA Ref 331668-006) but subsequent investigation by rotary drilling failed to prove the presence of a mine entry.

- 16.5.34 Although only one single mine entry was encountered during the recent ground investigation, due to the high occurrence of mining related activity in the vicinity of the study area, there remains the potential for unrecorded mine entries to pose an ongoing risk to surface stability site wide.
- 16.5.35 At least three of the shaft locations recorded by the Coal Authority are indicated to be beneath the existing A720 Edinburgh City Bypass. Design drawings for the A720 show that there was an intention to infill or cap the three shafts to the west of the roundabout prior to construction of the bypass. An article entitled “The Edinburgh City Bypass Gilmerton Section – To Grout or Not to Grout?” published in Municipal Engineer magazine, August 1989 indicates that two of the shafts were infilled with grout (Bore pit and Pit 36) and one was capped with a reinforced concrete slab (Pit 38). Design drawings for the bypass also show an intention to cap a shaft west of the bypass (Pit 27) but there are no records to confirm this was completed.
- 16.5.36 Based on Coal Authority records, mine entry investigation and construction records, it is considered that there are potentially up to ten mine entries within the land boundary of the scheme which could pose a risk to surface stability. If future instability occurs this could impact the new infrastructure and immediately adjacent land.
- 16.5.37 Figure 16.5 ‘Potential Shallow Mine Workings and Mine Entry Locations’ presents the details of potential mine entries and areas at risk of shallow mine workings across the site.

#### Coal Mining Related Mineral Resources

- 16.5.38 Coal bed methane gas and obtaining heat from mine water in flooded workings are potential coal mining related resources. Monitoring during and after the ground investigation site works recorded low levels of methane (<0.1 – 1.3% v/v steady state: refer to Appendix 16.1 - Land and Groundwater Contamination Assessment for full details), and consequently the shallow depth seams are considered unlikely to provide coal bed methane. The Coal Authority has advised there are other parties interested in obtaining heat from mine water using closed loop or reinjection system, although currently there are no proposals for either under the Proposed Scheme.

#### Open Cast Mining

- 16.5.39 No opencast coal mining sites have been exploited within the wider study area.

#### ***Mineral Extraction – Non-Coal Minerals***

- 16.5.40 Consultation with the Valuation Office Agency confirmed that former underground coal mining has been the main mineral extraction activity affecting the study area.
- 16.5.41 In the Limestone Coal Formation, which crops west of the study area but is present beneath the study area at around 500m depth, oil shale and limestone have been worked in the past and the bedrock strata is suitable for future prospective shale oil and shale gas.
- 16.5.42 Several sand, gravel and clay pits are within, or within close proximity of, the study area. The total dimensions and depths of the pits are unknown. Their approximate locations and maximum recorded extents are shown on Figure 16.4 ‘Plan of Potential Contamination Sources’. All of the excavations/pits appear to have been infilled at some time in the past but there is no record of the nature of the fill. These are also considered further in the ‘Potential Contamination Assessment’ Section below.

## Soil Quality

- 16.5.43 The agricultural land within the study area is classified by the Macaulay Institute Land Capability for Agriculture Survey. A summary plan of the Agricultural Land Capability classifications is shown in Figure 16.6 'Land Capability for Agriculture'.
- 16.5.44 The soil quality in and around Sheriffhall Roundabout is classed as 'Prime Agricultural Land' and is predominantly mapped as Land Classification 2 (land capable of producing a wide range of crops). A small parcel of Class 1 land (capable of producing a very wide range of crops) is located at the north eastern end of the study area and a parcel of Class 3.1 land (capable of producing a moderate range of crops) is located at the western end of the study area. This is consistent with the observations during site walkovers and intrusive ground investigation works, where it was observed that the majority of the land outside the current highway boundary, other than that already disturbed by other developments, infrastructure and land management practises, was in use for arable farming.
- 16.5.45 The Soil Survey maps show the surface soils of the area to be derived from two main types, one described as fluvioglacial soils derived from carboniferous rocks, the other drift deposits derived from carboniferous sandstone, shales and limestone. Both are noted as soils capable of sustaining vegetation for arable farming and permanent pasture.

## Geomorphology

- 16.5.46 Glacial mounds and ridges, possibly gravelly eskers, are indicated to occur through the centre of the study area within the vicinity of Sheriffhall and Dalkeith, as illustrated on Fig 16.2 Solid and Drift Geology. A mound observed during site walkovers and shown on the topographical survey extending north of Sheriffhall to Campend may be such a feature, otherwise the esker has been modified and slightly obscured by the existing city bypass. Elsewhere the land surrounding the existing A720 is predominantly level, gently sloping towards the carriageway.
- 16.5.47 The area of land around the Dean Burn south of the A720 and west of the A6106 forms a flood plain for the Dean Burn, as does the land immediately west of the A7 on the upstream side of the culvert under the A7.
- 16.5.48 No landslides or mass movements are recorded on the BGS landslide database in the study area. The Landmark Envirocheck Report quotes a Very Low Potential for landslide ground stability hazards. Ground dissolution is not a hazard at Sheriffhall due to the nature of the underlying bedrock geology. Table 16-17 'Ground Stability Risk' below summarises all ground stability risks for the site, as indicated by the Landmark Envirocheck Report.

**Table 16-17 Ground Stability Risk**

Ground Stability Hazard	Hazard Potential
Collapsible Ground (not related to mining)	Very low
Compressible Ground	Moderate
Ground Dissolution	No Hazard
Landslide	Very Low
Running Sand	Low
Shrinking/Swelling Clay	Very Low

- 16.5.49 Minor slope stability failures were observed on the A720 embankment at the eastern extents of the scheme during a 2007 walkover to inform the Atkins PSSR. A later walkover in 2013 did not observe any such failures, nor were any observed during intrusive ground investigation works in 2018. However, most of the existing embankment and cutting slopes across the site are vegetated with grass, small shrubs and occasionally small trees therefore; there is the potential for failures to be obscured by this vegetation.

- 16.5.50 Later slope inspection in 2019 to inform the Stage 3 design also did not record any evidence of slope instability in areas of slopes which would remain unchanged by the proposed earthworks. Again, the slopes were observed to be densely vegetated.
- 16.5.51 Running sand was recorded during construction for Borders Railway, in the cutting to the south of the A720.
- 16.5.52 Mine entries and historic shallow mine workings present beneath the study area pose a risk to ground stability.

### Designated and Non-Designated Geological Sites

- 16.5.53 There are no Sites of Special Scientific interest (SSSI) designated for geology or geomorphology in the study area.
- 16.5.54 No Regionally Important Geological Site (RIGS) are in the study area.

### Hydrogeology

- 16.5.55 This section should be read in conjunction with Appendix 11.5 – Hydrogeological Assessment Technical Note. Details on hydrology can be found in Chapter 11 - Road Drainage and Water Environment.
- 16.5.56 Groundwater strikes, where recorded in historic boreholes, vary widely between 0.6m and 22.5m below ground level, though predominantly, they occurred between 1.5m and 10m below ground level. Environmental geology maps show a groundwater contour at around 60mAOD although it records that water level data is sparse and that aquicludes and perched water may also be present. This data suggests that typically, groundwater could occur about 5m below ground level, which broadly aligns with recorded groundwater levels. However, localised circumstances are likely to influence this generalised level markedly, particularly where existing infrastructure and major surface or underground excavations. This section should be read in conjunction with Appendix 11.5 – Hydrogeological Assessment Technical Note and Appendix 16.1 - Land and Groundwater Contamination Assessment. Details on hydrology can be found in Chapter 11 - Road Drainage and Water Environment.
- 16.5.57 The BGS aquifer productivity report has been consulted and used to classify aquifer productivity, as follows:
- The glacial till recorded to cover much of the site regarded as 'not a significant aquifer' due to their low permeability. However, due to the heterogeneous nature of glacial till, sand and gravel bands may allow limited groundwater flow, but these are unlikely to be connected to the wider groundwater regime.
  - The glaciofluvial deposits which are recorded to cover localised parts of the site are regarded as highly productive (yields of >10 litres per second (l/s)), with intergranular flow through the soil matrix. This is also the case for the alluvial deposits which are expected to be encountered locally in the areas where watercourses exist.
  - The underlying bedrock geology of the area is recorded to be part of the Carboniferous Coal Measures series. The Coal Measures are classed as moderately productive aquifers (yields of 1-10 l/s) with flow predominately through fractures but also intergranular.
- 16.5.58 A search of SEPA's Water Environment Hub was conducted regarding the groundwater quality beneath the site in terms of the Water Framework Directive (WFD). Groundwater beneath the site falls into two groups; the Esk Valley Sand and Gravel Groundwater Body (ID 150723) which encompasses the areas where glaciofluvial deposits are anticipated (i.e. through Sheriffhall Roundabout, small area north of the scheme and to the south); and the Dalkeith Groundwater Body (ID 150552) which encompasses the entire site. The Esk Valley Sand and Gravel Aquifer is recorded to have an overall WFD status of 'Good'. The Dalkeith groundwater body is recorded to have an overall WFD status of 'Poor'.
- 16.5.59 Groundwater strikes, where recorded in historic boreholes, vary widely between 0.6m and 22.5m below ground level, though predominantly, they occurred between 1.5m and 10m below ground level. Environmental geology maps show

a groundwater contour at around 60mAOD although it records that water level data is sparse and that aquicludes and perched water may also be present. This data suggests that typically, groundwater could occur about 5m below ground level, which broadly aligns with recorded groundwater levels. However, localised circumstances are likely to influence this generalised level markedly, particularly where existing infrastructure and major surface or underground excavations for extraction of minerals have been created.

16.5.60 During the 2018 and 2019 ground investigations, groundwater levels were monitored. Groundwater level monitoring was initially completed in 107 piezometers, installed as part of the ground investigation works at the site between July 2018 and February 2019. Subsequently an additional 15 piezometers were installed, in which groundwater level monitoring was completed between April 2019 and May 2019. Groundwater level monitoring obtained data for water levels in the superficial deposits and bedrock strata. Full detail of the groundwater level monitoring and interpretation of the data is presented in Appendix 11-5 – Hydrogeological Assessment Technical Note. In summary:

- In superficial deposits the highest recorded water level during the period of monitoring was 68.62mAOD. The minimum monitored depth to water table varied between 0.04mbgl (59.95m AOD) in Borehole BH65 (located in the south of the area), and 11.16mbgl (50.35m AOD) in Borehole BH82 (located adjacent to the southern portion of the existing roundabout). Typically, the water levels are highest in the south and west of the area, and lowest in the north-east of the area. Due to the variability of the superficial deposits, groundwater is likely to be present in discrete pockets of granular deposits and may not be vertically or laterally continuous.
- Groundwater conditions in the bedrock are typically confined, with an average maximum pressure head of 5.38m, and a maximum groundwater level of 6.1m above the top of bedrock in BH17. During monitoring the average groundwater level fluctuation was 0.96m and the maximum groundwater level fluctuation was 1.81m.
- Water levels were monitored in a number of units in the Coal Measures. The recorded groundwater level varies between 3.92m and 21.3m below ground. It is likely that previously worked coal seams below this level are flooded.
- Groundwater associated with historic mining activity in the area tends to be poor quality with a low pH and elevated sulphate, iron and fluoride concentrations. Appendix 16.1 - Land and Groundwater Contamination Assessment provides full details of groundwater quality.

16.5.61 Information received from the Coal Authority shows that recent groundwater levels in the former coal workings are in the range 40m to 46m AOD. Where the coal seams have been worked, any remaining voids may be flooded where they are below the water table and in hydraulic continuity with the sandstone strata.

16.5.62 Difficult temporary conditions were encountered in excavations into water bearing glaciofluvial deposits ('running sands') on the Borders Railway construction in the Sheriffhall Mains area. Any excavation into these 'running sands' will require special dewatering and other construction measures.

16.5.63 The remains of a well are present at the south eastern extremity of the study area, south of Sheriffhall Farm.

16.5.64 Groundwater conditions at the site are also further detailed in the Ground Investigation Report prepared by AECOM.

### Potential Contamination Assessment

16.5.65 Consultation responses from MLC and the CEC confirm that the proposed road scheme is not within an area which has been designated as contaminated land as defined in Part IIA of Environmental Protection Act 1990.

16.5.66 The identified potential contamination sources within the site study area have been collated based on the PSSR 2014 review, historical ground investigation reports, the site inspections and the 2018 and 2019 ground investigation and post-field work monitoring. Thirty four potential contamination sources are listed in Appendix 16.1 - Land and Groundwater Contamination Assessment together with the summary of findings of the 2018 ground investigation in

relation to the presence of made ground and visual/olfactory evidence of potential contamination. The locations of each of the potential sources are included in Figure 16.4 'Plan of Potential Contamination Sources'.

- 16.5.67 Appendix 16.1 - Land and Groundwater Contamination Assessment includes the summary of results from the geo-environmental laboratory testing on selected samples collected from the 2018 ground investigation and 2018/2019 post-fieldwork monitoring which were screened against Generic Assessment Criteria (GAC) derived for the protection of human health and the water environment.
- 16.5.68 The Conceptual Site Model (CSM) and risk assessment were updated from the preliminary CSM presented in the 2014 PSSR and is included in Appendix 16.1 - Land and Groundwater Contamination Assessment. Potential plausible complete pollution linkages were assessed in accordance with Environment Agency's Model Procedures for the Management of Land Contamination (CLR11). The risk categories are based on the CIRIA C552 Contaminated Land Risk Assessment, A guide to good practice, 2001 as described in Table 16.6 'Matrix to Ascertain Qualitative Risk Ranking' and Table 16-7 'Summary Description of Classified Risk'.
- 16.5.69 The soil data obtained from the site shows that the majority of sample results were detected at concentrations below their respective GAC's which are considered to be protective of human health based upon a commercial/industrial end use and, for comparison purposes, public open spaces (parkland). Exceedances were recorded in one borehole (BH09 at 1.0m) for human health screening criteria for two PAH's (Polycyclic Aromatic Hydrocarbons) in soil. Test results exceeded screening levels for both commercial/industrial and public open space (park) GACs. These exceedances are localised and within one order of magnitude of the GAC. No asbestos was detected in the soil samples screened. The risk assessment findings reported in Appendix 16.1 - Land and Groundwater Contamination Assessment Table A16.1-7 categorised the baseline risk to human health as low.
- 16.5.70 With respect to the water environment, leachate, groundwater and surface water samples were tested for potential contaminants (2018 and 2019 ground investigations). The results were screened against respective GACs which are considered to be protective of the water environment based on both drinking water standards (DWS) and environmental quality standards (EQS). A number of DWS and EQS exceedances were recorded as listed in Appendix 16.1 - Land and Groundwater Contamination Assessment, including metals, PAH, sulphate, phenol and herbicides/pesticides.
- 16.5.71 The site is underlain by shallow and deep aquifers which are of poor water quality (as defined by the WFD status and discussed further in the Hydrogeological Note in Appendix 11-5). For soil leachate results from the 2018 Ground Investigations, PAH exceedances for EQS GAC and the DWS GAC were within one to two orders of magnitude of the GAC's. There were several soil leachate exceedances with regards to copper, iron, lead, manganese, nickel and zinc. Of these exceedances, all were within one order of magnitude of the GAC's.
- 16.5.72 Boron and iron concentrations reported within the groundwater were generally elevated when compared to their Stage 2 GAC. Six water samples exceeded both the DWS and EQS GAC's for boron. Iron results for DWS and EQS were also notably exceeded. The borehole locations associated with these results are not in any one area but are spread across the site within areas including the disused railway (Table A16.1-1 Source ref: S1), the historical sand pit (S4), pond (S16) and agricultural land (S21). The groundwater results reflect the existing poor aquifer water quality.
- 16.5.73 The surface water sampling results showed the majority of exceedances were typically within one order of magnitude of the GAC's. Boron exceeded the EQS & DWS GAC's at SW05 and SW06 on the first sampling visit, with concentrations in line with those encountered within boreholes. SW05 and SW06 are located within an area of agricultural land. The second sampling visit saw the boron concentration within these locations drop significantly, to levels below the GAC's.



16.5.74 The risk assessment findings reported in Appendix 16.1 - Land and Groundwater Contamination Assessment Table A16.1-7 categorised the baseline risk to the water environment as low to moderate/low.

16.5.75 The ground gas monitoring results are included in Appendix 16.1 - Land and Groundwater Contamination Assessment. Ground gas monitoring was carried out on 38 boreholes as part of the 2018/2019 post fieldwork ground investigation monitoring regime. Historical data from the 2008 and 2011 Borders Railway ground investigations were also reviewed. The ground gas monitoring included up to 8 visits between July 2018 and July 2019. Screening was carried out based on current published assessment criteria (HSE EH40/2005; CIRIA guidance; BS 8485:2015+A1:2019).

16.5.76 The following range of ground gas measurements were recorded for the 2018/2019 monitoring:

- Methane: 0.1 – 1.4% v/v (by volume) (maximum readings);
- Methane: <0.1 – 1.3% v/v (steady state);
- Carbon dioxide: 0.2 – 10.4% v/v (initial readings);
- Carbon dioxide: <0.1 – 14.8% v/v (steady state);
- Oxygen: 0.4 – 21.9% v/v (steady state);
- Carbon monoxide: <1 – 34ppm;
- Hydrogen sulphide: <1 – 2ppm;
- Barometric pressure: 972 – 1021mbars;
- Gas flow rate: <0.1 – 12.1l/hr.

16.5.77 The following range of ground gas measurements were recorded for the 2008 and 2011 Borders Railway ground investigations:

- Methane: Not detected – 0.1% v/v;
- Carbon dioxide: Not detected – 2.1% v/v;
- Oxygen: 6.7 – 20.5% v/v;
- Carbon monoxide: Not detected;
- Hydrogen sulphide: Not detected;
- Barometric pressure: 991 – 1018mbars;
- Gas flow rate: -0.8 – 5 l/hr.

16.5.78 In summary of the results above, methane and hydrogen sulphide concentrations were generally below the screening levels. Carbon dioxide readings were elevated above the HSE long term and short term workplace exposure limits on a number of occasions. Depleted oxygen levels were also recorded in a number of boreholes. The CSM and risk assessment included in Appendix 16.1 - Land and Groundwater Contamination Assessment categorised the baseline conditions for ground gases as low for human health and property receptors.

## 16.6 Potential Impacts

### Assessment Introduction

16.6.79 The environmental effects of the Proposed Scheme are discussed both in terms of the impact on the geology and soils during construction and the longer-term impact on geology and soils once the scheme is in operation. The

assignment of significance of effects, based on the magnitude of impact and the sensitivity of asset, is undertaken before the application of mitigation measures. The residual effect after mitigation is provided in Section 16.8 - Summary of Effects. Table 16-18 'Summary of Geology and Soils Mitigation Measures' summarises the significance of effects on Geology and Soils receptors before the application of mitigation measures.

16.6.80 Details of the proposed works are provided in Chapter 5 – The Proposed Scheme.

### Construction and Operational Impact Assessment

16.6.81 Where assessing the potential impacts from the Proposed Scheme below, construction and operational impacts have been considered together, as the majority of construction impacts to geology and soils will be permanent and remain throughout operation. The sensitivity of the features is based on the Sensitivity Criteria listed in Table 16-1 'Sensitivity Criteria – Geology and Soils, and the scale of impact is based on the Magnitude of Impact criteria listed in Table 16-2 'Magnitudes of Impact'.

#### **Superficial Geology**

16.6.82 The Proposed Scheme comprises predominantly the online widening of existing embankments and will involve earthworks to place additional fill material onto the existing embankments and on the adjacent existing ground. However, cuttings excavated through the superficial deposits, in particular the glaciofluvial deposits associated with the esker running through the roundabout, are also required to accommodate the new NMU routes and subways.

16.6.83 During construction excavation or in-situ improvement of superficial deposits with inadequate engineering properties may be required to form competent founding strata for embankments or structures. Temporary excavation to bedrock may also be required to construct new structural concrete slabs over mine shafts or inspect existing mine entry capping slabs.

16.6.84 Where excavated materials are considered suitable for re-use as fill material the excavated superficial deposits will provide material for embankment construction. Excavated material will only be removed off-site when the excavated materials do not comply with the permitted constituents and material properties of SHW Series 600 Table 6/1. Currently it is envisaged that at least 70% of the excavated material will be re-used within the Proposed Scheme.

16.6.85 Fill material, beyond that won from excavations, will be imported from off-site sources, not from borrow pits on site, thus limiting the disturbance of superficial deposits.

16.6.86 In locations where the groundwater level is above the base of the excavation (such as occurs at the NMU underpasses, NMU route through the roundabout and SuDs ponds), the excavation may be temporarily, or permanently below the groundwater level and without proper design and control during construction can lead to local slope failure and unnecessary disturbance to superficial deposits.

16.6.87 The Proposed Scheme is considered to have a minor magnitude of impact on the superficial deposits of the area due to the limited scale of excavation into the glaciofluvial deposits of the esker and small disturbance of superficial deposits compared with the overall large volume of natural resource of this type that exists in the region. The superficial deposits are considered to be of low importance they are not unique and occur elsewhere widely or, in the case of the esker, in a more pristine condition, in the same region. The superficial deposits have been disturbed previously during earlier phases of other construction works and therefore there is a small adverse cumulative effect. This produces a **slight adverse** significance of effect during construction. Operation has no further impact on superficial deposits.

16.6.88 During the construction phase the grouting works to stabilise the mine workings and mine entries will have a minor adverse impact on the superficial deposits during construction, due to potential grout run-off, water run-off and soil

disturbance during drilling. As the superficial deposits are of low Importance the significance of effect during construction is **slight adverse**. During operation, but before mitigation, there is no further impact to superficial deposits due to grouting works,

### ***Solid Geology***

- 16.6.89 The solid geology, including the structural geology, of the area is assigned a value of low importance as, other than the Sheriffhall fault, there are no rock outcrops or other local features of special geological interest. Bedrock is not expected to be permanently exposed at any of the excavations for the proposed works. and the Sheriffhall fault is not anticipated to be affected by the works, due to the scale of the fault line in comparison to the works. However, piling into rock for the foundations of major structures will be required, as will drilling associated with mine workings grouting. There will also be temporary exposure of bedrock at some structures. The magnitude of these impacts is assessed to be minor, due to the very large scale and magnitude of the geological resource compared with the minor scope of excavation or minimal penetration by new infrastructure. As such, due to the low importance of the bedrock resource, the significance of effect on the solid geology during construction is assessed as **slight adverse**.
- 16.6.90 Temporary rock exposures provide potential opportunities for supplementing existing earth science knowledge. Therefore, it may also be considered as a minor beneficial impact if the exposed rock, even if only temporarily and in the low value resource, reveals limited features of earth science interest; depending on what is exposed. Similarly, desk study and ground investigation works which have been undertaken to inform the design of the scheme, provides supplementary earth science information that is made available to the BGS. This is assessed as **slight beneficial** effect as the ground investigation data will add to the body of knowledge about the geological structure of the area. Mitigation is not required as the impact is assessed as beneficial.
- 16.6.91 The mine workings treatment, once complete is considered as a beneficial impact as it will stabilise the bedrock. The minor magnitude impact on the low value resource results in a **slight beneficial** effect significance.

### ***Mineral Resources – Coal Mining***

- 16.6.92 The Sheriffhall area has been subject to extensive underground coal mining. However, any seams of economic importance have already been exploited and therefore no economically viable coal resources will be sterilised by the Proposed Scheme. As such, the value of the mineral resource is considered negligible.
- 16.6.93 Mine workings treatment comprising infill consolidation grouting is proposed to stabilise the shallow mine workings and mine entries beneath affected parts of the scheme. The anticipated plan extent of the grouting is illustrated on Figure 16.4 'Plan of Potential Contamination Sources'.
- 16.6.94 For the Proposed Scheme, including the proposed mine workings treatment, the magnitude of impact on the mineral resource is assessed to be minor as there is detectable, but not major change to the mineral resource. The significance of effect on the mineral resource, which is fully exploited so is of negligible value, has been assessed as being **slight adverse**.
- 16.6.95 As there will be no further changes to the underlying mine workings or associated mine entries associated with the operation of the Proposed Scheme the significance of effect during operation will also be **slight adverse**.
- 16.6.96 The impact of the mine workings and mine entry grouting on the superficial deposits is discussed above. The impact on hydrogeology is discussed in detail in Appendix 11.5 – Hydrogeological Assessment Technical Note and is summarised later in this chapter. The impact on ground stability and geomorphology is discussed below.

16.6.97 The significance of effect on other potential coal mining related mineral resources, such as coal bed methane or obtaining heat from mine water, is assessed as **neutral**, there being no change to the sterilisation of the resources, and the resource is considered of medium value. Mitigation is therefore not required.

#### ***Mineral Resources – Non-Coal Minerals***

16.6.98 The Limestone Coal Formation, at least 500m deep below the site, contains mature organic-rich shale suitable for prospective shale gas. Exploiting this resource using hydraulic fracturing is currently not permitted by the Scottish Government. If it were permitted in the future the scheme would likely impose limits on the magnitude of induced earth tremors to protect the structure whilst not sterilising the resource. Given the scale of the resource and potential to exploit it elsewhere, the magnitude of this impact is assessed as minor. The shale gas is assessed as a medium value resource, thus the significance of effect for both construction and operation is **slight adverse**.

16.6.99 There are no other non-coal minerals with economic potential (based on current technology) recorded beneath the site. Therefore, no other economically viable minerals will be sterilised by the Proposed Scheme.

#### ***Soil Quality***

16.6.100 The Proposed Scheme will result in removal of some limited strips of Class 1 and Class 3.1 agricultural land located within the Scheme Extents. A larger area of Class 2 agricultural land will also be removed. When combined the extent of the scheme will require approximately 20 ha of prime agricultural land take. Prime agricultural land is regarded as being of high sensitivity.

16.6.101 During construction, and without mitigation, there is potential for disturbance to agricultural soils resulting from haul routes, temporary compounds, stockpiles and run-off. However, agricultural grade soils will be removed only to the extent necessary for the Proposed Scheme within the Land Made Available. The soil shall be stored and preserved for landscaping and reinstatement works, and particularly shall be reserved for re-use if land is being returned to agriculture.

16.6.102 Due to the large area of prime agricultural land to be lost the magnitude of the impact is assessed to be high; as a result, the significance of effect during construction and operation (prior to mitigation) has been assessed as being **very large adverse**.

#### ***Geomorphology***

16.6.103 The geomorphological features within the study area have been assessed to be of low importance as the esker can be considered a locally important feature. The scheme is predominantly an on-line widening scheme affecting mainly the existing road infrastructure and its immediate surrounding area, however there is limited scale excavation into the esker to form the NMU routes. The magnitude of impact of the Proposed Scheme on geomorphology has therefore been assessed as being minor. This produces a **slight adverse** significance of effect both during construction and operation. No mitigation measures are required.

16.6.104 Mine workings treatment may be considered as a beneficial impact as it enhances the stability of the area and facilitates the development of land possibly considered as marginal and unattractive for development. Stabilisation of undermined ground is seen as a moderate magnitude beneficial impact in Table 16-2 'Magnitude of Impact'. When combined with the low importance of the resource this creates a **slight beneficial** significance of effect. Mitigation is not required as the effect can be considered beneficial.

### ***Geological Designated and Non-Designated Sites***

16.6.105 There are no designated or non-designated sites such as SSSI or RIGS within the study area. As there is a 'no change' magnitude of impact and there are no receptors the significance of effect for both construction and operation are **neutral**.

### ***Hydrogeology***

16.6.106 The impact of the scheme on hydrogeology and groundwater is considered below and discussed in further detail in Appendix 11.5 - Hydrogeological Assessment Technical Note. The impacts of the scheme on hydrology and surface water features are discussed in Chapter 11 – Road Drainage and Water Environment.

#### Superficial Aquifers

16.6.107 Superficial glacial till and glacial fluvial deposits underlie the Proposed Scheme. It is assumed that the deposits are in hydraulic continuity with the nearby surface water features. There are no known abstractions from the superficial deposits in the study area. The superficial aquifer is considered to be of medium importance.

16.6.108 Groundwater levels in the superficial deposits have been monitored at a higher level than the proposed formation levels for the scheme and it is therefore assumed that the superficial deposits will require dewatering in order to enable construction. Impacts on groundwater flow are expected to be localised. The high-water table also makes the superficial aquifer susceptible to contamination from surface activities during construction. Piling and excavations, associated with the scheme's engineering works, also have the potential to impact on superficial groundwater flow locally.

16.6.109 The proposed scheme is considered to have a moderate magnitude impact on the quality of the groundwater in the superficial deposits during construction due to surface potentially contaminative activities, such as the leakage and spillages of fuels and chemicals. This produces a **moderate adverse** significance of effect on the superficial groundwater quality during construction. During operation the proposed scheme is considered to have a minor magnitude impact on the quality of groundwater in the superficial deposits. This produces a **slight adverse** significance of effect during operation.

16.6.110 The proposed scheme is considered to have a minor magnitude impact on the groundwater flow of the superficial aquifer during construction as impacts on groundwater flow are expected to be localised. This produces a **slight adverse** significance of effect on groundwater flow in the superficial deposits during construction. During operation the proposed scheme is considered to have a minor magnitude impact on the groundwater flow in the superficial aquifer as impacts on groundwater flow are expected to be localised. This produces a **slight adverse** significance of effect during operation.

#### Bedrock Aquifers

16.6.111 The Scottish Middle and Lower Coal Measures, known as the Dalkeith Bedrock Aquifer, underlie the Proposed Scheme. There are no known abstractions from this aquifer in the area. The Dalkeith Bedrock groundwater body is classified under the WFD. It has a current status of Poor, due to legacy mining activities negatively impacting on groundwater quality. However, the quantity and flow of the groundwater have a WFD status of Good. The Dalkeith bedrock aquifer is therefore considered to be of medium importance.

16.6.112 The proposed scheme is considered to have a Minor magnitude impact on the groundwater quality of the Coal Measures aquifer during construction. This produces a slight significance of effect on the quality of the groundwater in the bedrock during construction. During operation the proposed scheme is considered to have a negligible magnitude impact on the groundwater quality of the bedrock aquifer. This produces a **neutral** significance of effect.

16.6.113 The proposed scheme generally is considered to have a Minor magnitude impact on groundwater flow in the Coal Measures aquifer during construction, but locally in the vicinity of the grouting works, impacts are considered moderate. Overall, this produces a slight significance of effect on the groundwater flow in the bedrock during construction. During operation the proposed scheme is considered to have a Minor magnitude impact on the groundwater flow of the bedrock aquifer, but locally in the vicinity of the site grouting, impacts are considered Moderate. This produces a **slight adverse** significance of effect.

#### Designated and Non-Designated Sites

16.6.114 Dalkeith Oakwood SSSI is situated approximately 1.8km north-east of the study area. It is considered to be of high importance. As the woodland is not groundwater dependant and is located a significant distance from the proposed works the Proposed Scheme is likely to cause No Change to the Dalkeith Oakwood SSSI during operation or construction. This produces a **neutral** significance of effect during both construction and operation.

#### **Contamination**

16.6.115 During the construction phase, excavations and earthworks operations have the potential to disturb contaminated materials and create new pathways which may allow pollutant linkages to develop. The desk study and ground investigation findings have confirmed the presence of made ground at different locations in the study area which has been assessed with respect to the potential pollutant linkages.

16.6.116 Appendix 16.1 - Land and Groundwater Contamination Assessment summarises the findings of the previous ground investigations. Contaminants of concern were recorded in the made ground materials, and the water environment (groundwaters and surface waters). Ground gas monitoring indicated elevated carbon dioxide and depleted oxygen levels in a number of boreholes.

16.6.117 The conceptual site model and risk assessment process included in Appendix 16.1 - Land and Groundwater Contamination Assessment allows identification of the potential pollutant linkages that may occur during the construction and operation phases. The risk categories assessed as 'moderate/low risk' or above under the risk ratings described in Table 16-7 'Summary Description of the Classified Risk' are considered to be potentially significant and require consideration of mitigation controls.

16.6.118 For the construction phase, moderate/low risk was identified from potential contaminants within soil and groundwater for the surrounding site users, the water environment (shallow and deep groundwater; surface waters) and pets and grazing animals. A moderate risk was associated with ground gases to construction workers during the site activities.

16.6.119 For the operation phase, low and very low risk categories are associated with the road scheme.

16.6.120 The importance of the made ground soils associated with contaminants under Table 16-1 'Sensitivity Criteria' is considered negligible. During the construction phase the magnitude of impact on the made ground is considered minor as complete pollutant pathways may occur. The significance of effect is considered as **neutral**.

16.6.121 The importance of the water environment (superficial and deep aquifers; surface waters) is considered medium. During construction phase, prior to mitigation, an adverse effect may be realised as contaminants may potentially impact the water environment. The magnitude of impact is considered minor. The significance of effect is considered as **slight adverse**.

16.6.122 For the operation of the proposed scheme, the majority of the risk categories assigned were very low or low based on the CIRIA C552 risk ratings given in Appendix 16.1 - Land and Groundwater Contamination Assessment. Once the road has been constructed the majority of potential pollutant linkages will be broken by the road construction acting as a barrier or removal of any identified contaminated materials encountered during the construction works.

16.6.123 Given the above information, the importance relating to the impact of potential contamination during the operation of the scheme is considered to be low and the scale of impact as minor. As such, the overall significance of effect is **slight adverse** for the operational phase.

### Cumulative Impacts

16.6.124 Mine workings treatment is beneficial in all areas as it stabilises the ground. However, there could be an impact on the hydrogeology of the area if extensive mine workings treatment for several adjacent schemes in the Sheriffhall area is undertaken, thereby displacing existing mine water around the area and potentially reducing groundwater quality elsewhere, or by adversely disturbing the existing groundwater flow paths.

16.6.125 Cumulative limits imposed by the Sheriffhall scheme and adjacent developments (e.g. Shawfair and other proposed developments) on the exploitation of oil shale gas may locally limit the potential of the resource.

## 16.7 Mitigation

16.7.1 Mitigation measures are required where residual adverse impacts cannot be avoided by the design or construction taking into account best practice, legislation and appropriate guidance. Where mitigation is 'embedded' in the Proposed Scheme design this is considered before impact assessment is determined.

16.7.2 Appropriate mitigation will have to be included in the design, and in the construction operations. Where relevant mitigation measures will also be necessary in maintenance and operation of the Proposed Scheme. The mitigation will have to ensure that potential impacts are prevented wherever possible and at least minimised. Many best practise construction measures to minimise potential impacts on geology and soils, including the hydrogeology, are outlined in guidance issued by SEPA including the Guidance for Pollution Prevention (GPP) and Pollution Prevention Guidelines (PPG) listed in Section 16.3.

16.7.3 The findings of any further ground investigation and subsequent detailed design of the scheme will reduce the impact on many of the receptors and allow site specific Method Statements to be produced by the Contractor carrying out the construction works.

16.7.4 Prior to commencing any work, the contractor will obtain the consent of the controlling authorities, in particular SEPA and SNH, for an Environmental Method Statement.

16.7.5 A very important of the mitigation measure, which applies to a number of receptors, will be to carefully control the production and injection of blended cementitious grout for infilling underground voids in abandoned mine workings and mine entries (shafts). Measures (**GS-9**) should be implemented during both the design and construction of the works and are detailed under the Mineral Resources -Coal Minerals section below.

16.7.6 Mitigation relating to the various identified receptors, both during design and construction, is discussed below and summarised in Table 16-18 'Summary of Geology and Soils Mitigation Measures'. The mitigation measures cross-refer to the mitigation items (e.g. **GS-01**) in Chapter 19 – Schedule of Environmental Mitigation which will be used to inform the commitments in the contract document.

16.7.7 Mitigation measures denoted **M-xx** cross-refer to mitigation detailed in the Chapter 17 – Material Assets and Waste. Mitigation measures denoted **RDWE-xx** cross-refer to mitigation detailed in Chapter 11 – Road Drainage and Water Environment.

## Superficial Deposits

- 16.7.8 Standard controls and best practice such as those detailed in the Construction Code of Practice for the Sustainable Use of Soils on Construction Sites (DEFRA, 2009) and Good Practice Guide for Handling Soils (MAFF, 2000) are to be employed during construction (**GS-10**), e.g. minimisation of erosion by programming soil strips to consider weather conditions; use of appropriate temporary works including temporary dewatering as required to ensure stability of excavations and limit localised failures and soil loss; limiting haulage routes; positioning stockpiles to minimise disturbance to soils and removal of sediments in surface water run-off; careful planning of temporary compound; consideration of temporary soil storage to allow successful reuse and reinstatement; and reinstatement on completion of construction.
- 16.7.9 Scheme design will control and reduce settlement in soft/compressible soils by considering and applying appropriate ground improvement techniques;
- 16.7.10 Scheme design will consider the effect that the scheme will have on the stability of the surrounding ground and incorporating appropriate mitigation measures into the scheme design, e.g. slope stability analysis.
- 16.7.11 Scheme design, such as regrading and landscaping, will mitigate construction impacts on the superficial geology
- 16.7.12 SEPA require that SUDS facilities should be in place prior to any soil removal for the construction phase for the protection of the water environment.

## Solid Geology

- 16.7.13 Standard controls and best practice to be employed during construction including the use of appropriate drilling methods, site supervision and ongoing monitoring of the works to minimise disturbance to bedrock geology (**GS-13**).

## Mineral Resources - Coal Minerals

- 16.7.14 The significance of effect of the Proposed Scheme on the coal mineral resources is assessed as neutral, for which no mitigation is required. However, the treatment of the existing mine workings and mine entries by infill grouting to ensure the stability of the scheme has effects on a number of other receptors (such as superficial deposits, hydrology, hydrogeology and agricultural soils). Thus, a major part of the scheme mitigation measures will be to ensure the control of grout during mine workings and mine entry treatment.
- 16.7.15 Mitigation measures (**GS-9**) as below should be implemented during the construction of the works to:
- Control grout run-off on the ground surface and prevent grout reaching agricultural soils, watercourses or causing contamination of groundwater;
  - Minimise disturbance to superficial deposits and agricultural soils during grouting by use of appropriate construction controls such as that outlined in **GS-10**, grout-control, perimeter bunds, soil protection matting, silt traps and the like and best practise during drilling;
  - Prevent grout leaks below ground from mine workings or mine entries that are being infilled with grout; and
  - Implement grouting and monitoring to prevent displacement of mine gases and potentially contaminated mine waters.
- 16.7.16 SEPA shall be consulted to obtain their agreement with all proposed mine workings and mine entry treatment works. The Contractor shall comply with the guidance from SEPA including Stabilising mine workings with PFA grouts, Environmental code of practice 2nd Edition, BRE Report 509 (**GS-6**). Additionally, SEPA's local team will have to be notified when the grouting works start, what works are involved and what watercourse/ditches they may affect (**GS-8**).



- 16.7.17 The Coal Authority shall be consulted to obtain their agreement with all proposed works relating to stabilisation of mine workings and mine entries **(GS-7)**.
- 16.7.18 Further investigation is recommended to determine the locations of recorded mine entries across the site.

### Mineral Resources - Non-Coal Minerals

- 16.7.19 Exploration and extraction of oil shale gas by hydraulic fracturing techniques is not currently permitted in Scotland, in which case mitigation is not currently required. However, if permitted, mitigation to allow extraction of the resource whilst protecting the scheme would include prescribing limits on magnitude of seismic events **(GS-14)**.

### Soil Quality

- 16.7.20 The Scheme design will consider the potential loss of Class 1, Class 2 and Class 3.1 agricultural land; and minimise this loss where possible.
- 16.7.21 Standard controls such as those detailed in the Construction Code of Practise for the Sustainable Use of Soils on Construction Sites (DEFRA, 2009) and Good Practice for Handling Soils (MAFF, 2000) are to be employed during construction **(GS-10)**, e.g. Minimisation of erosion by programming soil strips to consider weather conditions; use of appropriate temporary works including temporary dewatering as required to ensure stability of excavations and limit localised failures and soil loss; limiting haulage routes; positioning stockpiles to minimise disturbance to soils and run-off of sediments; careful consideration of temporary compound; consideration of temporary soil storage to allow successful reuse and reinstatement; and reinstatement on completion of construction.

### Geomorphology

- 16.7.22 The following mitigation are good practise and shall be implemented to minimise effects of the scheme on geomorphology:
- Use of construction controls to restrict disturbance to the surrounding land **(GS-10)**.
  - Alternatives to primary aggregates will be investigated, including opportunities to use recycled or secondary aggregates in the construction of the Proposed Scheme; either sourced from construction and excavation waste obtained onsite or offsite; or secondary aggregates obtained from an alternative source **(M-3)**.
  - Treatment of mine entries and shallow mine workings is considered as mitigation against potential ground stability issues.

### Designated and Non-Designated Sites

- 16.7.23 No mitigation required.

### Hydrogeology

- 16.7.24 The mitigation measures relevant to hydrogeology and groundwater are summarised below. Detailed mitigation measures are provided in Appendix 11.5 - Hydrogeological Assessment Technical Note. Mitigation measures relating to hydrology and surface water features are discussed in Chapter 11 – Road Drainage and Water Environment.

### **Construction Phase**

- 16.7.25 A Construction Environmental Management Plan (CEMP) will be prepared which considers an appropriate site layout incorporating pollution prevention controls for containing fuel or other contaminant leakage. For example, containment of all fuel storage tanks in bunded areas; controlled refuelling operations; contained area for cement washout, appropriate secure storage of chemicals in contained areas; and appropriate treatment of surface water and

dewatering water prior to discharge in accordance with permitted discharge consents. This should follow SEPA environmental guidance for site layout and be in line with SEPA publication GPP 5 - Works and Maintenance in or Near Water (**GS-12**).

- 16.7.26 Prior to the commencement of below-ground construction, the groundwater quality should be established (**GS-11**).
- 16.7.27 Ensure the control of grout during the mine workings and mine entry treatment. This will include: preventing the grout extending past the target zone, which may be controlled by measures such as less fluid mixes and the use of gravel addition to the mix to form stiffer mixes for injection at the perimeter of the treatment zone ; assess any potential locations for mine water discharges via a water features survey and review of mine records prior to construction, design measures to prevent discharge of grout or contaminated groundwater, and conduct frequent visual monitoring to observe for areas of seepage of contaminated groundwater caused by grouting activities (**GS-9**). Refer also to **RDWE-12** in Chapter 11 - Road Drainage and Water Environment.:
- 16.7.28 Where piles extend into bedrock below groundwater they shall comply with SEPA methodology (**GS-5**) as outlined in the Groundwater Protection Policy for Scotland (SEPA, 2009). Refer also to **RDWE-13** in Chapter 11 - Road Drainage and Water Environment.
- 16.7.29 A programme of regular groundwater level and groundwater quality monitoring should be established and implemented prior to the commencement of any construction works (**GS-11**).

#### ***Operational Phase***

- 16.7.30 Operational impacts can also be mitigated through an effectively designed drainage scheme which discharges surface run-off away from the site.
- 16.7.31 In areas of mine workings treated with infill grouting, if practicable large voids should also be filled with permeable granular materials, such as gravel, to allow groundwater flow to remain and minimise hydraulic obstruction in the long term (**RDWE-12**).
- 16.7.32 There are not expected to be any changes to the existing mine water treatment works close to the site which may impact hydrogeological conditions at the site. Guidance from the Coal Authority and SEPA should be referred to as required.

#### **Contamination**

- 16.7.33 The mitigation measures relating to the assessment of potential contamination are included in the CSM and risk assessment (Table A16.1-7) in Appendix 16.1 – Land and Groundwater Contamination Assessment.

#### ***Construction Phase***

- 16.7.34 Standard mitigation measures for managing potential contamination in the ground shall be employed during the construction phase. These measures include site best practice with respect to earthworks management and identification and control of potentially contaminated soils encountered during the works (**GS-2**). Standard health and safety practices will be implemented with respect to risks associated with human health for construction workers (**GS-3** and **GS-4**).
- 16.7.35 Consultation with SEPA and local authorities shall be undertaken regarding the planned works in relation to land affected by contamination as standard good practice (**GS-1**).

***Operational Phase***

16.7.36 Based on the CSM and risk assessment, a residual risk was identified for site maintenance workers with respect to in ground activities. Standard good practice site procedures should be adopted to protect workers against risks from potential contaminants in made ground materials and the risk from ground gases **(GS-4)**.

**Table 16-18 Summary of Geology and Soils Mitigation Measures**

Mitigation Item	Location/ Approximate Chainage	Timing of Measure	Description	Mitigation Purpose/ Objective	Specific Consultation or Approval Required	Potential Monitoring Requirements
<b>GS-1</b>	Areas with identified contaminated land	Pre-Construction	Consultation to take place with SEPA and local authorities regarding the planned works in relation to land affected by contamination.	To reduce risk from contamination on site.	SEPA & Local Authorities	None required.
<b>GS-2</b>	Areas with identified contaminated land	Pre-Construction	Further investigation will be undertaken in areas identified as potentially affected by contamination (as part of earthworks screening). Information will be obtained to characterise the extent and type of contamination present and allow mitigation measures to be developed/put in place.	To identify and characterise potential contamination and to develop appropriate mitigation methods.	None required.	Contractor recording and reporting.
<b>GS-3</b>	Throughout the Proposed Scheme	Construction and Post-Construction	Risks to the construction and maintenance workers from potential contaminants including unrecorded contaminants, to be identified and mitigation measures put in place.	To identify and characterise potential contamination with respect to workers and to develop appropriate mitigation methods.	None required.	Contractor recording and reporting.
<b>GS-4</b>	Borehole locations throughout Proposed Scheme	Pre-Construction, Construction and Post-Construction	Further monitoring of boreholes will be undertaken where a risk from ground gases to site/maintenance workers, structures or adjacent site users has been identified. Procedures will be designed to ensure safe working practices are employed. Further risk assessment will be carried out where a post-construction gas risk has been identified and, if appropriate, mitigation measures are included in the design.	To identify and characterise potential ground gas risks with respect to workers and adjacent site users and to develop appropriate mitigation methods.	None required.	Contractor recording and reporting.
<b>GS-5</b>	At structures throughout the scheme	Construction	Piling into bedrock shall be in accordance with SEPA requirements outlined in the Groundwater Protection Policy (SEPA, November 2009)	To mitigate against impacts of piling on bedrock groundwater flow and quality	SEPA	None required.
<b>GS-6</b>	Throughout the Proposed Scheme	Pre-Construction & Construction	Comply with SEPA relevant to stabilising mine workings and mine entries including 'Stabilising mine workings with PFA grouts. Environmental code of practice 2nd Edition, BRE Report 509' and the SEPA requirement that an appropriate risk assessment for the proposed stabilisation of mine workings with PFA grout shall be produced prior to this activity being undertaken on site.	To mitigate against impacts of grout (used to infill mine workings and mine entries) on groundwater quality.	SEPA	None required.
<b>GS-7</b>	Throughout the Proposed Scheme	Pre-Construction & Construction	Consult with The Coal Authority prior to all mine workings and mine entry treatment works	To mitigate against impact on other coal seam resources.	The Coal Authority	None required.
<b>GS-8</b>	Throughout the Proposed Scheme	Pre-Construction & Construction	SEPA's local team should be notified when the grouting works start, what works are involved and what watercourse/ditches they may affect. SUDS should be in place prior to any soil removal for the construction phase.	To mitigate against potential impacts on water quality resulting from mine workings treatment.	SEPA	None required.
<b>GS-9</b>	Throughout the Proposed Scheme	Pre-Construction & Construction	Implement measures to: control grout run-off on the ground surface and prevent grout reaching agricultural soils, watercourses or causing contamination of groundwater; prevent grout leaks below ground into mine	To mitigate against grouting works impacting on geology and	None required	None required.

Mitigation Item	Location/ Approximate Chainage	Timing of Measure	Description	Mitigation Purpose/ Objective	Specific Consultation or Approval Required	Potential Monitoring Requirements
			workings or mine entries; and control mine gases and mine waters which may be contaminated. Preventing the grout extending past the target zone, which may be controlled by measures such as the use of gravel to form curtain walls to the grout; identifying any potential mine water discharges via a water features survey prior to construction and a visual monitoring	soils receptors, including hydrogeology		
<b>GS-10</b>	Throughout the Proposed Scheme	Construction	Minimisation of erosion by programming soil strips to consider weather conditions; use of appropriate temporary works including temporary dewatering as required to ensure stability of excavations and limit localised failures and soil loss; limiting haulage routes; positioning stockpiles to minimise disturbance to soils and run-off of sediments; careful consideration of temporary compound; reinstatement on completion of construction. Adherence to the Construction Environmental Management Plan (CEMP). Compliance with best practise guidance including: Sustainable Use of Soil on Construction Sites (DEFRA, 2009) Good Practice for Handling Soils (MAFF, 2000)	To mitigate against impact of construction works on superficial deposits and agricultural soils	None required	None required.
<b>GS-11</b>	Throughout the Scheme	Pre-Construction and Construction	Prior to the commencement of below-ground construction, the current groundwater quality should be established. Thereafter a programme of regular groundwater level and quality monitoring should be established and implemented prior to the commencement of any construction	To monitor groundwater during works	None required	None required.
<b>GS-12</b>	Throughout the Scheme	Pre-Construction and Construction	A Construction Environmental Management Plan (CEMP) should be prepared which should follow SEPA environmental guidance. Construction measures to be in line with SEPA guidance including: PPG 1 – Understanding Your Environmental Responsibilities -Good Environmental Practises (withdrawn but is still considered good practise), 2013 GPP 5 - Works and Maintenance in or Near Water, 2017 PPG 6 – Working at Construction and Demolition Sites (withdrawn but is still considered good practise), 2012	Minimise the potential for fuel or other contaminant leakage	SEPA	None required.
<b>GS-13</b>	At structures or other areas of piling	Construction	Standard controls and best practice to be employed during construction including the use of appropriate drilling methods, site supervision and ongoing monitoring of the works.	Minimise unnecessary disturbance to bedrock	None required	None required.
<b>GS-14</b>	Throughout the Proposed Scheme	Operation	Prescribed criterial and monitoring to allow exploitation of resource whilst protecting the scheme	Mitigate against sterilisation of resource	None	None required.

## 16.8 Residual Effects

16.8.37 Table 16-19 'Potential Geology and Soils Construction and Operation Impacts and Residual Effects' provides a summary of the pre-mitigation construction and operation impacts, mitigation measures and residual effects that have been described within this chapter.

### Superficial Geology

16.8.38 After implementation of good earthworks practices during construction and implementation of appropriate mitigation during grouting works the significance of effects for the Proposed Scheme on superficial deposits remains as **slight adverse**. During operation after mitigation the assigned significance of **slight adverse** is unchanged.

### Solid Geology

16.8.39 Although best practise in execution of the works is required the significance of effect after mitigation measures remains as **slight adverse**, as the rock will be permanently removed.

### Mineral Resources - Coal Mining

16.8.40 The significance of effect of the scheme on coal mineral resources is **slight adverse** before mitigation. After mitigation measures the effect remains as **slight adverse**.

16.8.41 Effectiveness of mitigation implemented during stabilisation of mine workings and mine entries is considered under the relevant receptors.

### Mineral Resources -Non-Coal Minerals

16.8.42 The significance of the effect of the scheme on non-coal mineral resources is **slight adverse** and after mitigation measures remains **slight adverse**.

### Soil Quality

16.8.43 After mitigation measures the significance of effect during construction and operation on soil quality will reduce but is still assessed as **very large adverse**.

16.8.44 It should be noted that areas of prime agricultural land within the Scheme Extents have also been designated as development land within MLC's Local Development Plan (2017) and therefore may be developed in the future irrespective of the Proposed Scheme. For more information on land take impacts on private property, community land, designated development land and agricultural land see Chapter 15 – People and Communities - Community and Private Assets, and Human Health.

### Geomorphology

16.8.45 The significance of effect of the scheme on geomorphology is generally **slight adverse** before mitigation. After mitigation measures the effect remains as **slight adverse**

16.8.46 Mitigation is not required for the **slight beneficial** effect that mine working stabilisation has on ground stability.

### Geological Designated and Non-Designated Sites

16.8.47 The absence of geological designated and non-designated sites means there are no mitigation requirements and the effect of the scheme is **neutral**.

## Hydrogeology

16.8.48 The residual impact on hydrogeological receptors after the implementation of mitigation measures are discussed only where the pre-mitigation assessment of the receptors has indicated an impact of high or moderate significance.

### ***Superficial Aquifers***

16.8.49 After implementation of the appropriate mitigation measures detailed above, the significance of the residual impacts on superficial groundwater quality and flow during construction is reduced and is assessed as **slight adverse**.

### ***Bedrock Aquifers***

16.8.50 After implementation of mitigation measures, the significance of the residual impacts on bedrock groundwater quality during construction is reduced and assessed as **neutral**.

16.8.51 After implementation of mitigation measures the locally moderate significance of effect of the Proposed scheme on bedrock groundwater flow during operation is reduced and the significance of the residual impact is assessed as **slight**.

## Contamination

16.8.52 With appropriate mitigation measures in place, the significant effect of all residual risks from contaminated land remains unchanged and is assessed as **slight adverse** during construction and **slight adverse** during operation.

Table 16-19 Potential Geology and Soils Construction and Operation Impacts and Residual Effects

Receptor	Predicted Impacts	Magnitude of Predicted Impact	Sensitivity of Receptor	Significance of Effect	Mitigation Measures	Residual Effects
<b>Superficial Geology</b>						
Construction	Potentially compressible soils, running sands and localised failures may be encountered. Soil erosion caused by stripping of vegetation, excavations, ground disturbance, etc. Landslides.	Minor	Low	Slight Adverse	Further ground investigation as required for detailed design stage to determine nature of the soils and subsequent design of scheme to minimise impact on underlying soils. Standard controls and best practice to be employed during construction ( <b>GS-10</b> ), e.g. Minimisation of erosion by programming soil strips to consider weather conditions; use of appropriate temporary works including temporary dewatering as required to ensure stability of excavations and limit localised failures and soil loss; limiting haulage routes; positioning stockpiles to minimise disturbance to soils and run-off of sediments; careful consideration of temporary compound; reinstatement on completion of construction. Minimise disturbance to superficial deposits and agricultural soils during grouting by use of appropriate construction controls grout-control, perimeter bunds, soil protection matting, silt traps and the like ( <b>GS-9</b> ) and best practise during drilling;	Slight Adverse
Operation	Potentially compressible soils, running sands and localised failures may be encountered. Soil erosion caused by stripping of vegetation, excavations, ground disturbance, etc. Landslides.	Minor	Low	Slight Adverse	Scheme design will assess and mitigate adverse impacts where present.	Slight Adverse
<b>Solid Geology</b>						
Construction	During construction, there will be no permanent exposure of bedrock but potential localised disturbance of bedrock associated with drilling for Ground Investigation and piling. Mine workings treatment will disturb bedrock during drilling and grouting works.	Minor	Low	Slight Adverse	Further ground investigation if required at detailed design stage to identify underlying solid geology, depth to bedrock. Standard construction controls and best practise, including appropriate drilling methods, site supervision and monitoring to minimise unnecessary disturbance of bedrock.	Slight Adverse
	Temporary exposure of bedrock will allow inspection of solid geology features. Ground Investigation will produce data about the solid geology to add to BGS knowledge.	Minor	Low	Slight Beneficial	None required for beneficial effect.	Slight Beneficial
Operation	Piles have localised impact on bedrock.	Minor	Low	Slight Adverse	Further ground investigation if required at detailed design stage to identify underlying solid geology, depth to bedrock. Scheme design will minimise impact on solid geology.	Slight Adverse



Receptor	Predicted Impacts	Magnitude of Predicted Impact	Sensitivity of Receptor	Significance of Effect	Mitigation Measures	Residual Effects
	Mine workings treatment, once complete, will stabilise the bedrock.	Minor	Low	Slight Beneficial	None required for beneficial effect.	Slight Beneficial
<b>Minerals – Coal Mining</b>						
Construction and operation	No economically viable coal resources will be sterilised by the Scheme.	Minor	Negligible	Slight Adverse	Consult with Coal Authority as required during design prior to grouting of shallow mine workings and mine entries <b>(GS-7)</b>	Slight Adverse
<b>Minerals – Non-Coal Minerals</b>						
Construction and Operation	Proposed works will not sterilise any mineral resources.	Minor	Medium	Slight Adverse	Prescription of criteria and monitoring to allow exploitation of resource whilst protecting the scheme <b>(GS-14)</b>	Slight Adverse
<b>Soil Quality</b>						
Construction and Operation	Loss of 20 ha of Prime Agricultural Land (Class1, Major Class 2 and Class 3.1).	Major	High	Large/ Very Large	Standard controls and best practice to be employed during construction <b>(GS-10)</b> , e.g. Minimisation of erosion by programming soil strips to consider weather conditions; use of appropriate temporary works including temporary dewatering as required to ensure stability of excavations and limit localised failures and soil loss; limiting haulage routes; positioning stockpiles to minimise disturbance to soils and run-off of sediments; careful consideration of temporary compound; reinstatement on completion of construction.	Very Large Adverse
<b>Geomorphology</b>						
Construction and Operation	Earthworks for the Proposed Scheme include cuttings and embankments which alter the geomorphology at the site.	Minor	Low	Slight Adverse	Construction controls to restrict disturbance of surrounding land <b>(GS-10)</b> Scheme design will assess and mitigate adverse impacts where present. Maximise re-use of site won fill to limit requirement for imported aggregates <b>(M-3)</b> . Cut/fill balance undertaken as part of design.	Slight Adverse
Operation	Treatment of mine entries and shallow mine workings is considered as beneficial impact as it will improve the ground stability of the area	moderate	Low	Slight Beneficial	None required for beneficial effect	Slight Beneficial
<b>Geological Designated and Non-Designated Sites</b>						
Construction and Operation	No geologically designated sites will be affected by the proposed works.	Neutral	Negligible	Neutral	None required.	Neutral
<b>Potential Contamination (refer also to Appendix 16-1 Land and Groundwater Contamination Assessment)</b>						

Receptor	Predicted Impacts	Magnitude of Predicted Impact	Sensitivity of Receptor	Significance of Effect	Mitigation Measures	Residual Effects
Construction	Disturbance of contaminated land and pollution of nearby receptors.	Minor	Medium	Slight Adverse	Further ground investigation at detailed design stage to identify areas of contamination and extent of any contamination <b>(GS-2)</b> . Standard construction controls and best practise, including site supervision and monitoring to minimise unnecessary disturbance contaminated land. Consultation with SEPA as required <b>(GS-1)</b>	Slight Adverse
Operation	Disturbance of contaminated land and pollution of nearby receptors.	Minor	Low	Slight Adverse	Scheme design to include best practise measures to limit impact on contaminated land and will assess and mitigate adverse impacts where present.	Slight Adverse
<b>Hydrogeology (refer also to Appendix 11-5 - Hydrogeological Assessment Technical Note)</b>						
Construction	Superficial Aquifer – Quality (Potential pollution of groundwater and aquifers from mine waters and mine gases resulting from consolidation grouting of mine workings and mine entries, and sediment or run-off from surface works).	Moderate	Medium	Moderate Adverse	Further ground investigation at detailed design stage to identify areas of contamination and extent of any contamination <b>(GS-2)</b> . Standard construction controls and best practise, including site supervision and monitoring to prevent pollution of groundwater. Scheme design to minimise impacts on groundwater. Construction Environmental Management Plan (CEMP) should be prepared and consider appropriate site layout and design (as per SEPA requirement) <b>(GS-12)</b> with the aim to minimise the potential for fuel or other contaminant leakage. Control of grout during the mine workings and mine entry treatment in accordance with SEPA requirements <b>(GS-6)</b> . Piling into bedrock below groundwater in accordance with SEPA requirements <b>(GS-5)</b> . Prior to the commencement of below-ground construction, the current groundwater quality should be established. Thereafter regular groundwater level and quality monitoring should be established and implemented prior to the commencement of any construction works <b>(GS-11)</b> .	Slight Adverse
	Superficial Aquifer – Flow (Disturbance of groundwater flow resulting from consolidation grouting of mine workings and mine entries or from excavation works).	Minor	Medium	Slight Adverse		
	Bedrock Aquifer - Quality	Minor	Medium			
	Bedrock Aquifer - Flow	Minor	Medium			
Operation	Superficial Aquifer – Quality	Minor	Medium	Slight Adverse	Further ground investigation at detailed design stage to identify areas of contamination and extent of any contamination <b>(GS-2)</b> . Scheme design will minimise impact on groundwater regime and will assess and mitigate adverse impacts where present. Effectively designed drainage scheme which discharges surface run-off away from the site.	Slight Adverse
	Superficial Aquifer – Flow	Minor	Medium			Slight Adverse
	Bedrock Aquifer - Quality	Negligible	Medium	Neutral		Neutral
	Bedrock Aquifer - Flow	Minor (locally Moderate)	Medium	Slight Adverse		Slight Adverse

## 16.9 Compliance with Policies and Plans

16.9.53 The approach used within this DMRB Stage 3 Assessment to assess compliance with policies and plans involved the following:

- describing the existing and, where appropriate, emerging planning policy guidance and development plan framework as applicable to the route options;
- assessing the likely impacts of the proposed route options on the achievement of the objectives and policies identified; and,
- reporting the likely conflicts or compliance of the route options on key strategic and local planning policy objectives.

16.9.54 An assessment of the compliance of the Proposed Scheme option with the policies and plans that apply directly to the geology and soils of the Sheriffhall area has been undertaken. The tables below present the policies relevant to geology and soils and demonstrate the compliance of the Proposed Scheme options.

### National Policy

#### **Scottish Planning Policy**

**Table 16-20 The Proposed Scheme Compliance with relevant SPP policies**

Policy	Compliance
A Low Carbon Place	Reuse of site won fill and minimising excavation and disposal of material from site will be standard construction practise to maximise use of site won resources and minimise use of primary materials.
Valuing the Natural Environment	There are no RIGS or peat land affected by the Proposed Scheme options. Soils will be protected from damage and compaction where possible, and reinstatement works will be undertaken as required. Some agricultural soils (Class 1, Class2, Class 3.2) will be lost but mitigation will reduce potential effect on adjacent agricultural soils. The benefits of the development, as outlined in Chapter 2- Need for the Scheme, are considered to outweigh the minor loss of land. Stabilisation of mine workings and mine entries will be undertaken using construction controls so as to minimise effects on the surface and sub-surface water environment
Promoting Responsible Extraction of Resources	There will be no sterilisation of mineral resources as the coal seams have been worked. The scheme benefits the area in that undermined land will be stabilised and developed. The scheme will maximise the use of site won fill and recycled aggregates where possible.

#### **National Planning Policy (NPF3)**

**Table 16-21 The Proposed Scheme compliance with relevant NPF3 policies**

Policy	Compliance
Natural Resilient Place <i>Respect, enhance and make responsible use of natural assets.</i>	The scheme will maximise the use of site won fill and recycled aggregates where possible. Methane levels in the coals are not sufficient to be a coal bed methane energy resource Some agricultural soils (Class 1, Class 2, Class 3,2) will be lost but mitigation will reduce potential effect on adjacent agricultural soils. The benefits of the development, as outlined in Chapter 2- Need for the Scheme, are considered to outweigh the minor loss of land. The scheme benefits the area in that land undermined by past mining land use will be stabilised and developed.

**Scottish Soil Framework****Table 16-22 The Proposed Scheme compliance with relevant Scottish Soil Framework policies**

Policy	Compliance
SO9 (Soil contamination reduced)	Sources of soil contamination within the scheme will be addressed during the works so prevent on-going soil contamination.
SO10 (Reduced pressure on soils by using brownfield sites in preference to greenfield)	Prime agricultural land (Class 1, Class 2 and Class 3.2) will be lost. However, the this is only a slight effect of the scheme and the benefits of the development, as outlined in Chapter 2- Need for the Scheme, are considered to outweigh the minor loss of land. The scheme will develop vacant land which (due to underlying mine workings) could be considered marginal.

**Scotland's Geodiversity Charter (2018)****Table 16-23 The Proposed Scheme compliance with Scotland Geodiversity Charter**

Policy	Compliance
Raise awareness	The need for the Scheme itself raises awareness of the Sheriffhall fault and past mining as the geological features which gave rise to the roundabout in the original construction. Works to treat mine workings will also raise awareness of the coal measures bedrock underlying the site.
Integrate Geodiversity	The scheme will maximise the use of site won fill and recycled aggregates where possible to be sustainable in terms of natural resources.
Conserve and Enhance	No designated geological sites on the scheme
Undertake Research	All ground investigation data will be sent to British Geological Society for adding to their database. Data related to coal mining will be sent to The Coal Authority.

**Planning Advice Note PAN33 (2000) - Development of Contaminated Land**

- 16.9.1 The assessment of potentially contaminated land and the environmental assessment process used for this geology and soils assessment has been undertaken in line with the guidance in PAN33.

**Regional Policy****Strategic Development Plan: SESplan (June 2013)****Table 16-24 The Proposed Scheme compliance with Strategic Development Plan**

Policy	Compliance
<b>Policy 4 - Minerals</b>	
Policy 4a	There will be no sterilisation of non-coal mineral resources and the coal seams underlying the site have been worked.
Policy 4d	Reuse of site won fill and minimising excavation and disposal of material from site will be standard construction practise to maximise use of site won resources and minimise use of primary materials
Sub-clause 103	Transportation will be minimised
Sub-clause 104	Methane levels in the coals are not sufficient to be a coal bed methane energy resource Onshore gas resources are to the west of Sheriffhall so should not be impacted by the Proposed Scheme.
<b>Policy 15 – Water and Flooding</b>	
Policy 15a	Stabilisation of mine workings and mine entries will be undertaken using construction controls to minimise effects on the surface and sub-surface water environment
<b>Policy 12 – Green Belt</b>	

Policy	Compliance
Sub-clause130	Prime agricultural land (Class 1, Class 2, Class 3.2) will be lost. However, the benefits of the development, as outlined in Chapter 2- Need for the Scheme, are considered to outweigh the minor loss of land.

## Local Policy

### *City of Edinburgh Council's Local Development Plan (2016)*

**Table 16-25 The Proposed Scheme Compliance with relevant Edinburgh LDP Policies**

Policy	Compliance
<b>Caring for the Environment – Natural Resources</b>	
Policy Env 22 - Pollution and Air, Water and Soil Quality	The schemes will have only a slight adverse impact on soil quality and/or ground stability. The scheme benefits the area in that undermined land will be stabilised and developed. Stabilisation of mine workings and mine entries will be undertaken using construction controls to minimise effects on the surface and sub-surface water environment
<b>Minerals</b>	
Policy RS 5 - Minerals	There will be no sterilisation of non-coal mineral and the coal seams underlying the site have been worked.

### *Midlothian Local Development Plan (2017)*

**Table 16-26 The Proposed Scheme Compliance with relevant Midlothian LDP Policies**

Policy	Compliance
<b>Safeguarding and Managing Our Natural Environment</b>	
Policy ENV 4 - Prime Agricultural Land	Prime agricultural land (Class 1, Class 2, Class 3.2) will be lost. However, the benefits of the development, as outlined in Chapter 2- Need for the Scheme, are considered to outweigh the minor loss of land.
Policy ENV 5 - Peat and Carbon Rich Soils	There are no significant deposits of peat or carbon rich soils affected by the Proposed Scheme option.
Policy ENV 10 - Water Environment	There are no significant areas of contaminated land from which pollution of water can occur, Stabilisation of mine workings and mine entries will be undertaken to minimise effects on the surface and sub-surface water environment.
Policy ENV 16 - Vacant, Derelict and Contaminated Land	The scheme will develop vacant land which (due underlying mine workings) could be considered marginal.
<b>Resource Extraction</b>	
Policy MIN 1 - Areas of Search for Surface Mineral Extraction	Hard rock quarrying is not proposed. There will be no sterilisation of non-coal mineral resources and the coal seams underlying the site have been worked.

## 16.10 Monitoring

16.10.1 After mitigation measures are implemented there are no significant adverse effects on geology and hydrogeology but the assessment indicates that the Scheme would have a large/very large adverse effect on agricultural soils, due to the area of land permanently acquired. This cannot be monitored. However, in conjunction with appropriate scheme design, the implementation of a CEMP and good practice during construction (as outlined in GS-10) can be monitored to ensure agricultural soils immediately beyond the Scheme Extents remain unaffected.

## 16.11 Statement of Significance

16.11.2 This chapter has considered the impact of the scheme on the geology and soils. The Proposed Scheme is assessed to have a 'negligible' to 'moderate' magnitude of adverse impact on the geomorphology, superficial and solid geology,

hydrogeology and mineral resources of the area resulting in a 'neutral' to 'slight' rating of residual significant effects after mitigation measures are employed. These are not considered significant for the purposes of this Environmental Impact Assessment. Additionally, the Proposed Scheme has a slight beneficial effect on geomorphology due to stabilisation of underlying mine workings, and a neutral/slight beneficial effect on solid geology due to the potential for increased geological knowledge and the stabilisation of mine workings.

16.11.3 The Proposed Scheme is expected to have a **very large residual** effect on soil quality due to a large area of prime agricultural land being acquired as part of the Scheme Extents.

## 16.12 References

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