Welsh Government

M4 Corridor around Newport

Environmental Statement Volume 1

Chapter 11: Geology and Soils

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Contents

11 Geology and Soils

11.1 Introduction

11.1.1 This chapter of the Environmental Statement (ES) assesses those effects that may arise from the Scheme with respect to ground conditions, ground stability, geology, hydrogeology and land contamination, in accordance with the Design Manual for Roads and Bridges (DMRB) (Vol 11, Section 3, Part 11) (Highways Agency, 1993) and associated Interim Advice Notes (IAN). The Scheme has the potential to have direct impacts on designated and non-designated areas of geological and geomorphological interest, either at a local or national scale. This assessment considers the potential significance of such effects and also the potential for the creation of new exposure through the construction works.

11.1.2 The chapter describes the assessment methodology, the baseline conditions currently existing in the study area, the potential significant environmental effects, the mitigation measures required to prevent, reduce or offset any significant adverse effects and the likely residual effects after these measures have been employed.

11.1.3 A number of potential sites of land contamination have been identified along the route of the proposed new section of motorway and the assessment of risk associated with potential contamination and remediation works to control and minimise identified risks is discussed in this chapter. Full details concerning land contamination management are provided in the Land Contamination Assessment Report and the Outline Remediation Strategy (Appendix 11.1 and Appendix 11.2, respectively).

11.1.4 The management of soils and materials is described in Chapter 12 of this ES (Materials). However, the suitability for reuse of contaminated soils is described in this chapter.

11.1.5 It should be noted that the effects on the agricultural use of soils are considered within Chapter 15 (Community and Private Assets) of this ES.

11.2 Legislation and Policy Context

11.2.1 The following sections describe the relevant legislation governing this Geology and Soils chapter. Due regard is also given to planning policy set out in the latter section.

Relevant Legislation

11.2.2 Geological sites of national importance are principally afforded protection under the Wildlife and Countryside Act 1981 (as amended) or the National Parks and Access to the Countryside Act 1949 by designation as Sites of Special Scientific Interest (SSSIs) or National Nature Reserves (NNRs). The Joint Nature Conservation Committee (JNCC) Geological Conservation Review (GCR) also identifies the best, most representative, earth science sites in Great Britain, with a view to their long term conservation. Many of these sites are of at least national importance and are either already notified as SSSIs or are being considered for notification.

11.2.3 Environmental legislation implemented as either Acts of Parliament or Regulations provides separate legislative drivers to manage land contamination.

11.2.4 The list below, though not exhaustive, includes the main legislative drivers for managing risks to human health and the environment from land contamination.

- Part IIA of the Environmental Protection Act (1990).
- Environment Act (1995).
- Contaminated Land (Wales) Regulations (2006) and Amendment (2012).
- Environmental Permitting (England and Wales) Regulations (2010).
- Groundwater Regulations (1998).
- Groundwater (England and Wales) Regulations (2009).
- Water Resources Act (1991).
- Water Act (2003).
- Groundwater Regulations (1998), which transpose the EC Groundwater Directive 80/68/EC into UK law.
- Water Environment (Water Framework Directive) (England and Wales) Regulations (2003), which transpose the Water Directive 200/60/EC into UK law.
- Waste Framework Directive (2008) as transposed via Waste (England and Wales) Regulations 2011.
- Landfill (England and Wales) Regulations (2002).
- Hazardous Waste (England and Wales) Regulations (2005).

11.2.5 In Wales, Part IIA of the Environmental Protection Act (EPA) 1990, as introduced by Section 57 of the Environment Act 1995, came into effect in September 2001 with the implementation of the Contaminated Land Regulations 2000 (now superseded by the Contaminated Land Regulations 2006/2012). Under Part IIA of the EPA, sites are identified as 'contaminated land' if they are causing, or if there is a significant possibility of causing, significant harm to human health or significant pollution of controlled waters. Controlled waters are defined by the Water Act 2003 as including both surface waters and groundwater within an aquifer. In general terms, the legislation advocates the use of a risk assessment approach to assessing contamination and remedial requirements.

Planning Policy Context

National Planning Policy

11.2.6 Planning Policy Wales (PPW 8) (Welsh Government, January 2016) acknowledges that the natural heritage of Wales includes its geology and associated land forms and soils. PPW provides extensive information on planning objectives and puts particular emphasis on the need for sustainable development in terms of the resources used, the maintenance of the environment, the economic use of land and the consideration of society in the general area. Within the document, it states the importance of the restoration of derelict and contaminated land.

11.2.7 The current national guidance on planning and pollution control, including development on potentially contaminated land, is outlined in Chapter 13 of PPW, Minimising and Managing Environmental Risks and Pollution.

11.2.8 PPW recognises that the planning system has an important role in avoiding or minimising the adverse effects of any environmental risks on present or future land use. The objectives for minimising and managing environmental risks and pollution are to (paragraph 13.1.2 of PPW):

- maximise environmental protection for people, natural and cultural resources, property and infrastructure; and
- prevent or manage pollution and promote good environmental practice.

11.2.9 This chapter also addresses ground stability. PPW sets out the following relevant principles (summary sections 13.5 to 13.9 of PPW).

- The planning system should guide development to lessen the risk from natural or human-made hazards.
- Land contamination and land instability should be considered when defining development plans.
- Planning decisions and policies should consider the requirements of Part IIA of the EPA and be consistent with it and need to take account of:
  - the potential hazards that contamination and instability present to the development itself, its occupants and the local environment; and
  - the results of specialist ground investigation and assessment to establish the presence or otherwise of contamination and unstable ground.

11.2.10 PPW recognises that geology forms part of the natural heritage of Wales and is not constrained to statutorily designated sites but extends across all of Wales. The objectives for the conservation and improvement of natural heritage outlined in Chapter 5 of PPW, Conserving and Improving Natural Heritage and the Coast, are to (paragraph 5.1.2):

- promote the conservation of landscape and biodiversity, in particular the conservation of native wildlife and habitats;
- ensure that action in Wales contributes to meeting international responsibilities and obligations for the natural environment;
- ensure that statutorily designated sites are properly protected and managed;
- safeguard protected species; and
- promote the functions and benefits of soils, and in particular their function as a carbon store.

11.2.11 Chapter 5 also comments upon ground stability.

11.2.12 PPW further states that non-statutory geological designations such as Special Landscape Areas (SLAs) or Sites of Interest for Nature Conservation (SINCs), should be soundly based on a formal scientific assessment of the nature conservation, landscape or geological value of the site but that such designations should not unduly restrict acceptable development (paragraph 5.3.11).

11.2.13 To comply with this requirement, some geological sites are afforded consideration at a local level.

11.2.14 Regionally Important Geodiversity Sites (RIGS) are currently the most important places for earth science conservation outside statutorily protected land such as SSSIs. RIGS form a network of sites within a county or region of geological sites that are considered worthy of protection for their earth science importance. They are identified by locally developed criteria, which may emphasise the local educational, historic and recreational resource rather than the national scientific significance (which is the remit of SSSI status). RIGS form a network of second tier sites that support the SSSI network but which do not have statutory protection (BGS, 2012).

Local Planning Policy

11.2.1 The assessment has had regard to the following local policy documents. It should be noted that whilst these documents provide context, they are not determinative.

11.2.2 The Local Development Plan (LDP) for Newport was adopted on 27 January 2015 (Newport City Council, 2015). The LDP sets out a number of objectives to achieve the overall goals of the Plan. Objective 6 relates to the Conservation of the Natural Environment while Objective 9 relates to Health and Wellbeing.

11.2.3 General Development Principle GP7 relates to Environmental Protection and Public Health and states that:

'Development will not be permitted which would cause or result in unacceptable harm to health because of land contamination, dust, instability or subsidence, air, heat, noise or light pollution, flooding, water pollution, or any other identified risk to environment, local amenity or public health and safety.'

11.2.4 Policy CE7 relates to Locally Designated Nature Conservation and Geological Sites.

'Proposals affecting locally designated sites will only be permitted where:

- *There would be no overall loss of the nature conservation resource for which the site has been designated;*
- *There would be no significant adverse effect on the geological interest of the site;*
- *Appropriate mitigation or compensatory measures can be achieved.'*

11.2.5 Other relevant policies include the following.

- SP1 - Sustainability, which requires development to be concentrated on sustainable locations on brownfield land and the provision of integrated transport systems.
- SP5 - Countryside, the supporting text for which includes consideration of the geological value of the countryside.
- CE8 - Locally Designated Nature Conservation and Geological Sites, which states that proposals affecting locally designated sites will only be permitted where there would be no significant adverse effect on the geological interest

of the site. Furthermore, CE8 identifies that the *'British Geological Survey have undertaken a South Wales RIGS Audit (BGS, 2012) which identifies 3 RIGS within the Newport County boundary, these are identified on the Constraints Map. Developers will need to ensure that proposals do not have a detrimental impact upon this important and finite element of the natural heritage'*.

11.2.6 The Monmouthshire Local Development Plan 2011-2021 was adopted in February 2014 (Monmouthshire County Council, 2014). Relevant policies include the following.

- Policy S13 - Landscape, Green Infrastructure and the Natural Environment, which requires that development proposals musty identify and, where appropriate, enhance the distinctive geological heritage. In addition, it requires the protection, management and enhancement of geological interests.
- Policy LC1 - New Development in the Open Countryside, which requires that development will have no unacceptable adverse impact on geological heritage.
- Policy NE1 - Nature Conservation and Development, which relates to locally designated sites of biodiversity or geological importance.

11.3 Assessment Methodology

Relevant Guidance

11.3.1 The assessment has been undertaken with due consideration of the following key guidance and standards.

- Highways Agency (1993, amended August 1994) DMRB Volume 11, Section 3, Part 11 Geology and Soils.
- Highways Agency *et al.* (1995) DMRB Volume 4, Section 1, Part 7, HD73/95 Site Investigation for Highway Works on Contaminated Land.
- Highways Agency *et al.* (2008a) DMRB Volume 4, Section 1, Part 2, HD22/08 Managing Geotechnical Risk.
- Highways Agency *et al.* (2008b) DMRB Volume 11, Section 2, Part 5 (HA 205/08).
- British Standards Institute (2010) BS5930: Code of Practice for Site Investigations including Amendment 2, issued 2010.
- British Standards Institute (2013a) BS10175: Code of Practice for Investigation of Potentially Contaminated Sites.
- British Standards Institute (2013b) Eurocode 7 (BS EN 1997-1 & EN 1997-2) (British Standards Institution 2007) and all relevant Normatives.
- British Standards Institute (2013c) BS8576: Guidance on investigations of ground gas. Permanent gases and Volatile Organic Compounds (VOCs).
- Environment Agency and Defra (2004) Model Procedures for the Management of Land Contamination (CLR11).

- Environment Agency (2013) Groundwater Protection: Principles and Practice (GP3).
- CIRIA (1996) Construction Industry Research and Information Association R132: A Guide for Safe Working on Contaminated Sites.
- CIRIA (2001) Contaminated land risk assessment: A guide to good practice (C552).
- CIRIA (2007) Assessing risks posed by hazardous ground gases to buildings (C665).
- CIRIA (2014) Asbestos in soil and made ground: A guide to understanding and managing risks (C733).
- CL:AIRE (2011) The Definition of Waste: Development Industry Code of Practice v2.
- Interim Advice Note 125/09(W) (2010) Supplementary guidance for users of DMRB Volume 11 'Environmental Assessment.
- Welsh Local Government Association (WLGA) and Environment Agency (2012) Development of Land Affected by Contamination: A Guide for Developers.

Study Area

11.3.2 The study area for the assessment covers the construction land take and permanent land take areas associated with the Scheme, including areas affected by Complementary Measures. Figure 2.16 of this ES shows the areas affected by permanent and temporary land take. The study area for land contamination includes all known potential areas of land contamination that intersect the new section of motorway and those sites that have plausible pollutant linkages that may be intercepted by the alignment. The potential for land contamination outside of the known potential areas of land contamination along the route has also been considered.

11.3.3 The geology and soils study area has been determined on the basis of the regional geology for the area and the site-specific data gathered during investigations. The detailed study area for geology is therefore based along a corridor following the route of the new section of motorway. Consideration is also given to the other sites associated with ancillary activities that may be situated outside the route alignment, most notably areas of excavation (borrow pits) and temporary land use during construction, including construction laydown areas that may be required.

11.3.4 In terms of the study areas for hydrology and hydrogeology a nominal 250 metre buffer either side of the proposed new section of motorway has been used. A larger area has been considered where effects have the potential to extend outside of this corridor (such as temporary land take) and/or the understanding of the baseline conditions is dependent on wider appreciation of conditions within the system as discussed within Chapter 16: Road Drainage and the Water Environment of this ES.

Approach to Identification of Baseline Conditions

11.3.5 The 2014 Preliminary Sources Study Report (PSSR) (Arup, 2014), a primarily desk based study, and the Land Contamination Assessment Report (Appendix 11.1) form the majority of the work undertaken to date in relation to the assessment of soils, geology and land contamination with respect to establishing baseline conditions. These documents utilise information obtained from the following sources.

- Factual Report on Ground Investigation for the Welsh Government (Geotechnical Engineering, 2015).
- Previous ground investigation data collected for the Scheme.
- The additional investigations local to the Scheme available in the archives of the British Geological Survey (BGS).
- Previous geotechnical desk study and interpretative reports.
- Reports on unexploded ordnance (UXO).
- GroundSure MapInsight report (including historic Ordnance Survey (OS) mapping of the docks area).
- Published geological information including geological maps, memoirs and technical papers.
- Other historic ground investigation data.
- Information from Natural Resources Wales (NRW).
- Walkover surveys.
- Local planning authority records.

11.3.6 The information contained within the PSSR has been validated and updated where appropriate. The assessment methodology and supplementary information used to validate the existing information and provide updated information is discussed in the following sections. Further details of the assessment of land contamination are provided in the Land Contamination Assessment Report (see Appendix 11.1).

Land Use

11.3.7 Consideration of land use establishes the former and current uses of the site, which could have caused land contamination. Significant issues associated with current and past activities, neighbouring land uses and other key environmental issues have been identified and considered. Information was obtained from the following sources.

- High resolution 2013/2014 aerial imagery and light detection and ranging (LiDAR) data.
- Current and historic OS mapping along the route obtained from the Welsh Government.
- Historic aerial photography along the route obtained from the Welsh Government.
- Environmental information obtained from NRW, including historic and authorised landfills, environmental pollution incidents ('major' and 'significant'

only as 'minor' incidents are not considered likely to have resulted in substantial levels of land contamination), industrial and waste sites, sites with current exemptions, licensed water abstractions and consented discharges to controlled waters.

- Local planning authority records (including contaminated land).
- Walkover surveys of selected sites.

Environmental Setting

11.3.8 It is important to establish the environmental setting because, irrespective of the level of contamination at a site, if its location is not 'sensitive' to this contamination, there is a reduced risk of an environmental impact to a receptor. Further detailed aspects of the environmental setting, including geology and hydrogeology, are presented in detail within the Baseline Water Environment (BWE) report provided in Appendix 16.2 of Chapter 16 of this ES.

11.3.9 The geological sequence underlying the sites and the hydrogeological classification has been established. The vulnerability of groundwater has been determined from this mapping and geological information. The locations of surface watercourses were identified along with the groundwater regime. Information from the following sources was obtained.

- Published BGS geological mapping.
- Published BGS RIGS audit report.
- Recent OS mapping.
- Environmental information obtained from NRW including historic and authorised landfills, environmental pollution incidents ('major' and 'significant' only), industrial and waste sites, sites with current exemptions, licensed water abstractions and consented discharges to controlled waters.
- Local planning authority records (including contaminated land).
- Newport City Council and Monmouthshire County Council websites.
- Walkover surveys of selected sites.
- NRW aquifer classification database.
- Ground conditions based on information provided by intrusive ground investigations, where available (see below).

11.3.10 Details of sensitive habitats and vegetation are shown in the figures to Chapter 10 of this ES.

Ground Conditions

11.3.11 Ground conditions pertaining to the Scheme have been obtained from ground investigation reports. Several ground investigations have been undertaken in the vicinity of the proposed new section of motorway, a number of which have included sampling within potentially contaminated sites. The key ground investigations reviewed and relied upon are set out below.

Ground Investigation (Norwest Holst Soil Engineering Ltd., 1998)

11.3.12 Details are provided in a factual report presenting the results of a detailed ground investigation carried out between Castleton and Magor along the 1995 alignment of the then 'M4 Relief Road' by Norwest Holst between October and December 1997. The 1995 alignment is within an approximate 150 metre buffer of the current alignment of the new section of motorway. The report includes logs from 87 cable percussion boreholes, of which 30 were extended by rotary coring techniques, 50 rotary cored boreholes, 15 rotary open hole boreholes (undertaken to facilitate groundwater monitoring installations), 11 machine dug trial pits and geophysical surveys in the vicinity of Castleton and Magor. The results from *in situ* and geotechnical and chemical laboratory testing are also included in the report.

Preliminary Chemical Investigation (Exploration Associates, 2000)

11.3.13 Details are provided in a factual report presenting the results of a preliminary chemical investigation carried out at ten separate sites along the then 'M4 Relief Road' alignment by Exploration Associates between January and February 2000. This alignment is within an approximate 170 metre buffer of the current alignment of the new section of motorway. The report includes the logs of 33 window sampler boreholes and 29 trial pits. The results from *in situ* and chemical laboratory testing are also included in the report.

Second Preliminary Ground and Chemical Investigation (Norwest Holst Soil Engineering, 2008)

11.3.14 Details are provided in a factual report including the results of the detailed ground investigation carried out between Magor and Castleton along the alignment of the 2006 'M4 South of Newport', which is similar to the alignment of the proposed new section of motorway. The investigation was undertaken between November 2007 and January 2008. The report includes logs from 53 cable percussion boreholes, 33 rotary cored boreholes, 51 window sampler probe holes, 10 cone penetration tests, 56 machine dug trial pits and 2 surface samples. The results from *in situ* and geotechnical and chemical laboratory testing are also included in the report.

11.3.15 In addition to the above investigations, data obtained from the supplementary phase of intrusive investigation for the Welsh Government were utilised.

Factual Report on Ground Investigation (Geotechnical Engineering, 2015)

11.3.16 Details are provided in the report for the supplementary phase of intrusive investigation undertaken for Welsh Government in 2015, presenting the results of a detailed ground investigation carried out along the route for the new section of motorway. The investigation was undertaken between January and April 2015 and included 138 boreholes, 45 trial pits and associated *in situ* testing. The report includes the results of chemical and geotechnical laboratory testing of soils, rocks and water samples. A programme of gas and groundwater monitoring during February to May 2015 was also undertaken and detailed with each borehole monitored on four occasions at approximately weekly intervals.

Other Reports

11.3.17 Other ground investigations undertaken at specific locations along the route for the new section of motorway have been undertaken by third parties associated with ongoing environmental liability management and regulatory obligations (e.g. at Tata Steelworks and Docks Way Landfill) and other new developments. Details of these other ground investigations are provided in the Land Contamination Assessment Report (Appendix 11.1).

Consultation

11.3.18 Table 11.1 provides details of the consultation undertaken in relation to geology and soils.

Table 11.1: Consultation Responses Relevant to this Chapter

Date	Consultee and Issue Raised	How/Where Addressed
Draft Plan consultation response (Welsh Government, 2014)	Public response: Potential effect of runoff on farm land. Assessment would be required of possible contamination of soils in areas that have been historically industrial.	This risk is considered at each of the potentially contaminated sites, the details of which can be found in Appendix 11.1 of this ES
Draft Plan consultation response (Welsh Government 2014)	Newport City Council: Potential for contaminated land to be present. Note that consideration would need to be given to implications for human health and environmental risk before re-using any material recovered from contaminated sites.	Both aspects are addressed throughout this ES chapter, in particular in the Baseline Environment and Mitigation sections. Further detail is provided in Appendix 11.1.
17 September 2015	Meeting with Natural Resources Wales (NRW), Monmouthshire County Council (MCC) and Newport City Council (NCC). Consideration would need to be given to potential sterilisation of contaminated sites where there is potential for future remediation action. Use of Suitable for Use Levels (S4ULs) to be agreed.	A draft Land Contamination Management Strategy (LCMS) has been prepared and agreed in principal setting out the general approach and regulatory position specific to the Scheme regarding the assessment and management of land contamination, including reuse of contaminated materials. The draft LCMS is provided in Appendix 11.3. Points raised are also addressed in the Land Contamination Assessment Report and Outline Remediation Strategy Report (Appendix 11.1 and 11.2, respectively).
September 2015	British Geological Survey: Consultation regarding the audit of RIGS in South Wales (BGS, 2012) (Rhian Kendall)	Identified two key sites within Newport County, namely Allt-yr-yn Quarry (OS grid reference ST 29004 88576) and Allt-yr-yn Viewpoint (OS grid reference ST 29285 88232). They also provided a copy of the 2013 Audit Report that was submitted to NCC. BGS confirmed that the candidate

Date	Consultee and Issue Raised	How/Where Addressed
		RIGS outlined in the Regionally Important Geological Sites (RIGS): Background Paper Deposit Plan (NCC, 2012) are not the same as the recommended RIGS in the Audit Report (BGS, 2012).
September 2015	NRW: Consultation regarding geological sites (including GCR sites) within Study Area (Christina Byrne)	No response received from NRW
September 2015	NCC: Consultation regarding geological sites within NCC LDA, most notably allocated RIGS (Mathew Sharpe)	Confirmed that the candidate RIGS in the background paper have been superseded by sites identified in the Audit Survey undertaken by BGS in 2013. The updated RIGS sites are included in the constraints mapping for the LDA (2011-2012) (NCC, 2015b). Only three sites were identified near the new section of motorway, namely Allt-yr-yn Quarry, Allt-yr-yn Viewpoint and Gold Cliff, the closest being 2.75 km away. The RIGS Mapinfo database file was provided.
September 2015	MCC: Consultation regarding RIGS and geological interest within MCC area. (Sarah Jones)	Confirmed there are no allocated RIGS within MCC jurisdiction. Referred back to BGS Audit Report (BGS, 2012) to determine sites of potential significance.
September 2015	NRW response to scoping report - Consideration required with regard to defining a strategy for soils not deemed suitable for use within the overall construction site. This includes soils within Llanwern Steelworks where treatment is either not deemed possible or following treatment does not meet reuse requirements.	Strategy defined within the Outline Materials Management Plan (see Appendix 3.2). Points raised are also addressed in the Land Contamination Assessment Report (Appendix 11.1) and Outline Remediation Strategy (Appendix 11.2).
September 2015	NRW response to scoping report - Requirement to define monitoring strategies and mitigation measures following piling risk assessments within Newport Docks.	Monitoring programmes and mitigation measures would be addressed within the Remediation Strategy (outline document provided at Appendix 11.2) developed for the Scheme. Points raised are also addressed in the Land Contamination Assessment Report Appendix 11.1).

Date	Consultee and Issue Raised	How/Where Addressed
September 2015	NRW response to scoping report - Demonstration required that Docks Way Landfill and Solutia Chemical Works would not be sterilised with respect to potential future remediation.	Points raised are addressed in the Land Contamination Assessment Report (Appendix 11.1) and Outline Remediation Strategy (Appendix 11.2).
13 October 2015	Newport City Council response to scoping report: NCC only support the use of S4ULs where levels do not exist in other standards such as 'Category 4 Screening Levels'. Further detail on what action would be taken should areas of contaminated land be discovered during construction.	In further discussion, an agreement of human health tier 2 generic screening approach sought by NCC. Confirmation of approach and justification of use of the S4ULs as primary screening criteria for human health. E-mail correspondence from Peter Macintosh dated 23rd October 2015 accepting the approach. Detail contained within the Land Contamination Management Strategy in Appendix 11.3.
November 2015	Monmouthshire County Council: Agreement of human health tier 2 generic screening approach sought.	Confirmation of approach and justification of use of the S4ULs as primary screening criteria for human health. E-mail correspondence from Paul White data 30th November 2015 accepting the approach. Detail contained within the Land Contamination Management Strategy in Appendix 11.3.
November 2015	Meeting with NRW to present findings of contamination risk assessment and preliminary approach to Tata lagoon remediation and contaminated materials management.	Assessment findings within Land Contamination Assessment Report (Appendix 11.1), Outline Remediation Strategy Report (Appendix 11.2), Land Contamination Management Strategy (Appendix 11.3) and Environmental Permitting Strategy (Appendix 11.5).
January 2016	Meeting with NRW to discuss preliminary Tata lagoon remediation design and motorway embankment construction.	Details of proposals presented are shown as Figure 16.6, 16.7, 16.8 and 16.9 and also addressed within Outline Remediation Strategy Report (Appendix 11.2), Land Contamination Management Strategy (Appendix 11.3).
February 2016	NRW comment on Land Contamination Management Strategy.	NRW agreed to the Land Contamination Management) Strategy (Appendix 11.3) albeit NRW need to confirm their regulatory position on waste status of Tata lagoons in terms of treatment and reuse of materials.
February 2016	NRW comments on Environmental Permitting Strategy.	NRW agreement of general approach within the Environmental Permitting Strategy (Appendix 11.5).

Approach to Assessment

Geology and Soils

11.3.19 An assessment of effects on geology is provided within this chapter. This provides a qualitative assessment of the effects on all designated and non-designated areas of geological and geomorphological interest within the study area. This assessment includes consideration of the potential for geological enhancement through the creation of new exposure.

11.3.20 The conditions along the new section of motorway have been reviewed in detail and the presence of existing cuttings and exposures recorded and assessed in terms of their value and/or sensitivity to inform the baseline conditions. The vertical and horizontal alignments of the route of the new section of motorway have been reviewed and, where existing cuttings and exposure are to be affected, these have been identified, as well as all areas where new exposures and cuttings would be created or where the route passes through areas of potential land contamination. Each of these has been assessed in relation to the following aspects.

- The potential for the proposed works to cause changes to the drainage and the hydrogeological regime.
- The potential for the proposed works to create new pathways between contaminated materials and identified receptors.
- The potential for the proposed works to spread contaminated material.
- The potential for the proposed works to affect designated and non-designated geodiversity sites.
- The potential for the proposed works to cause instability, soil erosion, topsoil loss/reduced quality or changes in topography.
- The potential for the proposed works to impact or be impacted by mining/quarrying including effects of mineral resource sterilisation.

Land Contamination Assessment

11.3.21 A detailed assessment of land contamination has been undertaken and full details of the assessment are contained within the Land Contamination Assessment Report (provided in Appendix 11.1). A summary of the approach to the assessment of land contamination is provided in this section.

11.3.22 Based upon guidance within Contaminated Land Report 11 (CLR-11) (Environment Agency and Defra, 2004), a risk assessment approach has been adopted to assess the risks associated with historic land contamination that may be present along the proposed route of the new section of motorway. The findings of the risk assessment have been used to enable management decisions to be taken on whether control measures are required to be implemented to mitigate potential risks to the environment and human health.

11.3.23 The tiers of the assessment are as follows.

1) Preliminary Risk Assessment and Defining Outline Conceptual Site Model (CSM).

2) Generic Site-Specific Risk Assessment (screening) and Subsequent Refinement of CSM.

3) Site-Specific Detailed Risk Assessment.

4) Remediation Strategy Design.

11.3.24 This tiered approach has been adopted for each of the potentially contaminated sites identified in the 2014 Preliminary Sources Study Report (PSSR) (Arup, 2014), which has the potential to affect or be affected by the new section of motorway along with other areas of interest identified during this assessment (since the 2014 PSSR was published). A total of 27 specific potentially contaminated sites have been considered along with other data, such as ground investigation reports and historic maps, along the proposed route of the new section of motorway.

11.3.25 The need for progression from tier to subsequent tier was driven by the findings of the previous tier with respect to the level and nature of risk identified and the type of likely remedial action or control measure needed to manage the risks identified. Tier 1 and Tier 2 risk assessments have been undertaken for all of the 27 identified potentially contaminated sites. An outline remediation strategy has also been designed and this may be supported by Tier 3 assessments to further refine specific areas of remediation to enable the remediation strategy to be finalised prior to construction. The Outline Remediation Strategy Report is provided in Appendix 11.2.

11.3.26 Details of the Tier 1 and Tier 2 risk assessment are set out below.

Preliminary Risk Assessment (Tier 1)

11.3.27 The Preliminary Risk Assessment consists of an appraisal of the source-pathway-receptor 'contaminant linkages', which is central to the approach used to determine the existence of 'Contaminated Land' according to the definition set out under Part 2A of the Environmental Protection Act 1990. For a risk to exist (under Part 2A), all three of the following components must be present to facilitate a potential 'contaminant linkage'.

- Source of contamination (Hazard).
- Pathway for the contaminant to move from the source(s) to receptor(s).
- Receptor (Target) that could be affected by the contaminant(s).

11.3.28 The mere presence of a contaminant source/hazard at a site does not mean that there will necessarily be attendant risks requiring remedial action or that the site will be designated as 'Contaminated Land'.

Generic Risk Assessment (Tier 2)

11.3.29 The purpose of the Tier 2 generic risk assessment is to further evaluate potential risks identified in the Tier 1 preliminary risk environment.

Generic Quantitative Risk Assessment (Tier 2) - Screening Criteria (Human Health)

11.3.30 The Generic Quantitative Risk Assessment (GQRA) aims to identify contaminants of concern and their spatial distribution and requires benchmarks

against which to compare the concentrations of soil contaminants. This requires the comparison of contaminant concentrations with Generic Assessment Criteria (GAC). The following GAC have been used in the assessment of human health.

- Suitable 4 Use Levels (S4ULs).
- Soil Guideline Values (SGV) for dioxins, furans and dioxin-like Polychlorinated biphenyls (PCBs).
- Category 4 Screening Level (C4SL) for lead.

11.3.31 Further details of the rationale and methodology are provided within the Land Contamination Assessment Report in Appendix 11.1. Where the concentrations of contaminants in soils are less than the S4ULs, the risks to human health are considered to be at minimal or tolerable levels and thus remediation is not required. Where concentrations are above S4ULs, this indicates that a risk to human health may exist warranting further assessment and, potentially, remediation.

11.3.32 For the end users of the new section of motorway (general public and maintenance workers), the chemical test results for soil samples, where available, have been screened against the lower of the public open space (POS) park land use and commercial land use scenarios. It is considered that the lower of the two scenarios would provide stringent criteria for the Scheme and represent a conservative approach. In addition, for organic contaminants those values corresponding to a Soil Organic Matter (SOM) of 1% are used, providing further conservatism to the assessment. These criteria are presented in the Land Contamination Assessment Report in Appendix 11.1.

11.3.33 Short term (acute) health risks to construction workers and the general public would be managed through the adoption and implementation of strict control and protection measures required under the Construction (Design and Management) Regulations (CDM) 2015 and the Health and Safety at Work Act (HSWA) 1974. At this stage, a qualitative risk assessment has been undertaken and the findings are described within this chapter. Full details of the assessment and management of risk to workers and the general public during construction are provided in the Land Contamination Assessment Report (Appendix 11.1).

Generic Quantitative Risk Assessment (Tier 2) - Screening Criteria (Groundwater)

11.3.34 Preliminary evaluation of potential impacts to surface water and groundwater from land contamination is undertaken via a screening assessment that compares observed water quality data with appropriate water quality Assessment Criteria (AC). The selection of AC depends on the conceptual model developed for a site and in particular the nature and sensitivity of controlled water receptors for which active pollutant linkages are considered likely to exist. Two sources of statutory and non-statutory water quality AC are typically used for the purpose of such screening assessments.

- Environmental Quality Standards (EQS), defined for the protection of the ecology of surface water environments.
- Drinking Water Standards (DWS), defined on the basis of health for water intended for human consumption.

11.3.35 The selection of screening criteria is discussed in detail within Chapter 16: Road Drainage and the Water Environment of this ES. Further details are also provided within the Contaminated Land Assessment Report in Appendix 11.1.

Generic Quantitative Risk Assessment (Tier 2) - Screening Criteria (Ground Gas)

11.3.36 The emission of soil gases may occur either from Made Ground, buried waste, soils and rocks or from other organic contamination.

11.3.37 Using guidance provided in CIRIA C665 'Assessing risk posed by hazardous ground gases to buildings' (CIRIA, 2007) and reference to the Workplace Exposure Limits (WELs) (Health and Safety Executive, 2011) ground gas monitoring results from ground investigations have been compared with screening threshold values as follows.

- Methane > 1 volume/volume percent (% v/v).
- Carbon dioxide > 5 % v/v.
- Carbon monoxide > 30 parts per million (ppm).
- Hydrogen sulphide > 5 ppm.

11.3.38 Where gas concentrations exceed the above criteria, further detailed risk assessment has been undertaken based upon CIRIA C665 (CIRIA, 2007). It is of note that this guidance is used to inform the gas risk assessment only as the Scheme is for a motorway (and other highway) end use and does not therefore include buildings. Further detail is provided within the Land Contamination Assessment Report provided in Appendix 11.1.

Assessment Criteria and Assignment of Significance

11.3.39 The Scheme has been assessed to ensure that all relevant impacts on geodiversity, hydrogeology and ground conditions are identified and that any environmental issues and risks associated with land contamination are considered. The overall assessment has been carried out in accordance with guidance as set out in the DMRB Volume 11, Section 3, Part 11 Geology and Soils (Highways Agency, 1993, amended August 1994), whilst the detailed assessment of the magnitude of impacts and significance criteria for effects has been undertaken using the methodology outlined in DMRB Volume 11, Section 2, Part 5 HA 205/08 (Highways Agency *et al.,* 2008b).

Receptor Sensitivity

11.3.40 The first step in undertaking the assessment was to assess the value (sensitivity) of the receptor or area affected by the Scheme. This was done using the descriptors of value described in Table 2.1 of HA205/08, as shown in Table 11.2.

Table 11.2: Environmental Value for Geology and Soils

Value (Sensitivity)	Typical Descriptors
Very high	**Geology (solid geology):** Very rare and of very high international, national and regional geological/geomorphological importance with no potential for replacement (e.g. designated sites of national importance including SSSI, active quarries and mining activities of national importance). **Soils (superficial geology/topsoil and subsoils):** Soils of very high importance and rarity, international scale and very limited potential for substitution. **Hydrogeology (aquifers):** Groundwater with a high quality and rarity on a regional or national scale with limited potential for substitution (e.g. principal aquifer providing potable water to a large population). **Surface water:** European Community (EC) Designated Salmonid/Cyprinid fishery Water Framework Directive (WFD) Class 'High' Site protected/designated under EC or UK wildlife legislation (SAC, SPA, SSSI, WPZ, Ramsar Site, salmonid water)/species protected by EC legislation. **Contamination/Dissolution features:** Human health (High sensitivity land use scenario e.g. residential, public open space). **UXO** Human health
High	**Geology (solid geology):** Of medium national and high regional geological/geomorphological importance with limited potential for replacement (e.g. currently non-designated GCR site, regionally important site, active quarries and mining activities of regional or local importance). **Soils (superficial geology/topsoils and subsoils):** Soils of high importance and rarity, national scale and limited potential for substitution. **Hydrogeology (aquifers):** Groundwater with a high quality and rarity on a local scale with limited potential for substitution, or attribute with a medium quality or rarity on a regional or national scale with limited potential for substitution (e.g. aquifer providing potable water to a small population and/or large resource potential). **Surface water:** WFD Class 'Good' Major Cyprinid Fishery Species protected under EU or UK habitat legislation **Contamination:** Sensitive receptor which is the reason for SSSI designation. Human health (Lower sensitivity land use scenario e.g. commercial, industrial, highway construction)

Value (Sensitivity)	Typical Descriptors
Medium	**Geology (solid geology):** Of low regional and high local geological/geomorphological importance with some potential for replacement (e.g. allocated RIGS or recommended RIGS). **Soils (superficial geology/topsoils and subsoils):** Soils of medium importance and rarity, regional scale, limited potential for substitution. **Hydrogeology (aquifers):** Groundwater with a medium quality and rarity on a local scale with limited potential for substitution, or attribute with a low quality and rarity on a regional or national scale with limited potential for substitution (e.g. secondary aquifer unit supporting abstraction for agricultural or industrial use and/or moderate resource potential). **Surface Water:** WFD Class 'Moderate' **Contamination:** Receptor which is of regional importance.
Low (or Lower)	**Geology (solid geology):** Of local geological/geomorphological importance with potential for replacement (e.g. non-designated exposure/former quarries and mining activities). **Soils(superficial geology/topsoils and subsoils):** Soils of low importance and rarity, local scale. **Hydrogeology (aquifers):** Groundwater with a low quality and rarity on a local scale with limited potential for substitution (e.g. non-aquifer unit that does not afford protection to underlying water bearing units). **Surface Water:** WFD Class 'Poor' **Contamination:** Receptor which is of local importance.
Negligible	**Geology (solid geology):** Of little local geological/geomorphological interest. **Soils (superficial geology/topsoils and subsoils):** Soils of very low importance and rarity, local scale. **Contamination:** Receptor with low importance and rarity.

Magnitude of Impact

11.3.41 The impacts of the Scheme, which are described in terms of the magnitude of the impact, have been determined on the basis of the five-point scale described in Table 11.3 below. These follow the general guidance set out in DMRB Volume 11, Section 2, Part 5 HA 205/08 (Highways Agency *et al.,* 2008b).

11.3.42 The definitions of certain magnitudes in relation to contamination are based on CIRIA C552 (CIRIA, 2001) and informed by CLR11 (Environment Agency and Defra, 2004).

Table 11.3: Magnitude of Impact on Geology and Soils

Magnitude of Impact	Typical Criteria Descriptors
Major	**Geology (solid geology):** The proposals are very damaging to the geological environment/soils resource of the area. May result in loss or damage to areas designated as being of regional or national geological interest. Loss of resource and/or quality and integrity of resource. Severe damage to key characteristics, features or elements. Impacts cannot be mitigated for (e.g. destruction of a designated site (SSSI or RIGS)). (Adverse) **Soils (Superficial geology/topsoils and subsoils):** Loss of soils resource and/or quality and integrity of resource; severe damage to key characteristics, features or elements. (Adverse) **Controlled Waters (aquifers/surface water):** Reduction of water quality rendering groundwater or surface water unfit to drink and/or substantial adverse impact on groundwater dependent environmental receptors. (Adverse) **Contamination:** Major effect upon receptor. Severe or irreversible effect on human health. Temporary severe or irreversible effect on ground/surface water quality. (Adverse)
	The proposals are very beneficial to the geological/hydrogeological environment/soils resource of the area. There are very few schemes likely to merit this score but it may be that the proposals result in the exposure of geological formations that may become of significant regional and or national interest. (Beneficial)
Moderate	**Geology (solid geology):** The proposals may adversely affect the geological/hydrogeological conditions/soils resource existing at the site but would not result in the loss of, or damage to, areas designated as being of regional or national geological interest. Loss of resource, but not adversely affecting the integrity. Partial loss of/damage to key characteristics, features or elements. Some mitigation may be possible but would not prevent scarring of the geological environment, as some features of interest would be lost or partly destroyed. (Adverse) **Soils(Superficial geology/topsoils and subsoils):** Loss of soils resource, but not adversely affecting the integrity; partial loss of/damage to key characteristics, feature or elements. (Adverse) **Controlled Waters (aquifers/surface water):** Reduced reliability of a supply at a groundwater or surface water abstraction source. (Adverse) **Contamination:** Moderate effect upon receptor. Long term or short term moderate effect on human health. Moderate effect on ground/surface water quality, reversible with time. (Adverse)
	There is moderate benefit to the geological/hydrogeological environment/soils resource of the area as a result of the Scheme proposals. There are very few proposals likely to merit this score but it may be that the project results in the exposure of geological formations that may become of significant interest or a brownfield contaminated site that is or is likely to be determined as Contaminated Land would be remediated by the proposed scheme. (Beneficial)

Magnitude of Impact	Typical Criteria Descriptors
Minor	**Geology (solid geology):** The proposals would not affect areas with regional or national geological interest/soils resource but may result in the loss of, or damage to, areas of local geological/soils resource interest. Cannot be completely mitigated for but opportunities exist for the replacement of lost or damaged areas which may be of similar local geological/soils interest. (Adverse) **Soils (superficial geology/topsoils and subsoils):** Some measurable change in soil attributes, quality or vulnerability; minor loss of, or alteration to, one (maybe more) key characteristics, features or elements. (Adverse) **Controlled Waters (aquifers/surface water):** Marginal reduced reliability of a supply at a groundwater or surface water abstraction source. (Adverse) **Contamination:** Non-permanent health effects to human health (easily prevented by means such as personal protective clothing etc.). Slight effect on ground/surface water quality, reversible with time. (Adverse)
	Minor benefit to the geological / hydrogeological environment / soils resource. The proposals may result in the exposure of geological formations that may become of significant local interest. (Beneficial)
Negligible	**Geology (solid geology)**: The proposals would result in very minor loss or damage to local area of geological interest/soils resource such that mitigation is not considered practical. Very minor loss or detrimental alteration to one or more characteristics, features or elements. (Adverse) **Soils(Superficial geology/topsoils and subsoils):** Very minor loss or detrimental alteration to one or more characteristics, features or elements of soils. (Adverse) **Controlled Waters (aquifers/surface water)**: Non-measurable change to quality, level and flow. (Adverse) **Contamination**: Results in no discernible change or an impact on attribute of sufficient magnitude to affect the use/integrity. (Adverse) E.g. Soil contaminants present, but risk assessment suggests negligible/low risk to human health. (Adverse)
	The proposals would be of minor benefit or positive addition to local areas of geological interest/soils resource, by potentially providing greater exposure and or protection. (Beneficial).
No change	**Geology, Soils, Controlled Waters and Contamination:** No observable impact either adversely or beneficially. No alteration to resource or its characteristics. No change to quality or flow.

Significance of Effect

11.3.43 The assessment of value (sensitivity) and the magnitude of impacts when combined, ultimately lead to arriving at an assessment of the significance of effects. The significance of effects has been derived based on professional judgement in accordance with Table 11.4, which is based on the guidance provided in Table 2.4 of HA205/08 (Highways Agency *et al.,* 2008b).

Table 11.4: Approach to Evaluating Significance of Effect

Value/ Sensitivity	Magnitude of Impact				
	No Change	**Negligible**	**Minor**	**Moderate**	**Major**
Negligible	Neutral	Neutral	Neutral or Slight	Neutral or Slight	Slight
Low	Neutral	Neutral or Slight	Neutral or Slight	Slight	Slight or Moderate
Medium	Neutral	Neutral or Slight	Slight	Moderate	Moderate or Large
High	Neutral	Slight	Slight or Moderate	Moderate or Large	Large or Very large
Very high	Neutral	Slight	Moderate or Large	Large or Very large	Very large

11.3.44 The significance of effect has been described using the terms very large, large, moderate, slight and neutral. Table 2.3 of HA205/08 provides the significance descriptors. For the purposes of this assessment effects of moderate and above are considered to be significant in terms of the EIA Regulations.

Limitations of the Assessment

11.3.45 The following limitations and assumptions have been noted.

- The contamination baseline assessment information is based on the data provided by previous historic ground investigations and the more recent 2015 Welsh Government Supplementary Ground Investigation (Geotechnical Engineering, 2015).
- The Construction Environmental Management Plan (CEMP) would set out the environmental measures that would be adopted during the construction phase. A Pre-CEMP is provided in Appendix 3.2 of this ES and this would be updated prior to construction. The CEMP would include the monitoring and contamination management requirements identified within the Outline Remediation Strategy Report for the Scheme (Appendix 11.2).

11.3.46 It is considered that the available ground investigation data are generally sufficient to inform this ES baseline and provide the basis for this assessment. However, further ground investigation is to be undertaken to provide supplementary specific data on 17 potentially contaminated sites (CL2, CL3, CL4, CL6, CL8, CL10, CL13, CL14, CL15, CL17, CL18, CL22, CL26, CL27, CL29, CL30 and CL41) prior to construction enable refinement and detailed design of a remediation strategy Details of the sites where supplementary ground investigation is to be undertaken are provided in Table 11.9 of this chapter. Figures 11.1a, 11.1b, 11.1c and 11.1d show the locations of the potential sites of land contamination.

11.4 Baseline Environment

11.4.1 A detailed description of many elements of the baseline environment is provided in the BWE Report (Geology, Hydrology and Surface Water Baseline) provided in Appendix 16.2 and in the Land Contamination Assessment Report in Appendix 11.1. This is summarised below.

Topography, Landform and Land Use

11.4.2 The proposed route of the new section of motorway would cross three distinct topographic zones as set out below.

- High elevation, Devonian hills in the west around Castleton (Junction 29 of the existing M4) (elevation of up to approximately 60 metre Above Ordnance Datum (AOD)).
- Low-lying, flat coastal plain of Gwent Levels (elevation below 10 metres AOD).
- High elevation Carboniferous hills in the east around Magor (Junction 23A of the existing M4) (elevation of up to approximately 60 metres AOD).

11.4.3 In its mid-section the new section of motorway would cross the River Ebbw and the River Usk, which discharge into the Severn Estuary, to the south of Newport. The proposed new section of motorway would also cross the Alexandra Docks, between the Usk and Ebbw. To the west and east are the Wentlooge Levels and Caldicot Levels, respectively. In the vicinity of Newport and at Llanwern steelworks the Levels have been extensively developed.

11.4.4 On the basis of topography, land use and drainage, the new section of motorway can be divided broadly into five zones, namely Castleton, Wentlooge Levels, the central section (including the River Ebbw Underbridge, Docks Way Junction and River Usk Crossing), Caldicot Levels and Magor. These are shown within drawings contained within the BWE Report in Appendix 16.2.

11.4.5 The predominant land use along the route of the new section of motorway is arable and pastoral farmland with isolated residential dwellings. The land use and Agricultural Land Classification across the study area are presented in Chapter 15 of this ES: Community and Private Assets.

11.4.6 Over half of the land within the permanent highway boundary of the new section of motorway would be constructed on brownfield land such as Newport Docks, Llanwern Steelworks and Solutia chemical works.

Geology

11.4.7 A detailed summary of the geology within the study area is provided in the BWE report in Appendix 16.2, with the key aspects of baseline geology summarised in Figures 16.2a to 16.2e and 163a to 16.3e. A summary of the geological ground model identified within the study area is provided in the Conceptual Hydrogeological Models presented in Figures 16.5a to 16.5e.

11.4.8 The geology encountered within the study area is summarised in Table 16.6 of this ES, which is reproduced below as Table 11.5.

Table 11.5: Geological Sequence

Geological Period	Supergroup	Group	Subgroup / Formation
Quaternary	-	-	Glacial Till (GT)
			Alluvium (ALV)
			Head (HD)
			River Terrace Deposits (RTD)
			Tidal Flat Deposits (TFD)
			Glaciofluvial Deposits (GFD)

Geological Period	Supergroup	Group	Subgroup / Formation
Triassic	-	Mercia Mudstone Group (MMG)	
		-	Mercia Mudstone (marginal facies)
Carboniferous	Carboniferous Limestone	Pembroke Limestone Group	Gulley Oolite Formation (GOF)
			Blackrock Limestone subgroup (BLF)
		Avon Group (AVG)	
Devonian	Old Red Sandstone (ORS)	Upper ORS	Tintern Sandstone (TSF)
			Quartz Conglomerate (QZ)
		Lower (ORS)	Brownstone Formation (BWF)
			St Maughans Formation (SMF)
Silurian			Raglan Mudstone Formation (RMF)

Solid Geology

11.4.9 The solid geology present beneath the study area consists of bedrock of Silurian, Devonian, Carboniferous and Triassic ages.

11.4.10 Areas of high elevation at the eastern end of the study area are dominated by Carboniferous strata, principally limestone units of the Avon Group and Pembroke Limestone Group, the latter including the Black Rock Limestone Formation and Gully Oolite Formation.

11.4.11 The majority of the route is situated above Triassic bedrock, which comprises Mercia Mudstone (formerly Keuper Marl). Localised areas of the Mercia Mudstone marginal facies are encountered in the east around the Carbonifeorus limestone high ground.

11.4.12 The western section of the study area is situated on older bedrock that includes Devonian St Maughan's Formation and Silurian Raglan Mudstone formation. Other Devonian units (i.e. the Brownstones Formation and Tintern Sandstone) are also encountered along the proposed route of the new section of motorway. The general description for each of the key lithological units encountered within the study area is provided in Table 11.6. These descriptions are taken from the BGS Lexicon of Named Rock Units (BGS, 2015).

Table 11.6: BGS Lithological Descriptions

Unit (Reference)	BGS Lithological Description
Mercia Mudstone Group (MMG)	Dominantly red, less commonly green-grey, mudstones and subordinate siltstones with thick halite-bearing units in some basinal areas. Thin beds of gypsum/anhydrite widespread, sandstones are also present.
Mercia Mudstone marginal facies (MMMF)	Variable, typically consisting of conglomerate and/or breccia with clasts derived locally from rocks lying immediately below the unconformable base of these deposits. The matrix generally consists of finer-grained rock fragments or, less commonly, siltstone, sandstone or micritic limestone.
Gully Oolite Formation (GOF)	Medium- to thick-bedded, pale grey, oolitic grainstone with subordinate beds of fine-grained skeletal packstones. Cross-laminated and cross-bedded, some burrowing. Locally dolomitized.

Unit (Reference)	BGS Lithological Description
Black Rock Limestone subgroup (BRL)	Thin- to thick-bedded, dark grey to black, foetid, fine- to coarse-grained skeletal (mainly crinoid) packstones with subordinate thin beds of shaly argillaceous skeletal packstone and mudstone. Widespread burrowing.
Avon Group (AG)	Interbedded grey mudstones and thin- to medium-bedded skeletal packstones with one to several thick units of ooidal and skeletal grainstones. Thin units of calcite mudstone and mudstone locally present. Sparse thin ironstones.
Tintern Sandstone Formation (TSF)	Buff-yellow sandstone with local lenticles of pebbles and subordinate marl partings.
Brownstone Formation (BWF)	Red, brown and purple fluvial sandstones with red mudstone interbeds.
St Maughans Formation (SMF)	Interbedded purple, brown and green sandstones and red mudstones with intraformational conglomerates containing calcrete clasts.
Raglan Mudstone Formation (RMF)	Red mudstones and silty mudstones with calcretes and sandstones.

11.4.13 The distribution of the key bedrock units is described in detail within the BWE Report (Appendix 16.2). The various previous ground investigations that have been undertaken (Section 11.3) have confirmed the geological sequence set out in published information.

Superficial Deposits

11.4.14 The superficial deposits within the study area are principally of Quaternary age and dominated by the sequence of deposits contained within the Gwent Levels. On higher ground located outside of the Gwent Levels, the Quaternary sequence is dominated by glacial till and more recent fluvial (i.e. river terrace deposits and alluvium) or head deposit. These superficial deposits have a poorly constrained relationship with the Quaternary sequence within the Gwent Levels themselves.

11.4.15 The detailed stratigraphy of the Gwent Levels sequence is described by Allen (Allen, 2001). The geology is dominated by Holocene deposits typically 10 to 15 m thick that comprise alternating estuarine clays and silts with peat horizons (recently termed Tidal Flat Deposits). Beneath much of the Wentlooge Levels and Caldicot Levels this sequence directly overlies a relatively continuous platform in the underlying bedrock with an elevation of between -7.5 metres AOD and -5 metres AOD that declines gently towards the Severn Estuary. In the central region of the study area around Newport, the bedrock platform is incised by valleys associated with the River Ebbw and River Usk. These valleys have been infilled with Pleistocene valley gravels and some sands that are occasionally capped by head deposits. These gravels directly underlie the Holocene estuarine sequence. The Pleistocene valley gravels extend to the west and east, beneath the Wentlooge Levels and Caldicot Levels, respectively.

11.4.16 This general sequence is described below with respect to recent terminology of the BGS (lexicon) summarised in Table 5.1 of the BWE report within Appendix 16.2 of this ES.

Alluvium

11.4.17 Recent fluvial deposits that are contained within the non-tidal valleys of principal watercourses are termed alluvium (ALV). The alluvium is of highly variable composition and extent, but typically comprises silty clay, with layers of silt, sand, peat and basal gravel.

Head

11.4.18 Head (HD) is a poorly sorted and poorly stratified deposit formed mostly by solifluction and/or hillwash and soil creep. Head essentially comprises sand and gravel, locally with lenses of silt, clay or peat and organic material. Small areas of localised head deposits are identified within the study area and are also expected in places beneath the Gwent Levels.

River Terrace Deposits

11.4.19 Isolated outcrops of River Terrace Deposits (RTDs) are present along the inland margin of the Tidal Flat Deposits of the Gwent Levels. The subcrop pattern of the River Terrace Deposits is not proven, but these deposits are generally restricted to areas of higher elevation situated outside of the Gwent Levels. The River Terrace Deposits comprise sand and gravel units, locally with lenses of silt, clay or peat and are of fluvial origin.

Glacial Till

11.4.20 Glacial Till (GT) caps bedrock to the north of the Gwent Levels along much of the local area, particularly in the west of the study area. Glacial Till has been previously termed Morainic Drift and is described as being '*highly variable from stiff, gravelly, silty clay to predominantly unconsolidated and unsorted gravels'*.

Tidal Flat Deposits

11.4.21 The majority of the study area crosses the Gwent Levels which is underlain by Tidal Flat Deposits (TFD) of Holocene age. The BGS consider that the Tidal Flat Deposits typically comprise soft silty clay, with layers of sand, gravel and peat and represent deposit laid down within the tidal zone, although these areas are now reclaimed through the construction of sea defences. The Tidal Flat Deposits have historically been termed estuarine alluvium, although this is now an obsolete lithostratigraphic term (see BGS lexicon). For the purpose of this study, the Tidal Flat Deposits are considered to be equivalent to the Holocene estuarine deposits of Allen (Allen, 2001), described above.

Glaciofluvial Deposits

11.4.22 Glaciofluvial Deposits (GFDs) have been identified at outcrops in localised areas along the inland margin of the Tidal Flat Deposits in the west of the study area. The Glaciofluvial Deposits comprise sand and gravel, locally with lenses of silt, clay or organic material, thought to be of glaciofluvial origin and sometimes occurring as sheet deposits.

11.4.23 For the purpose of this study, it has also been assumed that the Glaciofluvial Deposits defined by the BGS are equivalent to the Pleistocene sand and gravel deposits described by Allen (Allen, 2001) that pre-date and underlie the silty clays (and peats) of the Holocene Tidal Flat Deposits. It should be noted that historic geological cross-sections presented in the PSSR identify the concealed granular deposits situated beneath the estuarine alluvium as deep (granular) fluvial alluvium (Arup, 2014). Conversely, other authors have suggested that these granular deposits are the basal unit of that estuarine alluvium sequence (i.e. the Tidal Flat Deposits) (e.g. Andrews *et al.,* 1984). In light of this uncertainty, these granular deposits have been termed Glaciofluvial Deposits, reflecting the significant lithological and hydrogeological difference of the unit relative to other deposits within the expected stratigraphic sequence, most notably the overlying silt and clay of the Tidal Flat Deposits.

11.4.24 Although not proven, continuity between the concealed Glaciofluvial Deposits on the Gwent Levels and the superficial deposits situated inland from the Levels is not generally expected.

Topsoil and Anthropogenic Soils

Topsoils/Subsoils

11.4.25 Previous ground investigations have identified topsoils/subsoils being present along the route of the proposed new section of motorway particularly in areas that have not been subject to previous development such as agricultural land. The composition of the topsoils/subsoils is heavily influenced by the underlying geology. Topsoils/subsoils may be absent or generally of lower quality in areas that have been developed and in such areas its composition is typically variable with the potential to contain man-made inclusions such as fragments of brick and concrete. Further information on the nature and thicknesses of topsoils and subsoil horizons in areas of agricultural land is provided in Chapter 15 or this ES: Community and Private Assets.

Made Ground

11.4.26 Previous ground investigations and research has identified Made Ground within developed areas along the route of the proposed new section of motorway. Made Ground by its very nature is inherently variable both in terms of thickness and composition. More significant areas of Made Ground have been identified within the following areas along the route.

- Docks Way landfill comprising predominantly landfill waste.
- Newport Docks often associated with land reclamation activities to construct the docks.
- Historical landfills.
- Llanwern Steelworks comprising predominantly lagoon waste slag and reed beds.

11.4.27 Further detail is provided within the Land Contamination Assessment Report contained within Appendix 11.1 and associated annexes.

Designated and Non-designated Geological Sites

11.4.28 The following hierarchy of designated and non-designated geological sites has been used for the assessment.

- Designated geological sites of national or international importance (e.g. SSSI, NNR).
- Nationally important sites that have not been designated (e.g. JNCC GCR sites).
- RIG sites that have been adopted by the NCC and MCC as shown on their online planning constraints map (e.g. NCC, 2015b).
- Non-adopted RIG sites recommended by British Geological Survey in the South Wales RIGS Audit (2012).
- Special Landscape Areas or Sites of Importance for Nature Conservation.
- Non-designated geological exposure in road cuttings and/or historic quarries.

11.4.29 Through consultation with Newport City Council (NCC), Monmouthshire County Council (MCC) and British Geological Survey (BGS), all statutory and non-statutory designated geological sites located in the study area have been identified.

11.4.30 It can be concluded that no designated sites (statutory or non-statutory), nor rock faces associated with historical quarries (save backfilled pits and quarries identified within the Land Contamination Assessment Report), are located on the route of the new section of motorway. Areas of existing rock cut do exist in the vicinity of existing highways, most notably along the existing M4 around Castleton and Magor although these are not designated.

Structural Geology

11.4.31 An inferred fault (displacement unknown) cuts through the eastern end of the Magor junction on the existing M48.

11.4.32 Engineering geological mapping of rock cuts on the existing M4 located just east of Junction 23A Magor, was undertaken in order to characterise the geology and geotechnical properties of the rock masses to assist in the design of new rock cuts proposed as part of the widening works for the new section of motorway.

11.4.33 Descriptions of the Carboniferous Limestone in the Magor area indicate that dissolution features are common (e.g. sinkholes formed by dissolution of soluble rocks). Boreholes in this area have not conclusively established the presence or absence of sink holes in the vicinity of the proposed cut.

Geomorphology

11.4.34 On the basis of the topography and geology, the study area can be divided into five distinct geomorphological zones, namely Castleton, the Wentlooge Levels to the west of the River Usk, the Docks alongside the River Usk, the Caldicot Levels to the east of the River Usk and Magor.

Hydrology

11.4.35 A full description of the baseline hydrology in the vicinity of the new section of motorway is provided in the BWE report (Appendix 16.2) and summarised in Chapter 16 of this ES: Road Drainage and the Water Environment. Groundwater abstraction data are contained within the BWE report and flood risk is detailed within the Flood Consequence Assessment (Appendix 16.1).

11.4.36 The route of the new section of motorway would cross high ground in the east and west around Magor and Castleton, respectively. In its mid-section, the proposed new section of motorway would be low lying and would cross the River Ebbw and River Usk, to the south of Newport. The study area also includes the Alexandra Docks managed by Associated British Ports (ABP), situated between the River Usk and River Ebbw.

11.4.37 Approximately two thirds of the proposed new section of motorway would cross the reclaimed coastal marshes of the Gwent Levels. The Gwent Levels comprise the Wentlooge Levels and Caldicot Levels, to the west and east of the River Usk and River Ebbw, respectively. The Gwent Levels are an area of flat, reclaimed, coastal marshes that extend up to the Severn Estuary with an elevation typically of between 5 metres AOD and 6 metres AOD.

Hydrogeology

11.4.38 A full description of the baseline hydrogeology is provided in the BWE report (Appendix 16.2) and is summarised in Chapter 16 of this ES: Road Drainage and the Water Environment.

11.4.39 The general hydrogeological status of each of the geological units identified within the study area is summarised in Table 11.7. This includes the NRW aquifer designation for each unit and the BGS hydrogeological description.

11.4.40 NRW provides no formal designation for the Glaciofluvial Deposits that underlie the Tidal Flat Deposits within the centre of the study area. Where present, the Glaciofluvial Deposits form a laterally continuous saturated groundwater unit that is confined by the overlying silty clay of the Tidal Flat Deposits. Where exposed at the ground surface along the inland boundary with the Tidal Flat Deposits, the Glaciofluvial Deposits are designated a Secondary aquifer unit.

11.4.41 The majority of the study area is underlain by bedrock that comprises either the Mercia Mudstone Group or St Maughan's Formation. NRW consider these geological units to be Secondary B or Secondary A aquifers, reflecting the generally low productivity of these argillaceous rocks.

11.4.42 The limestone bedrock of the Carboniferous Limestone Series and localised breccias/conglomerates of the marginal facies of the Mercia Mudstone Group are designated as Principal aquifer units. These geological units are of limited extent and are largely restricted to the east of the study area.

Table 11.7: Hydrogeological Status of Geological Units

Unit (Reference)	Aquifer Designation (NRW)	Hydrogeology (BGS)	General Hydrogeological Status
Made Ground (MG)	-	-	Depends on lithology
Head (HD)	Secondary (undifferentiated)	-	Depends on lithology
Glacial Till (GT)	Secondary (undifferentiated)	-	Aquitard
Alluvium (ALV)	Secondary A	-	Depends on lithology
River Terrace Deposit (RTD)	Secondary A	-	Aquifer
Tidal Flat Deposit (TFD)	Unproductive strata in east. No designation in west.	-	Aquitard
Glaciofluvial Deposit (GFD)	Secondary A. Not defined for GFD below TFD	-	Aquifer Unit
Mercia Mudstone Group (MMG)	Secondary B	Low productivity aquifer. Largely argillaceous sequence with occasional sandstones yielding less than 0.5 litres per second (l/s) can be highly mineralised.	Aquifer Unit
Mercia Mudstone marginal facies (MMMF)	Principal aquifer	Moderately productive aquifer. Locally important aquifer generally producing hard groundwater from solution enhanced joints.	Aquifer Unit
Gully Oolite Formation (GOF)	Principal aquifer	Moderately productive aquifer. Massive karstic limestone aquifer with rapid response to rainfall. Yields highly variable from dry to 40 l/s.	Aquifer Unit
Black Rock Limestone (BRL)			
Avon Group (AG)			
Tintern Sandstone Formation (TSF)	Principal aquifer	Low productivity aquifer. Indurated multi-layered aquifer with small local yields from secondary fractures.	Aquifer Unit
Brownstone Formation (BWF)	Secondary A	Low productivity aquifer. Local sandstone and conglomerate aquifers yield small supplies.	Aquifer Unit
St Maughan's Formation (SMF)	Secondary A	Low productivity aquifer. Local sandstone and conglomerate aquifers yield small supplies.	Aquifer Unit

Unit (Reference)	Aquifer Designation (NRW)	Hydrogeology (BGS)	General Hydrogeological Status
Raglan Mudstone Formation (RMF)	Secondary A	Low productivity aquifer. Highly indurated argillaceous rocks with limited groundwater.	Aquifer Unit

11.4.43 A Conceptual Hydrogeological Model (CHM) has been developed for the Scheme based on a review of the hydrogeological baseline characterisation as presented in the BWE report (Appendix 16.2). The CHM is summarised in Figures 16.5a to 16.5e and is described further in Chapter 16: Road Drainage and the Water Environment of this ES.

Water Abstractions

11.4.44 Details of known water abstractions are provided in Chapter 16 of this ES and are shown on Figures 16.4a to 16.4e. In summary there are very limited numbers of abstraction points in the vicinity of the proposed new section of motorway and these relate to the following.

- Surface water abstraction in the Gwent Levels used by land owners for stock watering. No NRW abstraction licences have been issued in the Gwent Levels.
- Groundwater abstraction sources are restricted to bedrock or spring sources on higher ground around Castleton and Magor and are used for small domestic or agricultural supplies.

11.4.45 There are no documented abstractions from the Glaciofluvial Deposits, Tidal Flat Deposits or the underlying bedrock, in part because of the level of chloride rendering the groundwater non potable.

Mining

11.4.46 A review of mining and mineral resources within the study area has identified the following information.

- The mineral resources map of south east Wales indicates that the Scheme is outside the South Wales coalfield. There are no workable coal seams within 5 km of the route of the new section of motorway. There are no coal mining development areas within the Newport and Monmouthshire local planning authority boundaries. Coal is not identified as a mineral resource within either Newport of Monmouthshire within the Local Development Plans.
- There are no large operational quarries within the study area but there are a number of disused quarries along the route. These quarries are associated with the Carboniferous and Devonian rocks to the east of the study area.
- The mineral resources map shows two active workings within the immediate vicinity of the proposed new section of motorway. These are associated with the Llanwern Steelworks and the commodity worked is slag.
- Approximately 1 km to the east of the proposed new section of motorway there is a dormant limestone quarry called Ifton. The quarry is also marked as a significant building stone quarry and would be used as a source of

primary limestone aggregate to assist construction of the new section of motorway.

- No quarries are noted within or in close proximity to the western extent of the study area (between Castleton and west of the River Ebbw).

Unexploded Ordnance

11.4.47 The Scheme is located within areas at risk from the potential presence of buried unexploded ordnance (UXO), Newport Docks being a known target during World War II (WWII), with records of bombings in and around Newport. A detailed UXO assessment has been undertaken by Bactec (Bactec, 2014).

11.4.48 The study area has been subdivided into Low, Low-Medium, Medium and Medium-High Risk Zones as follows.

- Low Risk Zone - Parts of the study area occupied by historically unused, undeveloped agricultural land.
- Low-Medium Risk Zone - 300 metre radius centred on the WWII-era Heavy Anti-Aircraft Battery and the pillbox.
- Medium Risk Zone - 1.5 km radius centred on the WWII-era bombing decoy sites.
- Medium-High Risk Zone - 1.5 km radius centred on the Newport Docks, which were bombed several times, and 500 metre radii centred on the three bombing decoy sites, closest to the route.

11.4.49 A risk map presented in Annex P of the Bactec UXO report, which also shows the recommended risk mitigation measures, is provided within Appendix 11.4 of this ES.

Land Contamination and Ground Gas

11.4.50 A detailed description of land contamination potentially affecting the new section of motorway is provided in the Land Contamination Assessment Report in Appendix 11.1.

Identification of Potential Sources of Contamination

11.4.51 The 2014 PSSR identified 43 sites of potential land contamination source areas located within 150 m of six different route alignment options identified at that time and shown on Figure 11.1a to 11.1d. Based upon the route of the new section of motorway, 16 of the potential sites were considered to be very unlikely in terms of their off-site potential to impact the new section of motorway or for them to be affected by the new section of motorway as they are located beyond the temporary and permanent land take. They were therefore screened out from further assessment. The remaining 27 sites are presented within Table 11.8 and these have been assessed in further detail within the Land Contamination Assessment Report. All sites shown on Figure 11.1a to 11.1d are also differentiated between those potentially affected by the new section of motorway and those assessed as unlikely to be affected by the new section of motorway.

Table 11.8: Potential Land Contamination Sources Impacted by the Scheme

Potential Land Contamination Source Area	Description
CL-1 Castleton Interchange Spoil Heaps	Anecdotal evidence suggests that the spoil heaps were formed from excavation of surplus suitable fill and unsuitable marshy material and top soil during A48 (M) construction, in the late 1970s and from excavation spoil of an attenuation pond in 2009. Part of the site is within the permanent land take with no proposed construction works.
CL-2 Former Construction Storage Compound	Used as a storage compound for machinery and materials for M4/A48 (M), and later M4, construction and maintenance work.
CL-3 Pound Hill	A backfilled pit.
CL-4 Cefn Llogel Farm	A historic landfill which reportedly accepted inert waste.
CL-5 Church Road	An area of infilling and historic fly tipping.
CL-6 Radiator Manufacturers and Adjacent Land	Large areas of disturbed ground with ponds, some of which have been backfilled and former industrial site uses.
CL-8 Former Railway Bridge	Made Ground associated with embankments approach of former railway bridge.
CL-9 Green Lane Landfill	Licensed inert landfill with prior use for refuse tipping.
CL-10 Made Ground	Area with anecdotal evidence of Made Ground identified during 2014 walk over survey.
CL-13 Docks Way Landfill	Area 1 - historic landfill (now restored) accepting inert, household, commercial and industrial waste. Area 2 – active landfill receiving domestic refuse and industrial/commercial waste.
CL-14 Newport Docks	Industrialised area with many industrial and commercial uses. Also includes infilled historic River Ebbw channel. Possible refuse waste extending from Docks Way landfill onto the proposed Southern Distributor Road spur road.
CL-15 Stephenson Street Industrial Estate	Industrial area and docks with discrete features including former refuse tip and backfilled ponds.
CL-16 Infilled River Ebbw	Infilled River Ebbw area has been included within CL-14.
CL-17 Solutia Chemical Works	Chemical works including historical manufacturing processes associated with polychlorinated biphenyls (PCB). Particular site features comprising PCB cell (buried PCB impacted soil and wastes), Solutia Landfill (inert and industrial waste) and Phase III Monsanto landfill (inert waste).
CL-18 River Usk Pier Location	Mudflats of the River Usk (potentially contaminated river sediment).
CL-20 Mir Steel Works and Associated Waste Disposal Site	Steelworks, lagoons and waste disposal area (Slobsland Landfill). This area has been included as part of the CL-15 assessment.
CL-22 Former Llanwern Research Laboratories	Former research laboratories and benzene pipeline.
CL-26 Llanwern Steelworks Including reedbeds, metal recovery area and lagoons	Reedbeds, metal recovery area and 4 no. lagoons associated with adjacent steelworks.
CL-27 Elver Pill Reen and	Historic landfill, known infilling in the vicinity of Elver

Potential Land Contamination Source Area	Description
Green Moor Landfill	Pill Reen, suspected three discrete locations of buried steelworks waste (Green Moor Landfill).
CL-29 Spoil Heaps and Old Quarry, Llanwern Approach Road	Spoil mounds.
CL-30 Green Moor Quarry Landfill	Historical backfilling of quarry indicated as a refuse tip.
CL-32 Magor Depot (Wilcrick Depot)	Trunk Road Agency depot.
CL-33 B4245 Quarry	Partially backfilled quarry with unknown material.
CL-35 Magor Services	Service station including petrol filling station, car/HGV parking.
CL-38 Knollbury Cesspits	Three cesspits associated with campsite.
CL-39 The Elms Road Old Quarry and Lime Kiln	Partially backfilled quarry with unknown material.
CL-41 Severn Junction Tunnel Yard	Former railway land.

11.4.52 At each of the above areas, there is a potential for contaminants in soils and groundwater to exist. The level of contaminants varies widely from site to site and further details of the level of contamination at each site is provided in the Land Contamination Assessment Report in Appendix 11.1

Identification of Potential Receptors

11.4.53 Receptors that could be harmed from land contamination include human beings, other living organisms, crops and controlled waters. For each of the potential contamination source areas identified within the study area, a number of key receptors have been considered which include the following.

- General public users on land adjacent to the Scheme during construction.
- Construction workers, including site visitors.
- Controlled waters.
- Aquatic ecology.
- Future general public (motorway users).
- Future maintenance workers.
- Buildings/structures (risk of ingress of hazardous ground gases).

11.4.54 The following potential controlled water receptors have been assessed.

- Rivers and streams.
- Land drainage, including reens and ditches, particularly in part of the Gwent Levels SSSIs.
- Aquifers designated by NRW (Environment Agency website and NRW e-mail correspondence, 2015 - contained within the BWE report in Appendix 16.2).

11.4.55 Water levels are considered in detail within Chapter 16 of this ES: Road Drainage and the Water Environment.

Identification of Potential Pathways

11.4.56 There are a number of primary pathways through which contaminants could impact receptors and these include the following.

- Ingestion, dermal contact and inhalation of soils and dusts, and inhalation of vapours (construction workers, future motorway users and maintenance workers). It is expected that any contaminated soils within the majority of the new section of motorway would be encapsulated by either the motorway embankment or structures, thus severely limiting potential exposure and contamination to humans. However, in areas of cut or where soils are reused to construct the embankment and in any landscaping areas, there is potential for future motorway users and maintenance workers to be exposed to shallow soils.
- Ingestion, dermal contact and inhalation of dusts (adjacent site users). During construction, without control measures, dusts and soils may migrate offsite and impact nearby members of the public.
- Ingestion and dermal contact with potentially contaminated surface waters and groundwaters (construction workers and maintenance workers).
- Inhalation and accumulation of hazardous ground gases (humans and structures). Ground gases, such as methane or carbon dioxide, may migrate into confined places such as manholes or beneath/into buildings during the operational phase of the Scheme. Piled foundations may create preferential flow paths for ground gas.
- Lateral and vertical migration of contaminants (controlled waters). Contaminants within soils and groundwaters may migrate vertically or laterally through the underlying strata. The design of foundations and construction methods may also create preferential flow paths for vertical migration to underlying aquifers and potentially surface waters (e.g. piled foundations).

Risk Evaluation

11.4.57 An initial assessment of the 27 sites of potential land contamination has been made using the source-pathway-receptor approach consistent with CLR11 guidance. This is described in detail in the Land Contamination Assessment report, which includes the findings of the Tier 1 and Tier 2 Risk Assessments. Table 11.9 provides a summary of the potential sources and receptors relating to each potential site of land contamination, as well as potential contaminants of concern identified following the risk assessment undertaken in the Land Contamination Assessment Report. For each site, the source-pathway-receptor link is assigned a likelihood, severity and risk level as described within the Land Contamination Assessment Report (Appendix 11.1). The assessment is based on and informed by CIRIA C552 (CIRIA, 2001) and CLR11 (Environment Agency and Defra, 2004). The level of risk is defined on the following basis.

- Low Risk - it is considered unlikely that the source-pathway-receptor scenarios assigned to this risk designation will give rise to an impact on human health or the environment.
- Moderate Risk - it is possible, but not certain, that the source-pathway-receptor scenarios assigned to this designation may give rise to an impact on

human health or the environment, which may require remediation and/or control measures to mitigate risks.

- High Risk - there is a high potential that the source-pathway-receptor scenarios assigned to this designation may give rise to harm to human health or the environment and remedial action is likely to be required.

11.4.58 The range of risk levels for identified and potential contaminant linkages as determined by the Tier 1 and Tier 2 Risk Assessments in the Land Contamination Assessment report is provided in Table 11.9 together with details of the key potential contaminant linkages of concern.

Table 11.9: Potential Land Contamination Sources and Overall Risk

Site Name	Potential Contaminant Source	Potential Contaminants of Concern	Potential Receptors	Risk Range (lowest – highest)	Key Potential Contaminant Linkages
CL-1 Castleton Interchange Spoil Heaps	Spoil heaps; from flytipping and marshy soils [1]	Heavy metals and hydrocarbons. Possible ground gas.	Human health, Secondary A aquifer, surface waters	Very low - Low	None identified.
CL-2 Former Construction Storage Compound	Leaks/ spillages [1]	Possible hydrocarbons	Human health, Secondary A aquifer	Very low - Moderate to low[2]	Leaching of potentially contaminated soils to Secondary A aquifer
CL-3 Pound Hill	Backfilled quarry pit	None identified	Human health, Secondary A aquifer, surface water drainage	Very low – Low[2]	Abnormal gas regime recorded off site may indicate presence of waste currently not identified by supplementary ground investigation.
CL-4 Cefn Llogel Farm	Possible inert waste associated with landfill [1]	Possible heavy metals and hydrocarbons with waste and perched water. Possible ground gas from waste.	Human health, surface waters	Very low - Moderate to low[2]	Dermal, ingestion and inhalation of potentially contaminated soils/dusts and ground gas or vapours to construction workers. Potentially contaminated surface water runoff / leaching of Made Ground to controlled surface waters.
CL-5 Church Road	Buried fly-tipping	Elevated hydrocarbons in soils, Heavy metals in groundwater	Human health, Secondary A and B aquifers, surface water drainage	Very low – Low	None identified

Site Name	Potential Contaminant Source	Potential Contaminants of Concern	Potential Receptors	Risk Range (lowest – highest)	Key Potential Contaminant Linkages
CL-6 Radiator Manufacturers and Adjacent Land	Made Ground, contaminated groundwater, peat (no historical ground investigation data available for temporary land take associated with construction compound)	Ground gas associated with peat; groundwater saline (brackish) and with inorganic contaminants. Potential contaminants within the Made Ground. Additionally, possible solvents and paints within the proposed temporary land take.	Human health, Secondary A and B aquifers, surface waters	Very low – High[2]	Risk of potential ground gas (explosion) to construction workers. Leaching of potential contaminants from Made Ground and saturated flow from perched water migrating into surface water. Potential new pathways created through band drains.
CL-8 Former Railway Bridge	Made Ground	Limited information. Various possible including heavy metals and hydrocarbons	Human health/groundwater aquifers, surface waters	Very low – Low[2]	None identified
CL-9 Green Lane Landfill	Waste from historic landfilling, peat	Heavy metals, organic and inorganic contaminants, ground gas	Human health/groundwater aquifers, surface waters	Very low - Moderate	Risk of potential ground gas (explosion) to construction workers.
CL-10 Made Ground	Made Ground	Limited information. Various possible including heavy metals and hydrocarbons though indicated to be predominantly inert	Human health/groundwater aquifers, surface waters	Very low – Moderate[2]	Potential new pathways created through band drains allowing contamination of surface water and aquifer.
CL-13 Docks Way Landfill	Made Ground, peat (Scheme land take excludes landfill areas) (Landfilled material extending beyond Site	Organics in Made Ground and ground gas.	Human health, Secondary B aquifer, surface waters	Very low – High[2]	Elevated ground gas (explosion) to construction workers during piling. Piling and construction affecting current gas regime leading to risks to adjacent properties. Leaching potential from Made Ground

Site Name	Potential Contaminant Source	Potential Contaminants of Concern	Potential Receptors	Risk Range (lowest – highest)	Key Potential Contaminant Linkages
	boundary considered in CL-15 Stephenson Street Industrial Estate).				and saturated flow from perched water migrating into surface water. Potential new pathways created through piles allowing contamination of surface water and aquifer.
CL-14 Newport Docks	Various industrial usage, peat	Various possible including heavy metals, organics/inorganics, asbestos and ground gas.	Human health, Secondary B aquifer, surface waters	Very low – Moderate[2]	Hydrocarbon and inorganic impacted soils impacting on construction workers. Migration of contaminants in soils and perched waters into aquifers and surface waters through piling. Elevated ground gas (explosion) to construction workers during piling.
CL-15 Stephenson Street Industrial Estate	Various industrial usage, peat, historical landfilled material associated with adjacent Docks Way Landfill.	Various possible including heavy metals, organics/inorganics and ground gas.	Human health, Secondary B aquifer, surface waters	Very low – Moderate[2]	Risk of potential ground gas (explosion) to construction workers. Localised hydrocarbon impaction of soils. Impacted shallow and deep aquifers and potential new pathways through piling.
CL-16 Infilled River Ebbw (included in CL-14 above)					
CL-17 Solutia Chemical Works	Chemical works, inert and industrial waste landfills	Organochlorines and aromatic based organic compounds including PCBs. Widespread elevated PCBs and pH in soils. Ground gas.	Human health, Secondary B aquifer, surface waters	Very low – High[2]	Migration of contaminants in soils and perched waters into aquifers and surface waters through piling. Elevated ground gas (explosion) to construction workers during piling.

Site Name	Potential Contaminant Source	Potential Contaminants of Concern	Potential Receptors	Risk Range (lowest – highest)	Key Potential Contaminant Linkages
CL-18 River Usk Pier Location	Contaminated river sediments	Various including hydrocarbons, heavy metals and other inorganics.	Human health/Secondary B aquifer, surface waters, River Usk	Very low – Moderate[2]	Inhalation of ground gas or hydrocarbon vapours from superficial deposits during construction. Dermal contact with, and ingestion of contaminated perched groundwaters/aquifer.
CL-20 Mir Steelworks and Associated Waste Disposal Site (included in CL-15 above)					
CL-22 Former Llanwern Research Laboratories	Made Ground comprising ash, slag and demolition rubble. Benzene pipeline	Various including heavy metals, hydrocarbons (including benzene)	Secondary B aquifer, human health	Very low– Moderate[2]	Potential new pathways created through band drains allowing contamination to surface water and aquifer.
CL-26 Llanwern Steel Works - Including Lagoons Areas	Made Ground including sludge and slag with impacted perched water	Various including heavy metals, inorganics and hydrocarbons. Ground gas.	Human health, Secondary B aquifer, surface waters	Very low - High[2]	Dermal, ingestion and inhalation of potentially contaminated soils/dusts and ground gas by construction workers. Potential new pathways created through band drains allowing contamination to surface water and aquifer.
CL-26 Llanwern Steel Works – Reedbed 1 and Metal Recovery Areas (main alignment)	Made Ground comprising slag and reedbed sediment with impacted perched water	Various including heavy metals, inorganics and, hydrocarbons	Human health, groundwater aquifers, surface waters	Very low – High[2]	Dermal, ingestion and inhalation of potentially contaminated soils/dusts and ground gas to construction/maintenance workers and general public. Potential new pathways created through band drains allowing contamination to surface water and aquifer.
CL-27 Elver Pill Reen and Green Moor Landfill	Slag and industrial wastes	Various including heavy metals, hydrocarbons	Human health, Secondary B aquifer, surface waters	Very low - High[2]	Potential new pathways created through band drains allowing contamination of surface water and aquifer.

Site Name	Potential Contaminant Source	Potential Contaminants of Concern	Potential Receptors	Risk Range (lowest – highest)	Key Potential Contaminant Linkages
CL-29 Spoil Heaps and Old Quarry, Llanwern Approach Road	Spoil materials	Various including hydrocarbons, heavy metals and other inorganics	Human health, superficial and bedrock aquifers	Very low - Low[2]	None identified
CL-30 Green Moor Quarry Landfill	Quarry infill materials	Limited information. Various possible	Human health, Principal aquifer	Very low-Moderate[2]	Dermal, ingestion and inhalation of potentially contaminated soil/dusts and vapours to construction workers
CL-32 Magor Depot (Wilcrick Depot)	Leaks/ spillages including underground storage tanks. Made Ground	Hydrocarbons, Volatile Organic Compounds (VOCs),Semi Volatile Organic Compounds (SVOCS)	Human health, Secondary A aquifer	Very low - Moderate	Inhalation of hydrocarbon vapours, soil dust, dermal contact with and ingestion of contaminated soils by construction workers. Leaching/migration of contaminants from Made Ground, buried tank or fuel spills to aquifer.
CL-33 B4245 Quarry	Infill materials	Limited information. Various possible including heavy metals and hydrocarbons	Human health, superficial and bedrock aquifers	Very low–Moderate[2]	Dermal contact, ingestion and inhalation of soils/dusts and ground gas or vapours from quarry in-fill materials by construction workers. Leaching/migration of contaminants into aquifer.
CL-35 Magor Services	Leaks / spillages	Hydrocarbons	Human health, groundwaters and surface waters	Low - Moderate to low[2]	Migration of hydrocarbon contamination via groundwaters and subsequent inhalation of vapours by human receptors, contamination of groundwaters and surface water.
CL-38 Knollbury Cesspits	Cess pits	Sewage	Human health	Very low	None identified
CL-39 The Elms Road Old Quarry and Lime Kiln	Made Ground	Various including heavy metals and hydrocarbons	Human health, groundwaters and surface waters	Low - Moderate	Dermal, ingestion and inhalation of potentially contaminated soils/dusts and vapours to construction workers.

Site Name	Potential Contaminant Source	Potential Contaminants of Concern	Potential Receptors	Risk Range (lowest – highest)	Key Potential Contaminant Linkages
					Potential new pathways created through band drains allowing contamination to aquifer.
CL-41 Severn Junction Tunnel Yard	Made Ground	Various including heavy metals	Human health, groundwaters and surface waters	Very low - Moderate to low[2]	Leaching of Made Ground during construction works into surface waters. Possible soil-water linkage identified for TPH.

Notes to Table 11.9
Note 1: No historical ground investigation data available.
Note 2: (risk): risk level to be updated following findings of supplementary ground investigation.

11.4.59 The sites with the highest risk requiring site specific remediation are identified as follows.

- Docks Way Landfill.
- Solutia Chemical Works.
- Llanwern Steelworks.

11.4.60 Further information on these specific areas is summarised in the following sections, with further detail provided within the Land Contamination Assessment report.

11.4.61 A detailed remediation strategy would be developed and implemented to address the various identified risks within Table 11.9. An Outline Remediation Strategy Report is provided in Appendix 11.2. This would include a discovery strategy to deal with unexpected and previously undetected contamination encountered anywhere along the Scheme during construction. Further details are provided in Section 11.9 of this chapter.

Docks Way Landfill (CL-13)

11.4.62 This is an active landfill site operated by Newport City Council. The site can be split into two areas: Area 1 (an unlined dilute and disperse landfill, which is now fully restored) and Area 2 (an engineered containment landfill). Newport City Council operates these landfills under two environmental permits issued by NRW (Area 1 under Waste Management Licence no. EAWML30058 and Area 2 under Pollution Prevention Control Permit no. DP3733BK - variation notice no. MP3730MJ).

11.4.63 Waste previously accepted into Area 1 included inert, household, commercial and industrial waste as well as bonded asbestos containing material and 'special waste'. Waste accepted into Area 2 comprises domestic and commercial waste.

11.4.64 The proposed main alignment of the new section of motorway and slip roads to the Docks Junction would be carried predominantly on piled embankments south of the site. The new section of motorway would also include a section of piled

embankment to support the Southern Distributor Road (SDR) link road along the eastern edge of the landfill.

11.4.65 The only area where the alignment impinges upon the landfill permit boundary would be the southern tip of Area 2 where the piled embankment abuts to the bridge over the River Ebbw. This is outside of the engineered waste disposal cells and therefore no landfilling of waste is expected to have taken place at this location. Consequently, no specific works associated with Area 2 are expected to be needed other than ensuring the existing containment and engineering controls are maintained during construction and future operation. The proposed land take would, however, extend onto the landfill's permitted area and therefore it is proposed the environmental permit for this area is surrendered by Newport City Council and the permit boundary revised accordingly.

11.4.66 Borehole records confirm that landfilled materials, typically 4-5 metres thick have been placed beyond the landfill boundary of Area 1 and further ground investigation is to be undertaken to confirm the extent and nature of these materials along the proposed SDR link road. The potential presence of asbestos within the landfill materials cannot be discounted and would be investigated during the proposed ground investigation.

11.4.67 Ground gases elevated above screening criteria have been recorded within borehole monitoring wells on the periphery of Area 1 and Area 2 within and in the vicinity of the proposed SDR link road which are associated with wells constructed within the waste materials.

Solutia Chemical Works (CL-17)

11.4.68 The site comprises an active chemical plant with a number of waste disposal areas including an engineered cell (known as the 'PCB cell') containing buried chemical (mainly polychlorinated biphenyls - PCBs) waste, as well as a historic inert and an active industrial landfill. The site is operated by Solutia.

11.4.69 A piled embankment is proposed to be constructed in the eastern part of the site and the new section of motorway would continue over the western part of the site on a viaduct.

11.4.70 It is currently proposed that no construction would be undertaken in or on the PCB cell so as not to affect its integrity. To achieve this, the motorway viaduct over the Solutia site has been designed such that the PCB cell is bridged and the viaduct piers and foundations would be constructed outside the PCB cell. The bridging over the PCB cell would also enable the cell to be regularly inspected, monitored and maintained to allow Solutia to maintain its integrity.

11.4.71 The piled embankment section crosses part of the historic inert and industrial landfill.

11.4.72 Soil testing has identified elevated concentrations of some heavy metals, Polycyclic Aromatic Hydrocarbons (PAHs) and PCBs within the landfill area and external areas outside the PCB cell.

11.4.73 Perched water within the Made Ground has been identified as grossly contaminated with hydrocarbons. Further investigation of this site is to be undertaken to further refine the conceptual site model and allow remediation design to be developed further.

Llanwern Steelworks (CL-26)

11.4.74 The Llanwern Steelworks were constructed in the early 1960s. Slag heaps and settlement lagoons associated with the steelworks have been constructed to the south of the main steelworks site located to the north of the A4810. This lagoons area (CL-26) comprises, from west to east, Reedbed 1, former fragmentation and metal recovery area, sludge lagoons and a non-hazardous landfill. These are described separately in the following sections and detailed information is contained within the Land Contamination Assessment report.

Reedbed 1

11.4.75 This comprises a 600 metre by 300 metre area of reedbed network for surface water treatment for the Llanwern Steelworks prior to authorised discharge into the Severn Estuary. These are formed by a raised bund creating wetland basins with reed growth. This reedbed is used as a backup reedbed in case Reedbed 2 (located in CL-27) is unable to operate.

11.4.76 Reedbed 1 is located within the Gwent Levels SSSIs. Water quality monitoring found the adjacent boundary ditches and reens to be of relatively poorer quality than seen elsewhere within the Levels, with possible evidence of impact from the Llanwern Steelworks land use in this area.

11.4.77 The previous ground investigations have identified the bunds to be typically 0.5-1 metre higher than surrounding ground levels and comprising of coarse slag material. The base of the bunds was found in previous investigations to be generally 0.5-1.5 metres below surrounding ground level. Within the reedbeds, sediment described as black sandy clay with many roots was encountered with a typical thickness of 1-2.4 metres.

11.4.78 The new section of motorway would cross through the south western section of Reedbed 1. It is proposed that the highway would be constructed on a 1-2 m high earth embankment. As set out in Chapter 3, construction of the embankment would require surcharge and the installation of band drains.

11.4.79 With the exception of widespread alkaline conditions and discrete raised organics, no other contaminants were found to be in exceedance of the generic Tier 2 human health screening assessment.

11.4.80 Elevated levels of metals and inorganics were identified within the perched water within the Made Ground and Tidal Flat Deposits. Elevated levels of organic contaminants were also identified within the perched water within the Made Ground and to a lesser extent within the perched groundwater within the Tidal Flat Deposits (noted to be intermittent and inconsistent).

11.4.81 Contaminated perched waters in Made Ground may be in continuity with land drainage and would require suitable water management strategy to prevent potential impact to surface waters as well as protection against any contaminated run-off. During the operational phase, the motorway hardstanding would significantly limit the infiltration of rainwater through the soils and therefore leaching any soil contaminants in Made Ground into the water would be very limited.

11.4.82 The use of band drain and piles may provide new pathways which may lead to water within the Tidal Flat Deposits and possibly any perched water within the

Made Ground to enter the currently confined aquifer within the Glaciofluvial Deposits and Mercia Mudstone. A piling risk assessment would be required prior to construction and based on the results of the piling risk assessment, control measures may be required to protect controlled waters.

Metal Recovery Area

11.4.83 This comprises the former slag process metal recovery of Llanwern Steelworks. Whilst the slag process ceased in the late 1980's, the land is now leased for industrial processes including asphalt manufacturing and slag recycling.

11.4.84 The Metal Recovery Area is located within the Gwent Levels SSSIs. Water quality within the boundary ditches and reens was found to be of relatively poorer quality than seen elsewhere within the Gwent Levels, indicating possible evidence of impact from the Llanwern Steelworks land use in this area.

11.4.85 Consistent with the historical land use as a slag process area, typically a 2-3 metre thick mantle of coarse slag material with variable proportion of bricks was identified across the whole area. Widespread hydrocarbon contamination was identified in the exploratory hole records within the soils and perched water within the area of a former Frag Plant[1] location.

11.4.86 The new section of motorway would cross through part of the Metal Recovery Area. In this area the new section of motorway would include the following.

- A new junction (Glan Llyn junction) is proposed to provide a connection to the A4810. This would include a piled overbridge some 10 metres in height and piled embankments associated with the slip roads. The slip roads on the north of the junction would encroach on the area.
- A link road is proposed across the area, running from the Glan Llyn junction on piled embankment until the height drops below 5 metres, then on embankment with band drains.
- A new highway maintenance depot (Glan Llyn Depot) is proposed towards the north western corner of the Metal Recovery Area (highway boundary shown in Figure 18 of the relevant annex of Appendix 11.1).

11.4.87 As well as widespread alkaline conditions, the main contaminant of concern to human health is associated with the widespread hydrocarbon contamination within the area of the proposed Glan Llyn Depot.

11.4.88 Elevated levels of metals and pH were identified within the perched water within the Made Ground. The presence of organics (TPH and PAHs) specific to the Glyn Llyn Depot was also identified.

11.4.89 Elevated levels of metals and inorganics were identified within the perched groundwater within the Tidal Flat Deposits. The presence of organic contaminants has also been identified beneath the Glyn Llyn Depot area and off site (noted to be intermittent and inconsistent). The groundwater within the Mercia Mudstone is indicated to have similar metal and inorganic concentrations to the perched water body within the Tidal Flat Deposit.

[1] Defragmentation plant used to process, crush and sort slag material.

11.4.90 Water quality in some surrounding ditches / reens is considered to be of good quality with elevated metals and organics identified in others. The presence of organics may be linked with the hydrocarbon contamination identified within the Metal Recovery Area although this cannot be confirmed.

11.4.91 Risks to controlled waters are in line with those defined within Reedbed 1.

Llanwern Lagoons

11.4.92 As part of the Llanwern Steelworks, a number of sludge lagoons were filled with wastes and byproducts from the Basic Oxygen Steelmaking (BOS) processes and blast furnaces. The sludge lagoons are operated by Tata Steel under an environmental permit (EPR/HP3899FC/V003) and include Lagoon 12, Lagoon 25, Lagoon 27 (split into four quadrants NE, SE, SW, NW) and Lagoon 26. The latest modification of the permit in 2009 is to cease any further waste disposal operation and the area has since been put into aftercare. Lagoon 27SE and Lagoon 26 have not been filled.

11.4.93 A second permit (EPR/GP3331SV) issued in 2007 is specific to Lagoon 26 for the use of the area as a non-hazardous landfill. Whilst the permit is currently active, no installations associated with the permit requirement have been constructed and no waste has been disposed within the lagoon. Previous ground investigations have identified the presence of slag material with various inclusions of limestone, concrete, brick, metal and wood fragments to depths of generally between 1-4.5 metres below ground level. The Made Ground is believed to be associated with material disposal under the former permit.

11.4.94 A third environmental permit (EPR/BS3905IP) is held by Tata Steel applicable to Lagoon 27 which forms part of the on-site treatment facility, accepting waste from the Hot Mill activity.

11.4.95 In general, the lagoons consist of 5-8 metre raised bunds made of coarse slag containing slag sludge and waste within. The base of the lagoons is considered to be some 2-4 metres below general ground level.

11.4.96 The lagoon materials are considered to require treatment so as to render the material suitable for reuse as engineered fill for the proposed highway construction and also to ensure that the waste is considered fully recovered and does not cause an unacceptable risk to human health and controlled waters.

11.4.97 The southern boundary of the lagoon area is bounded by the northern extent of the Gwent Levels SSSIs. Water quality within the boundary ditches and reens was found to be of relatively good quality with no obvious evidence of impact from the Llanwern Steelworks land use in this area.

11.4.98 The slag material used to form the lagoon bunds containing the waste has elevated concentrations of lead and a high pH and as such could cause a risk to construction workers.

11.4.99 The main alignment of the new section of motorway within the site is to be positioned on an embankment and a junction (Glan Llyn junction) is proposed linking the new section of motorway to the A4810. The link road joining the motorway and the A4810 is currently proposed to pass through the Metal Recovery Area and join the A4810 at an existing roundabout. The junction would be founded on piled embankment whilst the main alignment and link road would

initially be surcharged with settlement enhanced by the installation of band drains.

11.4.100 The area impacted by the route corridor comprises the south western corner of Reedbed No.1 and the south eastern corner of the Metal Recovery Area of the Site.

11.4.101 A water treatment area to collect road drainage from the motorway and link road is proposed within the eastern area of the Metal Recovery Area.

11.4.102 The construction of the new section of motorway across the lagoons would require the reinstatement of the existing peripheral containment through construction of a new bund within the area of the waste lagoons being retained by Tata Steel. The existing environmental permits would require modification and the land within the permanent land take would be surrendered. Areas of land to the south of the permanent land take would also require remediation to enable permit surrender.

Land Contamination Elsewhere Within the Study Area

11.4.103 The potential for ground contamination and ground gas for the areas outside the sites of potential contamination shown on Figure 11.1 has been assessed and is discussed within the Land Contamination Assessment report. It is noted that the risk assessment uses a conservative screening criterion for the protection of human health (chromium VI, which is anthropogenic). The levels of total chromium in soils, although elevated in some soil samples above the screening criterion, are considered to be at background levels and are not considered to represent unacceptable risks to human health. No other specific areas of land contamination requiring remediation have been identified within the permanent and temporary land take. However, the following issues would require management in accordance with the remediation strategy.

- Alkaline soils particularly within the existing M4 junctions and Castleton and Magor.
- Elevated ground gases considered to be associated predominantly with natural soils (organics clays and peats of the Tidal Flat Deposits).

11.4.104 The overall risk level for areas outside the study area is considered to be very low. However, a discovery strategy would be implemented to manage unexpected or previously unidentified land contamination encountered during excavation.

Future Baseline Conditions

11.4.105 Consideration has been given to the potential for changes in the baseline conditions in the medium to long term as a result of climate change. The Climate Change Risk Assessment in Wales (Welsh Government and Defra, 2012) has been reviewed, together with other climate change prediction tools. With respect to soils, the Climate Change Risk Assessment for Wales identifies the following considerations.

- Reduction in soil moisture and lower river flows, and an increase in the frequency and magnitude of droughts.

- Changes in soil organic carbon, although the ways in which it might be affected are not adequately understood at present.
- Increase in soil erosion in drier summers.
- Wetter soils and increased waterlogging in winters with higher levels of precipitation.
- It is not considered likely that there would be significant changes in geological conditions.

11.4.106 These factors have been taken into consideration, where practicable, in the assessment of effects.

11.5 Mitigation Measures Forming Part of the Scheme Design

11.5.1 The design of the new section of motorway has taken into account the locations of existing features, including known areas of contaminated land. For example, it is proposed that no construction would be undertaken in or on the Solutia PCB cell so as not to affect its integrity. To achieve this, the motorway viaduct over the Solutia site has been designed such that the PCB cell would be bridged and the viaduct piers and foundations would be constructed outside the PCB cell. The bridging over the PCB cell would also enable the cell to be regularly inspected, monitored and maintained to allow Solutia to maintain its integrity.

11.5.2 Based on the assessment of ground investigation data, it is considered that ground instability may be caused by soft soils of the Tidal Flat Deposits beneath embankments. Therefore the following ground improvement measures have been included within the design (see Chapter 3 for further details).

- Surcharging to be used with band drains for embankments up to 5 metres (permanent height).
- Piling for embankments over 5 metres (permanent height).
- Placement of geotextile basal reinforcement.

11.5.3 Following the philosophy of the Land Contamination Management Strategy provided in Appendix 11.3 the design of the new section of motorway has been undertaken such that the potentially large volumes of contaminated materials are not simply excavated and removed from the permanent and temporary land take areas and disposed of off site. Instead, a substantially more sustainable risk based design approach has been adopted using UK good practice guidance to meet legal and regulatory requirements. The general design principle of retention and reuse of contaminated materials within the Scheme, provided the materials are geotechnically suitable and, once placed, do not result in unacceptable risks to human health or controlled waters, is proposed. Unsuitable contaminated materials would be treated on site under a suitable environmental permit to render them suitable. The lagoon waste material in the Llanwern Steelworks area would be treated on site including the use of cement stabilisation methods undertaken by a specialist remediation contractor.

11.5.4 To minimise risks to human health and the environment, whilst maintaining the design principle, the following mitigation measures have been incorporated into the design.

- Placement of contaminated soils and treated contaminated soils within the core of the main motorway embankment subject to compliance with specific risk based suitability for reuse criteria).
- The motorway carriageway and placement of uncontaminated topsoils and subsoils on the flanks of the motorway embankment would act as a barrier between the contaminated materials and site users during the operation of the new section of motorway.
- Bridging solution over the Solutia PCB cell.

11.5.5 This approach also has the following positive sustainability benefits.

- Reduction of construction traffic from public roads as most contaminated materials would be retained on site and not disposed of off site.
- Mitigation of substantial burden on waste management facilities and landfill through reuse of contaminated soils on site.
- Reduction in the need for imported or site won clean materials.

11.5.6 Operational impacts of the new section of motorway include potential pollution of surface watercourses, the groundwater and soils immediately adjacent to the route. This may result from fuel and chemical spills as a result of accidents, general vehicle or road degradation, incomplete fuel combustion and atmospheric deposition. The design includes appropriate mitigation measures in the form of suitable drainage systems with hydrocarbon interceptors to capture road runoff and prevent contamination of the surrounding environment. The potential for surface spray and airborne pollutants impacting on adjacent soils would be mitigated by the planting of vegetation tolerant to such environments.

11.5.7 In addition, the construction phase for the new section of motorway would include a range of mitigation measures developed taking into account the findings of the assessment process. Details of these measures are provided in Section 11.9 below.

11.5.8 The following mitigation measures are form part of the design of the Scheme.

- All surface water runoff from the Scheme would be directed to the Scheme drainage system (see Appendix 2.2).
- Cutting drainage would be installed to minimise the risk of seepage and consequent exposure.

11.6 Assessment of Potential Land Take Effects

Proposed New Section of Motorway

11.6.1 In order to assess the potential environmental effects on geology and soils along the route of the new section of motorway as a result of permanent land take it is first necessary to identify the geology and soils receptors and their sensitivity. Table 11.10 sets out the receptors relevant to geology and soils.

Table 11.10: Sensitive Receptors

Receptor Name	Receptor Type	Receptor Location	Sensitivity
Solid geology	Rock in areas of cut: Castleton - mudstones and sandstone of the St Maughans Foundation (SMF). Magor – Tintern Sandstone Formation (TSF), Carboniferous Limestone and Mercia Mudstone marginal facies (MMMF).	Cuttings at Castleton and Magor	Negligible
Superficial geology	Soils	Within and adjacent to new section of motorway	Low
Topsoils and subsoils	Topsoils and subsoils	Within and adjacent to new section of motorway	Medium
Aquifers (superficial and bedrock)	Groundwater	Beneath the new section of motorway	Low to medium*
Surface Waters (reens and rivers)	Surface water	Within and adjacent to new section of motorway	Low to very high*

*Sensitivity of receptor variable along the new section of motorway

11.6.2 Table 11.11 characterises the possible potential impacts on the geology and soils receptors that may occur as a result of the permanent land take associated with the new section of motorway.

Table 11.11: Potential Impacts on Geology and Soils from Permanent Land Take

Receptor Name	Receptor Type	Receptor Location	Potential Impacts
Solid geology	Rock in areas of cut - Castleton - mudstones and sandstone of the St Maughans Foundation (SMF). Magor – Tintern Sandstone Formation (TSF), Carboniferous Limestone and MMMF	Cuttings at Castleton and Magor	Loss of exposures. Alteration of rock properties following excavation, leading to changes in the hydrogeological regime/stability condition. Creation of new exposures of rock.
Superficial geology (Tidal Flat Deposits)	Soils	Majority of new section of motorway	Ground instability including excessive settlement.
Topsoils and subsoils	Topsoils and subsoils	Adjacent to carriageway through new section of motorway	Topsoil stripping and loss of local seed bank. Over half of the land within the permanent highway boundary crosses many brownfield sites and previously developed land such as Tata Steelworks, Newport Docks, industrial estates and existing paved areas. In many of these areas,

Receptor Name	Receptor Type	Receptor Location	Potential Impacts
			topsoil is absent. Thus the potential impact of topsoil loss would be limited to greenfield areas such as farmland in the Gwent Levels and around Magor and Castleton.
Aquifers (superficial and bedrock)	Groundwater (Controlled water)	Beneath the new section of motorway	Migration of contaminants in soils and perched groundwater creation of new pathways including band drains and piling.
Surface waters (reens, rivers and road drainage)	Surface water	Within and adjacent to new section of motorway	Migration of contaminants in soils and perched groundwater and surface water runoff into surface waters.
Surface waters (reens)	Surface water	Surface waters/reens adjacent and near areas where band drains are proposed within TFD	Hydrostatic pressure of aquifer which can be saline may mean band drains create vertical pathways connecting shallow groundwater and ultimately surface waters.
Specific Areas of Potential Land Contamination			
CL-6			
Surface waters (reens)	Surface water	In and around potential contamination source area	Contaminants in the aquifer have the potential to connect to perched groundwater (and surface waters) via band drain installation.
CL-17			
Surface waters (reens)	Surface water	In and around CL-17	Hydrostatic pressure of aquifer near base of Made Ground may connect the aquifer and perched groundwaters through piling.
CL-26			
Surface waters (reens)	Surface water	In and around CL-26	Hydrostatic pressure of saline aquifer near base of Made Ground and lagoon wastes and land drainage. Band drains could create vertical pathways connecting the aquifer and surface waters.
CL-27			
Surface waters (reens)	Surface water	In and around CL-27	Saline groundwater aquifer may connect surface waters via band drains and piles.

11.6.3 The magnitude of impact and significance of effects during permanent land take is presented in Table 11.12

Table 11.12: Magnitude of Impacts and Significance of Effects - Permanent Land Take

Receptor Name	Potential Effects	Magnitude of Impacts	Potential Significance of Effect
Solid geology	Loss of exposures Alteration of rock properties following excavation, leading to changes in the hydrogeological regime/stability condition. Formation of new exposures providing overall increase in rock exposure.	Negligible (beneficial)	Neutral
Superficial geology	Ground instability - excessive settlement.	Minor (adverse)	Slight (adverse)
Topsoils and subsoils	Topsoil stripping and loss of local seed bank and potential creation of pathways for contamination migration.	Minor (adverse)	Slight (adverse)
Aquifers (superficial and bedrock)	Migration of contaminants in soil and perched groundwater into aquifer.	Minor to Moderate (adverse)	Neutral to moderate (adverse)*
Surface waters (reens, rivers and road drainage)	Migration of contaminants in soil/perched groundwater and surface water runoff into surface waters.	Moderate (adverse)	Slight (adverse) to large (adverse)*
Specific Areas of Potentials Land Contamination			
CL-6			
Surface waters (reens)	Contaminants in the aquifer have the potential to connect to perched groundwater (and surface waters) via band drains.	Moderate (adverse)	Large (adverse)
CL-17			
Surface waters (reens)	Hydrostatic pressure of aquifer near base of Made Ground may connect he aquifer and perched groundwaters through piling.	Moderate (adverse)	Large (adverse)
CL-26			
Surface waters (reens)	Migration of contaminants in lagoon wastes, treated materials, soils and	Major (adverse)	Very large (adverse)

Receptor Name	Potential Effects	Magnitude of Impacts	Potential Significance of Effect
	waters entering into surface water.		
CL-27			
Surface waters (reens)	Saline groundwater aquifer may connect surface waters via band drains and piles.	Moderate (adverse)	Large (adverse)

*This receptors sensitivity varies along the length of the new section of motorway.

11.6.4 Over half of the route alignment would cross many brownfield sites and previously developed land such as Tata Steelworks, Newport Docks, industrial estates and existing paved areas. In many of these areas, topsoil is absent and thus the potential impact of topsoil loss would be limited to greenfield areas such as farmland in the Gwent Levels and around Magor and Castleton.

Complementary Measures

11.6.5 The extent of Complementary Measures is described in Chapter 2: Scheme Description. These works, including reclassification of the existing M4 would be within the footprint of the existing highway. Taking into account the nature and scale of the works proposed, there would be no significant predicted effects on geology and soils arising from the implementation of complementary measures.

11.7 Assessment of Potential Construction Effects

Proposed New Section of Motorway

11.7.1 In order to assess the potential environmental effects on the geology and soils along the new section of motorway as a result of construction, it is first necessary to identify the geology and soils receptors and their sensitivity. Table 11.13 below sets out the sensitive receptors during construction.

11.7.2 Of the 27 known or potential land contamination areas, there are some where the identified effect or magnitude of impact differs from those general impacts and effects which may be expected across the new section of motorway. Therefore the receptor sensitivity for these specific areas has also been listed in Table 11.13.

11.7.3 The potential impacts and effects on these receptors are also identified in Tables 11.14 and 11.15 below, in addition to the general impacts and effects.

Table 11.13: Sensitive Receptors during Construction

Receptor Name	Receptor Type	Receptor Location	Sensitivity
Topsoils and subsoils	Topsoils and subsoils	Adjacent to carriageway through new section of motorway	Medium
Aquifers (superficial and bedrock)	Groundwater	Beneath the new section of motorway.	Low to medium *
Surface waters (reens and rivers)	Surface water	Within and adjacent to new section of motorway	Low to very high *

Receptor Name	Receptor Type	Receptor Location	Sensitivity
Adjacent site users	Human	Adjacent to carriageway through new section of motorway	Very high
Construction workers	Human	Construction works area including temporary land take	High
Specific Areas of Potential Land Contamination			
CL-6			
Surface waters (reens)	Surface water	In and around CL-6	Very high
CL-13			
Construction workers	Human	Construction works area within CL-13	High
Surface waters (River Ebbw)	Surface water	In and around CL-13	High
Aquifers (superficial and bedrock)	Groundwater	Beneath and around CL-13	Medium
CL-14			
Construction workers	Human	Construction works area within CL-14	High
CL-17			
Construction workers	Human	Construction works area within CL-17	High
Adjacent site users	Human	Adjacent to construction works area	Very high
Surface waters (reens)	Surface water	In and around CL-17	Very high
Aquifers (superficial and bedrock)	Groundwater	Beneath and around CL-17	Low
CL-18			
Surface waters (River Usk)	Surface water	In and around CL-18	Very high
Construction workers	Human	Construction works area within CL-18	High
CL-26			
Construction workers	Human	Construction works area within CL-26	High
Adjacent site users	Human	Adjacent to construction works in CL-26	Very high
Surface waters (reens)	Surface water	In and around CL-26	Very high
Aquifers (superficial and bedrock)	Groundwater	Beneath and around CL-26	Low
CL-27			
Surface waters (reens)	Surface water	In and around CL-27	Very high

* This receptor's sensitivity varies along the length of the new section of motorway.

11.7.4 Table 11.14 characterises the potential impacts that may occur as a result of the construction of the new section of motorway on geology and soils receptors.

Table 11.14: Potential Impacts on Geology and Soils during Construction

Receptor Name	Receptor Type	Receptor Location	Potential Impacts
Topsoils and subsoils	Topsoils and subsoils	Adjacent to carriageway through new section of motorway	Topsoil loss from stripping and associated loss of local seed bank. Uncontrolled surface runoff during construction and erosion of topsoil.
Construction workers	Human	Construction works area throughout new section of motorway	Adverse health effects as a result of exposure to contamination through dermal contact, ingestion and inhalation of contaminated soil/soil derived dust. Ground gas migration and inhalation of gases / explosion.
Construction workers	Human	Wentlooge and Caldicot Levels	Explosion from ground gas build up in confined space and during piling and band drain installation.
Construction workers	Human	Construction works area	Explosion from buried, unidentified unexploded ordnance.
Adjacent land users including general public	Human	Land adjacent to the new section of motorway	Explosion from buried, unidentified unexploded ordnance.
Construction workers and adjacent site users	Human	Magor Interchange	Collapse of potential dissolution features.
Aquifers (superficial and bedrock)	Ground water	Beneath the new section of motorway	Migration of contaminants in soil and perched groundwater. Piling and band drain installation may increase this risk.
Surface waters (reens and rivers)	Surface water	Within and adjacent to new section of motorway	Migration of contaminants in soil and perched groundwater and runoff into surface water.
Surface waters (reens and rivers)	Surface water	Within and adjacent to new section of motorway	Piling and band drain installation allowing saline groundwater or contaminated groundwater entering surface water.
Construction workers and adjacent land users including general public	Human	Adjacent to carriageway through new section of motorway	Adverse health effects as a result of exposure to contamination through dermal contact, ingestion and inhalation of contaminated soil derived dust. Ground gas migration and inhalation of gases/explosion.
Surface waters (reens)	Surface water	In and around potential contaminant source areas	Contaminants in perched groundwater and leaching of contaminants from Made Ground migrating into surface waters. Piling and band drain installation may increase this risk.
Effects from Specific Areas of Potential Land Contamination			
CL-6			
Surface waters (reens)	Surface water	In and around potential contamination source area	Contaminants in the aquifer have the potential to connect to perched groundwater (and surface waters) during band drain installation.

Receptor Name	Receptor Type	Receptor Location	Potential Impacts
CL-13			
Construction workers	Human	Construction works area	Exposure to waste / Made Ground with potentially elevated levels of soil contamination and asbestos. Inhalation of ground gases with elevated concentrations.
Surface waters (River Ebbw)	Surface water	In and around CL-13	Contaminants in perched groundwater and leaching of contaminants from Made Ground migrating into surface waters. Piling and band drain installation may increase this risk.
Aquifers (superficial and bedrock)	Groundwater	Beneath and around CL-13	Installation of piles and band drains may create pathways connecting the impacted perched groundwaters and aquifer.
CL-14			
Construction workers	Human	Construction works area	Exposure to Made Ground with elevated levels of contamination and visual/olfactory evidence of hydrocarbons.
CL-17			
Construction workers	Human	Construction works area	Exposure to widespread soil contamination. Exposure to ground gas.
Construction workers and adjacent land users including general public	Human	Adjacent construction works area	Exposure to contaminated soil derived dusts.
Surface waters (reens)	Surface water	In and around CL-17	Contaminants in perched groundwater and leaching of contaminants from Made Ground migrating into surface waters. Piling and band drain installation may increase this risk.
Aquifers (superficial and bedrock)	Groundwater	Beneath and around CL-17	Migration of contamination within Made Ground and perched groundwater during piling.
CL-18			
Construction workers	Human	Construction works area within CL-18	Exposure to groundwater contamination.
Surface waters (River Usk)	Surface water	In and around CL-18	Contaminants in groundwaters potentially mobilised during dewatering impacting upon surface waters.
CL-26			
Construction worker	Human	Constructions works area within CL-26	Exposure to contaminants in soils and waters and ground gases
Adjacent site users	Human	Adjacent to construction works in CL-26	Exposure to contaminated soil derived dusts and ground gases

Receptor Name	Receptor Type	Receptor Location	Potential Impacts
Surface waters (reens)	Surface water	In and around CL-26	Migration of contaminants in lagoon wastes, soils and waters entering into surface waters.
Aquifers (superficial and bedrock)	Groundwater	Beneath and around CL-26	Migration of contaminants in lagoon wastes, soils and waters entering aquifer
CL-27			
Surface waters (reens)	Surface water	In and around CL-27	Contaminants in perched groundwater and leaching of contaminants from Made Ground migrating into surface waters. Saline groundwater aquifer may connect surface waters via band drains and piles.

11.7.5 The magnitude of impact during construction is presented in Table 11.15.

Table 11.15: Magnitude of Impacts and Significance of Effects during Construction

Receptor Name	Potential Effects	Magnitude of Impacts	Potential Significance of Effect
Topsoils and subsoils	Topsoil stripping and loss of local seed bank. Uncontrolled run off and soils erosion.	Minor (adverse)	Slight (adverse)
Construction workers	Collapse of potential dissolution features.	Major (adverse)	Large (adverse)
Construction workers	Explosion from unidentified unexploded ordnance during construction.	Major (adverse)	Very large (adverse)
Adjacent land users including general public	Explosion from unidentified unexploded ordnance during construction.	Major (adverse)	Very large (adverse)
Construction workers and adjacent land users including general public	Exposure through dermal contact, ingestion and inhalation of contaminated soil derived dusts.	Minor (adverse)	Moderate (adverse)
Construction workers	Explosion or inhalation of ground gases.	Major (adverse)	Large (adverse)
Aquifers (superficial and bedrock)	Migration of contaminants in soils and perched groundwater through creation of new pathways including band drains and piling.	Moderate (adverse)	Slight to moderate (adverse)*
Surface waters (reens and rivers)	Migration of contaminants in soils and perched groundwater and surface water runoff into surface waters.	Moderate (adverse)	Slight (adverse) to large (adverse)*
Surface waters (reens and rivers)	Piling and band drain installation allowing saline intrusion or contaminated groundwater entering surface waters.	Moderate (adverse)	Slight (adverse) to large (adverse)*

Receptor Name	Potential Effects	Magnitude of Impacts	Potential Significance of Effect
Specific Areas of Potential Land Contamination			
CL-6			
Surface waters (reens)	Contaminants in the aquifer have the potential to connect to perched groundwater (and surface waters) during band drain installation.	Moderate (adverse)	Large (adverse)
CL-13			
Construction workers	Exposure to waste / Made Ground with potentially elevated levels of contamination and asbestos. Inhalation of ground gases with elevated concentrations.	Major (adverse)	Large (adverse)
Surface waters (River Ebbw)	Contaminants in perched water and soils migrating into surface water.	Moderate (adverse)	Moderate (adverse)
Aquifers (superficial and bedrock)	Piling and band drains may create pathways connecting the impacted perched groundwaters and aquifer.	Moderate (adverse)	Moderate (adverse)
CL-14			
Construction workers	Exposure to Made Ground with elevated levels of contamination and visual / olfactory evidence of hydrocarbons.	Moderate (adverse)	Moderate (adverse)
CL-17			
Construction workers	Widespread elevated soil contamination and ground gases.	Major (adverse)	Large (adverse)
Construction workers and adjacent land users including general public	Exposure to contaminated soil derived dusts.	Major (adverse)	Very large (adverse)
Surface waters (reens)	Contaminants in perched groundwater and leaching of contaminants from Made Ground migrating into surface waters. Piling and band drain installation may increase the risk.	Moderate (adverse)	Large (adverse)
Aquifers (superficial and bedrock)	Migration of contamination within Made Ground and perched groundwater during piling into aquifer.	Moderate (adverse)	Slight (adverse)
CL-18			
Construction workers	Exposure to groundwater contamination.	Major (adverse)	Large (adverse)
Surface waters (River Usk)	Contaminants in groundwaters potentially mobilised during dewatering impacting upon surface waters.	Moderate (adverse)	Large (adverse)
CL-26			
Construction worker	Exposure to contaminants in soils and waters and ground gases	Major (adverse)	Large (adverse)
Adjacent site users	Exposure to contaminated dusts.	Moderate (adverse)	Large (adverse)
Surface waters (reens)	Migration of contaminants in lagoon wastes, soils and waters entering into surface waters.	Major (adverse)	Very large (adverse)

Receptor Name	Potential Effects	Magnitude of Impacts	Potential Significance of Effect
Aquifers (superficial and bedrock)	Migration of contaminants in lagoon wastes, soils and waters entering aquifer.	Moderate (adverse)	Slight (adverse)
CL-27			
Surface waters (reens)	Contaminants in perched groundwater and leaching of contaminants from Made Ground migrating into surface waters. Saline groundwater aquifer may connect surface waters via band drains and piles.	Moderate (adverse)	Large (adverse)

*This receptor's sensitivity varies along the length of the new section of motorway

Complementary Measures

11.7.6 The extent of Complementary Measures is described in Chapter 2: Scheme Description. These works, including reclassification of the existing M4 would be within the footprint of the existing highway. Taking into account the nature and scale of the works proposed, there would be no significant predicted effects on geology and soils arising from the implementation of complementary measures.

11.8 Assessment of Potential Operational Effects

Proposed New Section of Motorway

11.8.1 The sensitivity of the geology and soils receptors is in line with those identified within the construction effects assessment with the addition of motorway end users / maintenance worker receptors. These are set out in Table 11.16.

Table 11.16: Sensitive Receptors during Operation

Receptor Name	Receptor Type	Receptor Location	Sensitivity
End users (motorists) and maintenance workers	Human	Carriageway and adjacent areas through new section of motorway	High

11.8.2 Table 11.17 characterises the potential impacts that may occur as a result of the operation of the new section of motorway on geology and soils receptors.

11.8.3 Where potential effects on receptors have been identified that are related to areas of known or potential land contamination, an assessment of potential effects has been undertaken.

Table 11.17: Potential Impacts on Geology and Soils during Operation

Receptor Name	Receptor Type	Receptor Location	Potential Effects
Topsoils and subsoils	Topsoils and subsoils	Throughout the new section of motorway	Pollution of soils immediately adjacent to carriageway due to traffic spray/airborne pollutants
Adjacent land users including general public	Human health	Adjacent to carriageway through new section of motorway	Exposure through dermal contact, ingestion and inhalation of contaminated soil derived dusts. Ground gas migration and inhalation of gases.
End users and maintenance workers	Human health	On and adjacent to the carriageway through the new section of motorway	Exposure through dermal contact, ingestion and inhalation of contaminated soils and dusts. Ground gas migration and inhalation of gases.
End users, adjacent site users and maintenance workers	Human health	Wenlooge and Caldicot Levels	Explosion or inhalation of ground gases.
Surface waters (reens, rivers and road drainage)	Surface water	Within and adjacent to new section of motorway	Pollution from surface water runoff, accidental spillages.
Groundwaters	Groundwater	Beneath the new section of motorway	Pollution from surface water runoff, accidental spillages.
Surface waters (reens)	Surface water	Surface/waters and reens adjacent and near areas where band drains are proposed within TFD	Hydrostatic pressure of saline aquifer may mean band drains create vertical pathways connecting shallow groundwater and ultimately surface waters.
Specific Areas of Potential Land Contamination			
CL-6			
Surface waters (reens)	Surface water	In and around potential contamination source area	Contaminants in the aquifer have the potential to connect to perched groundwater (and surface waters) during band drain installation.
CL-13			
End users, adjacent site users and maintenance workers	Human health	Within and adjacent to the new section of motorway	Explosion or inhalation of ground gases.
Surface waters (River Ebbw)	Surface water	In and around CL-13	Impacted perched groundwaters / leachate may be intercepted by the land drainage ultimately discharging to the River Ebbw.

Receptor Name	Receptor Type	Receptor Location	Potential Effects
CL-15			
End users, adjacent site users and maintenance workers	Human health	Within and adjacent to the new section of motorway	Explosion or inhalation of ground gases.
CL-17			
Maintenance workers	Human	Outside pier / embankment footprints	Exposure to elevated soil contamination from Made Ground remaining on site.
End users and maintenance workers	Human health	On and adjacent to the carriageway through the new section of motorway	Exposure through dermal contact, ingestion and inhalation of contaminated soils and dusts. Ground gas migration and inhalation of gases.
Surface waters (reens)	Surface water	In and around CL-17	Hydrostatic pressure of aquifer near base of Made Ground may connect the aquifer and perched groundwaters through piling.
Aquifers (superficial and bedrock)	Groundwater	Beneath and around CL-17	New pathways may connect impacted soils and perched groundwaters to aquifers through piling.
CL-26			
Surface waters (reens)	Surface water	In and around CL-26	Hydrostatic pressure of aquifer potentially near base of Made Ground and lagoon wastes and land drainage. Band drains could create vertical pathways connecting the aquifer and surface waters.
Aquifers (superficial and bedrock)	Groundwater	Beneath and around CL-26	New pathways may connect impacted soils and perched groundwaters to aquifers through piling.
End users and maintenance workers	Human health	On and adjacent to the carriageway through the new section of motorway	Exposure through dermal contact, ingestion and inhalation of contaminated soils and dusts. Ground gas migration and inhalation of gases.
CL-27			
Surface waters (reens)	Surface water	In and around CL-27	Saline groundwater aquifer may connect surface waters via band drains and piles.

11.8.4 The magnitude of impact and significance of effect during operation is presented in Table 11.18.

Table 11.18: Magnitude of Impacts and Significance of Effects during Operation

Receptor Name	Potential Effects	Magnitude of Impacts	Potential Significance of Effect
Topsoils and subsoils	Pollution of soils immediately adjacent to carriageway due to traffic spray/airborne pollutants.	Negligible (adverse)	Slight (adverse)
Adjacent land users including general public	Exposure through dermal contact, ingestion and inhalation of contaminated dusts. Ground gas migration and inhalation of gases.	Negligible (adverse)	Slight (adverse)
End users and maintenance workers	Exposure through dermal contact, ingestion and inhalation of contaminated soils and dusts. Ground gas migration and inhalation of gases.	Negligible (adverse)	Slight (adverse)
End users, adjacent site users and maintenance workers	Explosion or inhalation of ground gases.	Negligible (adverse)	Slight (adverse)
Surface Waters (reens and rivers)	Pollution from surface water runoff, accidental spillages.	Negligible (adverse)	Slight (adverse)
Aquifers	Pollution from surface water runoff, accidental spillages.	Negligible (adverse)	Slight (adverse)
Specific Areas of Potential Land Contamination			
CL-6			
Surface waters (reens)	Contaminants in the aquifer have the potential to connect to perched groundwater (and surface waters) via band drains.	Moderate (adverse)	Large (adverse)
CL-13			
Surface waters (River Ebbw)	Impacted perched groundwaters / leachate may be intercepted by the land drainage ultimately discharging to the River Ebbw.	Moderate (adverse)	Moderate (adverse)
End users, maintenance workers and adjacent site users	Exposure through dermal contact, ingestion and inhalation of contaminated soils and dusts. Ground gas migration and inhalation of gases.	Minor (adverse)	Moderate (adverse)
CL-17			
Maintenance workers	Exposure to elevated soils contamination from Made Ground remaining on site.	Moderate (adverse)	Moderate (adverse)

Receptor Name	Potential Effects	Magnitude of Impacts	Potential Significance of Effect
Surface waters (reens)	Hydrostatic pressure of aquifer near base of Made Ground may connect the aquifer and perched groundwaters through piling.	Moderate (adverse)	Large (adverse)
Aquifers (superficial and bedrock)	Contaminants within Made Ground and perched groundwaters migrating into aquifer via piles.	Moderate (adverse)	Slight (adverse)
End users	Exposure through dermal contact, ingestion and inhalation of contaminated soils and dusts. Ground gas migration and inhalation of gases.	Minor (adverse)	Moderate (adverse)
CL 26			
Surface waters (reens)	Migration of contaminants in lagoon wastes, treated materials, soils and waters entering into surface water.	Major (adverse)	Very large (adverse)
Aquifers (superficial and bedrock)	Migration of contaminants in lagoon wastes, treated materials, soils and waters entering into aquifer.	Moderate (adverse)	Slight (adverse)
End users and maintenance workers	Exposure through dermal contact, ingestion and inhalation of contaminated soils and dusts. Ground gas migration and inhalation of gases.	Minor (adverse)	Moderate (adverse)
CL-27			
Surface waters (reens)	Saline groundwater aquifer may connect surface waters via band drains and piles.	Moderate (adverse)	Large (adverse)

Complementary Measures

11.8.5 The extent of Complementary Measures is described in Chapter 2: Scheme Description. These works, including reclassification of the existing M4 would be within the footprint of the existing highway. Taking into account the nature and scale of the works proposed, there would be no significant predicted effects on geology and soils arising from the implementation of complementary measures.

11.9 Additional Mitigation and Monitoring

11.9.1 The assessment of the potential significance of effects on the geology and soils along the length of the new section of motorway has shown that there would potentially be a number of effects requiring mitigation measures to lessen and potentially avoid these effects.

11.9.2 The following section sets out the proposed mitigation measures to lessen the environmental impacts on geology and soils.

Land Take Mitigation

11.9.3 The impact of loss of topsoil within the permanent land take area would be mitigated through the following measures.

- Topsoil would be stockpiled wherever possible prior to main construction works commencing to enable reuse.
- Topsoil would be carefully, temporarily stockpiled and managed during construction to minimise topsoil quality deterioration and loss whilst stockpiled.
- Topsoil would be reused within the Scheme subject to compliance with reuse criteria, to achieve the landscape design (see Chapter 9 of this ES: Landscape and Visual). The reuse of topsoil would enable the natural seed bank to be maintained rather than importing new materials.
- A Soil Handling Methodology would be prepared for the new section of motorway which would identify the methods for stripping, handling, storage and replacement of soils taking into account current good practice guidance.

11.9.4 Further information of the mitigation and management of soils on agricultural land including the Soil Handling Methodology is provided in Chapter 15 of the ES: Community and Private Assets. This would be incorporated within the CEMP to be managed by the main contractor in accordance with ISO14001 part of the Environmental Management System (EMS). Further details of the proposed measures are provided in the Pre-CEMP at Appendix 3.2 which would be updated prior to construction. Full details the Environmental Management for the Scheme are provided within Chapter 18: Environment Management.

11.9.5 Mitigation of the potential effects of land contamination will be implemented through a remediation strategy and the details of which are set out in the Outline Remediation Strategy Report (Appendix 11.2). Further details of the remediation design, remediation strategy and Pre-CEMP is described in the Construction Mitigation section of this ES chapter.

Construction Mitigation - General Approach

11.9.6 The following mitigation measures would be followed to minimise the potential for adverse effects on geology and soils during the construction phase. Wherever possible, adverse effects would be minimised through further detailed design prior to construction. Where mitigation is not possible, then controls would be put in place during construction (and the operational phase) to ensure appropriate management of the potential adverse effect.

Geology and Soils

11.9.7 The general approach to the mitigation of construction impacts on geology and soils would be as follows.

- Reduce the loss of soil and geological resources, whilst at the same time enabling investigation and study of the resource over the longer term.
- Use of controlled cut techniques to minimise alteration of rock properties.
- Remove scree slopes/vegetation from old rock cut areas to uncover new rock exposures.

- Careful management, stockpiling and reuse of topsoils and subsoils.

Land Contamination

11.9.8 The general approach to the mitigation of construction impacts from contamination by the contractor would include the following.

- Avoid the mobilisation and spread of potential contaminants in soils and waters during construction.
- Treatment of known areas of contamination causing a potential risk to receptors.
- Use of guidance such as the Environment Agency's Pollution Prevention Guidelines (PPG) (in particular PPG1, PPG5, PPG6, PPG21) as sources of good practice. These guidance documents although formally withdrawn on 17th December 2015 include recommendations regarding use of fuel spill kits and safe storage requirements. The application of appropriate working methods developed using these guidance documents would be used to mitigate against potential human health and controlled water contaminant linkages being created during construction.
- Good working practices would be applied, e.g. damping down of dust during dry conditions to prevent exposure to workers and off-site dispersion, good hygiene to be adopted by construction workers and use of appropriate Personal Protective Equipment (PPE).
- Pollution risks from the storage of fuel for plant and machinery as well as leaks and spillages would be addressed with the adoption of appropriate method statements and working practices.
- Controls for dealing with previously unidentified or unexpected contamination.

Construction Mitigation - Specific Approach

11.9.9 Prior to construction, the following assessments and plans would be undertaken and prepared to refine the design and mitigation measures.

Geology and Soils

11.9.10 The use of band drains and piles within areas of potential land contamination would be subject to site specific piling risk assessments in line with NRW guidance (EA, 2001) and may require the use of additional control measures such as clean drilling techniques particularly in any potential areas of land contamination. Where contamination risks are considered high, band drains would not be installed through contaminated soils for instance at the Tata lagoons area.

11.9.11 Soil erosion may be encountered in deep cuttings during formation works as a consequence of groundwater seepage and silt/fine sand content of the soil strata. Residual instability following construction would be mitigated by installation of deep drainage trenches to lower groundwater and inhibit seepage, and placement or erosion protection matting at specified locations.

11.9.12 All cut and fill slope would require stability assessments.

11.9.13 Implementation of a discovery strategy would ensure appropriate mitigation of risks in the event that dissolution features are encountered during construction works in the eastern part of the new section of motorway.

Land Contamination Management and Remediation Strategy

11.9.14 The assessments have identified a number of sites that have or could have contaminated soils or groundwater and soils that are known to generate ground gas that would be affected by the Scheme. Potential contaminant linkages and potential risks have been identified to controlled waters, construction workers and the general public during and post construction and future maintenance workers at some of the sites. Further action would be undertaken by the contractor to minimise the risks and undertake remediation as necessary. The overarching philosophy and regulatory mechanisms of the management of land contamination in relation to the Scheme is set out within the Land Contamination Management Strategy provided in Appendix 11.3. This has been agreed with NRW, MCC and NCC.

11.9.15 An outline remediation strategy has been prepared using guidance within CLR-11 Model Procedures for the Management of Land Contamination (Environment Agency and Defra, 2004). The outline strategy is provided in Appendix 11.2. Prior to construction the remediation strategy would be agreed with NRW, MCC and NCC.

11.9.16 Further ground investigation would be undertaken at some of the potential land contamination source areas. The data from the ground investigation would be used to further refine the potential risks and the design of any remediation required. The remediation strategy would be prepared and implemented to reduce potential and identified risks from land contamination to tolerable risk levels both during construction and also during operation (including permanent land take). As a minimum, the remediation strategy would ensure that, following construction, the permanent land take area could not meet the definition of Contaminated Land under Part IIA of the Environment Act 1990.

11.9.17 The remediation strategy would include the following.

- A Remedial Options Appraisal, which would consider the most appropriate remediation option to break each identified contaminant linkage.
- A Remediation Implementation Plan that sets out the objectives and requirements of the remediation to be undertaken.
- A Remediation Verification Plan that sets out the 'lines of evidence' to be gathered during remediation to demonstrate that the remediation objectives are achieved.

11.9.18 The remediation strategy would include information on procedures, controls and requirements to be followed during the management of contaminated materials during construction including the following.

- Dealing with previously unidentified or unexpected contamination.
- Verification, inspection, sampling and analysis to confirm expected contamination and ground conditions.
- Verification, inspection, sampling and analysis to enable material arisings to be checked for suitability for reuse with or without treatment.

- Methodologies for the treatment, handling, stockpiling and reusing of contaminated materials.
- Control measures to prevent risks to prevent identified risks to construction workers and general public during construction.
- Design and implementation of groundwater and surface water monitoring programme pre- and post- construction.
- Piling risk assessment (with specific reference to the EA guidance piling into contaminated sites) and control measures to be adopted during piling and band drain installation to mitigate any unacceptable risks to controlled waters.
- Detailed ground gas risk assessment and gas control measures needed during construction and, if required, during operation.
- Detailed dewatering risk assessment and control measures.

11.9.19 The majority of identified potential land contamination source sites and areas outside these sites within the permanent and temporary land take would not require specific remediation. Rather the contaminated soils and waters in the permanent and temporary land take area would be managed through the implementation of the Remediation Strategy Report and the Materials Management Plan as well as general compliance with the Health and Safety at Work Act 1974 and associated regulations.

11.9.20 An Outline Remediation Strategy has been prepared and is included in Appendix 11.2. This would be developed further following the outcome of the additional ground investigation and during detailed design. The final remediation strategy would be agreed with NRW, MCC and NCC prior to the construction phase commencing and would be described in the Remediation Strategy Report. Specific remediation would be required at CL-26 (Llanwern Steelworks) to deal with contaminated materials and wastes which are present within the permanent and temporary land take area. The remediation would also be designed and undertaken to facilitate partial surrender of the existing environmental permits at Llanwern Steelworks. Similarly, the remediation design would also enable modification or surrender of other environmental permits shown on Figure 11.2 affected by the new section of motorway.

Land Contamination Remediation Design

11.9.21 If contaminated materials cannot be treated on site they would be disposed of off-site to a suitably licensed disposal facility, However, it is not anticipated that large volumes of materials would require off-site disposal based upon the considerable amount of ground investigations undertaken to date.

11.9.22 Figures 16.6, 16.7, 16.8 and 16.9 of this ES provide information on the preliminary conceptual design of the embankment wherein potentially contaminated and contaminated materials would be used as part of general embankment fill subject to complying with suitable for reuse criteria. The potential risk for contaminants to migrate from the motorway embankment core and pollute surface waters and groundwater has been assessed and is considered low. This is discussed in Chapter 16: Road Drainage and the Water Environment.

11.9.23 Suitability for reuse criteria for soils to be used as general embankment fill have been developed which would be used during the construction phase to determine

whether contaminated soils can be reused. The suitability for reuse criteria would be protective of both human health and the sensitive water environment of the Gwent Levels. Contaminated soils that fail the suitability for reuse criteria would require treatment or would be disposed of off site.

11.9.24 The design would be refined further following assessment of the additional ground investigation results and during detailed design and the remediation design would be agreed with the NRW, NCC and MCC, prior to construction.

11.9.25 The deep aquifer is identified to have elevated metals and inorganic contaminants which could reduce surface water quality during construction if the band drain/pile allow direct or indirect linkage. Groundwater controls would need to be put in place to collect any waters arising from band drains during construction to prevent pollution of any adjacent surface waters. Furthermore a piling risk assessment following NRW guidance would be undertaken to mitigate the potential impact of the band drains and sites to allow specific mitigation measures to be implemented.

11.9.26 The reuse of contaminated materials within the Scheme would be set out in, and managed by, the implementation of the Remediation Strategy and also the preparation and implementation of a Materials Management Plan (MMP), prepared in accordance with Definition of Waste: Development Industry Code of Practice (CL:AIRE, 2011). The Outline Remediation Strategy is provided at Appendix 11.2. An Outline Materials Management Plan has been prepared (Appendix 3.2) and is included within the Outline Remediation Strategy Report in Appendix 11.2 and would be developed further and then formally submitted to NRW prior to construction commencing.

11.9.27 Further detail of the reuse of materials is provided in Chapter 12 of this ES: Materials.

11.9.28 A UXO Mitigation Strategy would be developed using guidance within Unexploded Ordnance: A guide for the Construction Industry (CIRIA, 2009), to mitigate risks from unidentified unexploded ordnance. The UXO Mitigation Strategy would draw upon information from within the Explosive Ordnance Threat Assessment Report (Bactec, 2014).

Construction Environmental Management Plan (CEMP)

11.9.29 The Construction Environmental Management Plan (CEMP) would set out the environmental measures that would be adopted during the construction phase by the contractor. A Pre-Construction Environmental Management Plan (Pre-CEMP) is provided in Appendix 3.2 of this ES. The Pre-CEMP would be reviewed and updated by the contractor following detailed design such that appropriate environmental management controls and protocols are in place prior to construction. The CEMP would include controls to be adopted by the contractor during construction that would mitigate potential impacts associated with geology and soils, as well as topsoil and land contamination management. The CEMP would incorporate controls set out in the following documents.

- Soil Handling Methodology Report.
- Remediation Strategy Report, including Materials Management Plan.
- Pollution and Prevention Plan

- Groundwater and Surface Water Management Plan
- UXO Mitigation Strategy Report.

11.9.30 An Outline Remediation Strategy is contained within Appendix 11.2 of this ES. An Outline Pollution and Prevention Plan and Groundwater and Surface Water Management Plan have all been prepared and are contained within the Pre-CEMP (Appendix 3.2 of this ES). These outline plans would all be updated and agreed with NRW prior to construction.

Operational Mitigation

Mitigation of Potential Impacts on Geology and Soils

11.9.31 As set out in Section 11.5, the design includes appropriate mitigation measures in the form of suitable drainage systems with hydrocarbon interceptors to capture road runoff and prevent contamination of the surrounding environment.

11.9.32 The following additional mitigation measures are to be implemented during the operational phase.

- No confined spaces associated with the Scheme would be accessible to the public. Any maintenance workers entering into any confined spaces would require adoption and strict health and safety controls to comply with current health and safety legislation and guidance concerning entry into confined spaces.
- Monitoring of groundwater, surface waters and slope stability would continue for 5 years after the completion of construction.
- Routine maintenance and regular inspections of the slopes would continue for the lifetime of the new section of motorway.
- A remediation verification report would be produced upon completion of construction and this would include details and plans of where any contaminated, potentially contaminated and treated contaminated soils have been used in construction. Such information would be provided within the Health and Safety File which would be a reference document for designing future maintenance works so that adequate controls can be introduced to protect maintenance workers should they be deemed a requirement.

11.9.33 Mitigation of the potential effects from existing land contamination during the operational phase would be provided through the implementation of the remediation strategy.

11.10 Assessment of Land Take Effects

Proposed New Section of Motorway

11.10.1 On the basis of the mitigation measures discussed in Section 11.9, the magnitude of impacts and significance of the effects of land take following mitigation are summarised in Table 11.19.

Table 11.19: Magnitude of Impacts and Significance of the Land Take Effects Following Mitigation

Receptor Name	Effect Resulting from the Development of the Scheme	Magnitude of Impact following Mitigation	Significance of Effect following Mitigation
Solid geology	Loss of exposures. Alteration of rock properties following excavation, leading to changes in the hydrogeological regime/stability condition. Formation of new exposures, providing overall increase in rock exposure.	Negligible (beneficial)	Neutral
Superficial geology	Ground instability - excessive settlement.	Negligible (adverse)	Slight (adverse)
Topsoils and subsoils	Topsoil stripping and loss of local seed bank and potential creation of pathways for contamination migration.	Negligible (adverse)	Slight (adverse)
Aquifers (superficial and bedrock)	Migration of contaminants in soil / perched groundwater into aquifer.	Negligible (adverse)	Slight (adverse)
Surface waters (reens and rivers)	Migration of contaminants in soil / perched groundwater and surface water runoff into surface waters.	Negligible (adverse)	Slight (adverse)
Specific Areas of Potential Land Contamination			
CL-6			
Surface waters (reens)	Contaminants in the aquifer have the potential to connect to perched groundwater (and surface waters) via band drains.	Negligible (adverse)	Slight (adverse)
CL-17			
Surface waters (reens)	Hydrostatic pressure of aquifer near base of Made Ground may connect he aquifer and perched groundwaters through piling.	Negligible (adverse)	Slight (adverse)
CL-26			
Surface waters (reens)	Migration of contaminants in lagoon wastes, treated materials, soils and waters entering into surface water.	Negligible (adverse)	Slight (adverse)

Receptor Name	Effect Resulting from the Development of the Scheme	Magnitude of Impact following Mitigation	Significance of Effect following Mitigation
CL-27			
Surface waters (reens)	Saline groundwater aquifer may connect surface waters via band drains and piles.	Negligible (adverse)	Slight (adverse)

Complementary Measures

11.10.2 The extent of Complementary Measures is described in Chapter 2: Scheme Description. These works, including reclassification of the existing M4 would be within the footprint of the existing highway. Taking into account the nature and scale of the works proposed, there would be no significant predicted effects on geology and soils arising from the implementation of complementary measures.

11.11 Assessment of Construction Effects Following Mitigation

Proposed New Section of Motorway

11.11.1 On the basis of the mitigation measures discussed in Section 11.9, the magnitude of impacts and significance of the effects from construction following mitigation are summarised in Table 11.20.

Table 11.20: Magnitude of Impacts and Significance of the Construction Effects following Mitigation

Receptor Name	Effect Resulting from the Development of the Scheme	Magnitude of Impact following Mitigation	Significance of Effect following Mitigation
Topsoils and subsoils	Topsoil stripping and loss of local seed bank.	Negligible (adverse)	Neutral
Construction workers	Collapse of potential dissolution features.	Negligible (adverse)	Slight (adverse)
Construction workers	Explosion from unidentified unexploded ordnance.	Negligible (adverse)	Slight (adverse)
Adjacent land users including general public	Explosion from unidentified unexploded ordnance.	Negligible (adverse)	Slight (adverse)
Construction workers	Construction workers exposed through dermal contact, ingestion and inhalation of contaminated soil and soil derived dusts. Inhalation of vapours / gases.	Negligible (adverse)	Slight (adverse)
Construction workers	Explosion from ground gases on construction workers.	Negligible (adverse)	Slight (adverse)
Construction workers and adjacent land users including general public	Adjacent land users exposed through dermal contact, ingestion and inhalation of contaminated dusts.	Negligible (adverse)	Slight (adverse)

Receptor Name	Effect Resulting from the Development of the Scheme	Magnitude of Impact following Mitigation	Significance of Effect following Mitigation
Aquifers (superficial and bedrock)	Migration of contaminants in soils and perched groundwater to aquifer.	Negligible (adverse)	Slight (adverse)
Surface waters (reens, rivers and road drainage)	Migration of contaminants in soils and perched groundwater and surface water runoff into surface waters.	Negligible (adverse)	Slight (adverse)
Surface waters (reens and rivers)	Piling and band drain installation allowing saline intrusion or contaminated groundwater entering surface waters.	Negligible (adverse)	Slight (adverse)
CL-6			
Surface waters (reens)	Contaminants in aquifer have potential to connect to perched groundwaters (and surface waters) during band drain installation.	Negligible (adverse)	Slight (adverse)
CL-13			
Construction workers	Construction workers exposed to waste / Made Ground with potentially elevated levels of contamination and asbestos. Inhalation of ground gases with elevated concentrations.	Negligible (adverse)	Slight (adverse)
Surface waters (River Ebbw)	Impacted perched groundwaters / leachate may be intercepted but the land drainage ultimately discharging to the River Ebbw.	Minor (adverse)	Slight (adverse)
Aquifers (superficial and bedrock)	Piling and band drains may create pathways connecting the impacted perched groundwaters and aquifer.	Minor (adverse)	Slight (adverse)
CL-14			
Construction workers	Construction workers exposed to Made Ground with elevated levels of contamination and visual / olfactory evidence of hydrocarbons.	Negligible (adverse)	Slight (adverse)
CL-17			
Construction workers	Construction workers exposed to elevated soil contamination and ground gases.	Negligible (adverse)	Slight (adverse)
Construction workers and adjacent land users including general public	Construction workers and adjacent land users exposed to contaminated soil derived dusts.	Negligible (adverse)	Slight (adverse)
Surface waters (reens)	Contaminants in perched groundwater and leaching of contaminants from Made Ground migrating into surface waters. Band drains would not be installed through contaminated soils,	Negligible (adverse)	Slight (adverse)

Receptor Name	Effect Resulting from the Development of the Scheme	Magnitude of Impact following Mitigation	Significance of Effect following Mitigation
Aquifers (superficial and bedrock)	Migration of contamination within Made Ground and perched groundwater during piling to aquifer.	Minor (adverse)	Slight (adverse)
CL-18			
Construction workers	Construction workers exposed to groundwater contamination.	Negligible (adverse)	Slight (adverse)
Surface waters (reens)	Contamination in groundwater potentially mobilised during dewatering impacting upon surface waters.	Negligible (adverse)	Slight (adverse)
CL-26			
Construction workers	Construction workers exposed to contaminants in soils and waters.	Negligible (adverse)	Slight (adverse)
Adjacent site users	Adjacent site users exposed to contaminated dusts.	Negligible (adverse)	Slight (adverse)
Surface waters (reens)	Migration of contaminants in lagoon waste, soils and waters entering surface waters. Band drains would not be installed through contaminated soils,	Minor (adverse)	Moderate (adverse)
Aquifers (superficial and bedrock)	Migration of contaminants in lagoon wastes, soils and waters entering aquifer.	Minor (adverse)	Neutral
CL-27			
Surface waters (reens)	Contaminants in perched groundwater and leaching of contaminants from Made Ground migrating into surface waters. Saline groundwater aquifer may connect surface waters via band drains and piles.	Negligible (adverse)	Slight (adverse)

Complementary Measures

11.11.2 The extent of Complementary Measures is described in Chapter 2: Scheme Description. These works, including reclassification of the existing M4 would be within the footprint of the existing highway. Furthermore, the procedures described in the Remediation Strategy Report would be followed in the unlikely event that unexpected land contamination is identified during construction.

11.11.3 Taking into account the nature and scale of the works proposed, there would be no significant predicted effects on geology and soils arising from the implementation of Complementary Measures.

11.12 Assessment of Operational Effects

Proposed New Section of Motorway

11.12.1 On the basis of the mitigation measures discussed in Section 11.9, the magnitude of impacts and significance of the adverse effects during operation following mitigation are summarised in Table 11.21.

11.12.2 Mitigation measures also employed during the construction phase would ensure materials left *in situ* / reused within the Scheme are suitable for use and would not pose unacceptable risk to human health or the environment during the operational phase. This would be achieved through the implementation of the Remediation Strategy and Materials Management Plan as set out in Section 11.9.

Table 11.21: Magnitude of Impacts and Significance of the Operational Effects following Mitigation

Receptor Name	Effect Resulting from the Development of the Scheme	Magnitude of Impact following Mitigation	Significance of Effect following Mitigation
Topsoils and subsoils	Pollution of soils immediately adjacent to carriageway due to traffic spray/airborne pollutants.	Negligible (adverse)	Neutral
Adjacent land users including general public	Adjacent land users exposed to contaminated soil derived dusts and inhalation of ground gases.	Negligible (beneficial)	Slight (beneficial)
End users and maintenance workers	End users and maintenance workers exposed to contaminated soils and soil derived dusts and inhalation of ground gases.	Negligible (beneficial)	Slight (beneficial)
End users, adjacent site users and maintenance workers	Explosion of ground gases for end users and maintenance workers.	Negligible (adverse)	Slight (adverse)
Surface waters (reens and rivers).	Pollution of surface waters from surface water runoff, accidental spillages.	Negligible (adverse)	Slight (adverse)
Aquifers	Pollution of groundwaters from surface water runoff, accidental spillages	Negligible (adverse)	Neutral
CL-6			
Surface waters (reens)	Contaminants in the aquifer have the potential to connect to perched groundwater (and surface waters) via band drains.	Negligible (adverse)	Slight (adverse)
CL-13			
Surface waters (River Ebbw)	Impacted perched groundwaters/leachate may be intercepted by the land drainage ultimately discharging to the River Ebbw.	Negligible (adverse)	Slight (adverse)
End users and maintenance workers	End users and maintenance workers exposed through dermal contact, ingestion and inhalation of contaminated soils/soil derived dusts.	Negligible (beneficial)	Slight (beneficial)

Receptor Name	Effect Resulting from the Development of the Scheme	Magnitude of Impact following Mitigation	Significance of Effect following Mitigation
CL-17			
Maintenance workers	Maintenance workers exposed to elevated soil contamination within Made Ground remaining on site.	Negligible (adverse)	Slight (adverse)
Surface waters (reens)	Potentially impacted aquifer connecting perched groundwaters via piling and migration to surface waters.	Negligible (adverse)	Slight (adverse)
Aquifers (superficial and bedrock)	Elevated contamination within Made Ground and perched groundwaters connecting to aquifer via piles.	Negligible (adverse)	Neutral
End users	End users exposed through dermal contact, ingestion and inhalation of contaminated soils and soil derived dusts. Ground gas migration and inhalation of gases.	Negligible (beneficial)	Slight (beneficial)
CL-26			
Surface waters (reens)	Migration of contaminants in lagoon waste, treated materials, soils and waters entering surface water.	Negligible (adverse)	Slight (adverse)
Aquifers (superficial and bedrock)	Migration of contaminants in lagoon waste, treated materials, soils and waters entering aquifer. Band drains would not be installed through contaminated soils.	Negligible (adverse)	Slight (adverse)
End users and maintenance workers	Exposure through dermal contact, ingestion and inhalation of contaminations, soils and soil derived dusts. Ground gas migration and inhalation of gases	Negligible (beneficial)	Slight (beneficial)
CL-27			
Surface waters (reens)	Saline groundwater aquifer may connect surface waters via band drains and piles.	Negligible (adverse)	Slight (adverse)

Complementary Measures

11.12.3 The extent of Complementary Measures is described in Chapter 2: Scheme Description. These works, including reclassification of the existing M4 would be within the footprint of the existing highway. Therefore, it is assessed that there would be no significant effects on geology and soils arising from the implementation of complementary measures. Furthermore, the procedures described in the Remediation Strategy would be followed in the unlikely event that unexpected land contamination is identified during construction. This would effectively mitigate any operational effects.

11.13 Assessment of Cumulative Effects

11.13.1 The assessment of cumulative effects with other proposed developments is provided in Chapter 17 of this ES.

11.14 Inter-relationships

11.14.1 This chapter assesses the significance of effects on geology and soils. Other potential impacts on the water environment are considered within Chapter 16: Road Drainage and the Water Environment, which provides a detailed assessment of the baseline water environment conditions. The sensitivity of the surface water and groundwater receptors used within this chapter are as defined within Chapter 16.

11.14.2 The receptors discussed in this chapter are also linked to Chapter 12: Materials. The design of the new section of motorway in terms of the cut and fill balance is discussed within Chapter 12. The design aims for all materials (soils and rocks) generated by the Scheme to be reused within the Scheme, wherever possible. The reuse of these materials (and materials derived from Scheme designated borrow pits) would require demonstration that they are both environmentally and geotechnically suitable.

11.14.3 In terms of loss of topsoil as a resource this has been qualitatively assessed within this chapter. Further more detailed assessment is provided within Chapter 15: Community and Private Assets, including the assessment of impacts on agricultural land using the agricultural land classification.

11.14.4 The impact of construction dusts is assessed in greater detail within Chapter 7: Air Quality.

11.14.5 Environmental Management of the Scheme is set out within Chapter 18: Environmental Management.

11.14.6 Further details of inter-related effects are provided in Chapter 17.

11.15 Summary of Effects

11.15.1 The effects of the Scheme on soils and geology including land contamination have been assessed and these are summarised in Table 11.22.

11.15.2 The route of the proposed new section of motorway has been subject to a number of detailed ground investigations that have provided data on the ground conditions to provide a detailed understanding of the geological and hydrogeological baseline conditions. The data generated during ground investigations have also allowed assessments to be undertaken on the level of risk to humans and the environment associated with land contamination based on the Scheme both during construction and its operation.

11.15.3 The Scheme would not affect any designated geological sites and some new rock exposures would be created providing a beneficial effect.

11.15.4 The potential impacts on topsoil and subsoil during construction would be mitigated through the adoption of a Soils Handling Strategy. This would be used to control the way that topsoils and subsoils are managed and stored during

construction to allow reuse as part of the Scheme whilst maintaining soil quality, as far as possible. The effect on topsoils from pollutants in traffic spray during operation would be of neutral significance.

11.15.5 In total, 27 areas potentially affected by land contamination along the proposed route of the new section of motorway have been identified, each of which has been subject to an individual assessment to determine the need for remediation to protect the environment and human health. For some of the potentially contaminated sites, potential risks have been identified that require remediation to ensure human health and the environment (including the sensitive reens of the Gwent Levels) are mitigated. Exposure by construction workers, the general public and future maintenance workers to potentially contaminated soils, waters and ground gases have been assessed along with the risk of contaminants migrating into surface waters and ground waters.

11.15.6 A remediation strategy has been developed in line with UK guidance to mitigate risks from known potential areas of land contamination and this is set out in the Outline Remediation Strategy Report (Appendix 11.2). Contaminated soil arisings from excavations would be subject to compliance testing against suitability for reuse criteria. Suitable materials would then be reused within the Scheme typically as general embankment fill. Some contaminated soils would need treatment particularly in the Tata lagoons area. The Outline Remediation Strategy also provides procedures to deal with the unlikely event of unexpected or previously unidentified land contamination being encountered during construction. The final remediation strategy would also ensure the handling, treatment, movement and reuse of contaminated soils is controlled in line with a Material Management Plan that would be prepared using the Definition of Waste Code of Practice (CL:AIRE 2011). Upon completion of construction of the Scheme, a Remediation Verification Report would be prepared to prove 'Lines of Evidence' to NRW, MCC and NCC that the remediation has been completed in line with the agreed remediation strategy.

11.15.7 The potential effects of potentially contaminated surface water runoff and prevention of potentially contaminated groundwaters entering surface waters during construction would be mitigated through the implementation of a Groundwater and Surface Water Management Plan. Surface water and groundwater monitoring would be undertaken during construction and for up to 5 years following construction. With these measures in place effects on water quality would be of neutral or slight adverse significance. The exception to this is during the construction phase in the area of the sludge lagoons (CL-26), where a minor adverse impact, whilst unlikely, could occur and thus the potential effect could be of moderate adverse significance.

11.15.8 Potential effects from ground gases impacting on human health during construction would be mitigated using good practice guidance and adoption of strict safe working procedures resulting in slight adverse effects. The effects from any ground gases during the operational stage would be mitigated through the incorporation of gas protective mitigation measures and the significance of effects would be limited to slight adverse.

11.15.9 Risks to human health from any contamination during the operational phase would be minimal. This is because the construction of the Scheme would result in a barrier being created in the form of the motorway embankment itself or clean topsoils and subsoils being placed as part of Scheme landscaping. The

hardstanding and landscaped areas would effectively break any potential contaminant linkages between contaminated soils and human receptors. The effects to human health during operation would generally be of slight beneficial significance as a result of the Scheme as the likelihood for humans coming into contact with contamination is reduced compared to the baseline.

11.15.10 The effects of potential contamination on surface waters during operation would be mitigated through the remediation strategy and modifying construction methods in known and potentially contaminated areas, such as not installing band drains in contaminated soils and careful selection of piling techniques. The Scheme would result in slight adverse effects to the water environment.

11.15.11 The potential risks during construction in the unlikely event of buried UXO being encountered would be mitigated through the implementation of a UXO Mitigation Strategy which would follow good practice guidance. The risks from buried UXO being encountered during construction are assessed to be of slight adverse significance.

11.15.12 With the mitigation measures proposed, the only potentially significant effect could be on the sensitive surface waters of the Gwent Levels where a potentially significant effect is predicted during construction associated with the handling and management of lagoon wastes.

Table 11.22: Summary of Likely Environmental Effects on Geology and Soils

Receptor	Sensitivity of receptor	Description of impact	Short / medium / long term	Magnitude of impact (without mitigation)	Significance of effect (without mitigation)	Magnitude of impact (with mitigation)	Significance of effect (with mitigation)	Significant / Not significant
Land Take								
Solid geology	Negligible	Net creation of rock exposures.	Long term	Negligible (beneficial)	Neutral	Negligible (beneficial)	Neutral	Not significant
Superficial geology	Low	Ground instability - excessive settlement.	Medium term	Minor (adverse)	Slight (adverse)	Negligible (adverse)	Slight (adverse)	Not significant
Topsoils and subsoils	Medium	Topsoil stripping and loss of local seed bank and potential creation of pathways for contamination migration.	Long term	Minor (adverse)	Slight (adverse)	Negligible (adverse)	Slight (adverse)	Not significant
Aquifers (Superficial and bedrock)	Low to Medium*	Migration of contaminants in soil and perched groundwater into aquifer.	Medium to long term	Minor to moderate (adverse)	Neutral to moderate (adverse)	Negligible (adverse)	Slight (adverse)	Not significant
Surface waters (reens and rivers)	Low to Very High*	Migration of contaminants in soil and perched groundwater and surface water runoff into surface waters.	Medium to long term	Moderate (adverse)	Slight to large (adverse)	Negligible (adverse)	Slight (adverse)	Not significant
Surface waters (reens) – CL-6	Very High	Contaminants in the aquifer have the potential to connect to perched groundwater (and surface waters) via band drains.	Medium to long term	Moderate (adverse)	Large (adverse)	Negligible (adverse)	Slight (adverse)	Not Significant
Surface waters (reens) – CL-17	Very High	Hydrostatic pressure of aquifer near base of Made Ground may connect he aquifer and perched groundwaters through piling.	Medium to long term	Moderate (adverse)	Large (adverse)	Negligible (adverse)	Slight (adverse)	Not Significant

Receptor	Sensitivity of receptor	Description of impact	Short / medium / long term	Magnitude of impact (without mitigation)	Significance of effect (without mitigation)	Magnitude of impact (with mitigation)	Significance of effect (with mitigation)	Significant / Not significant
Surface waters (reens) – CL-26	Very High	Migration of contaminants in lagoon wastes, treated soils and waters entering into surface water.	Medium to long term	Major (adverse)	Very large (adverse)	Negligible (adverse)	Slight (adverse)	Not Significant
Surface waters (reens) – CL-27	Very High	Saline groundwater may connect to surface waters via band drains.	Medium to long term	Moderate (adverse)	Large (adverse)	Negligible (adverse)	Slight (adverse)	Not Significant
Construction								
Topsoils and subsoils	Medium	Topsoil loss and loss of local seed bank. Uncontrolled surface water runoff and erosion of topsoil.	Long term	Minor (adverse)	Slight (adverse)	Negligible (adverse)	Neutral	Not significant
Construction workers	High	Collapse of potential dissolution features - hazard to human health.	Long term	Major (adverse)	Large (adverse)	Negligible (adverse)	Slight (adverse)	Not significant
Construction workers and adjacent land users including general public	High and Very High	Explosion from buried unidentified unexploded ordnance - hazard to human health.	Long term	Major (adverse)	Very large (adverse)	Negligible (adverse)	Slight (adverse)	Not significant
Construction workers and adjacent land users including general public	Very High	Exposure to contamination through dermal contact, ingestion and inhalation of contaminated soil/soil derived dust.	Short to long term	Minor (adverse)	Moderate (adverse)	Negligible (adverse)	Slight (adverse)	Not significant
Construction workers	High	Explosion from ground gas build up in confined space and during piling and band drain installation - hazard to human health.	Long term	Major (adverse)	Large (adverse)	Negligible (adverse)	Slight (adverse)	Not significant

Receptor	Sensitivity of receptor	Description of impact	Short / medium / long term	Magnitude of impact (without mitigation)	Significance of effect (without mitigation)	Magnitude of impact (with mitigation)	Significance of effect (with mitigation)	Significant / Not significant
Aquifers (Superficial and bedrock)	Low to Medium*	Migration of contaminants in soil and perched groundwaters through creation of new pathways including piling and band drains.	Short term	Moderate (adverse)	Slight to moderate (adverse)	Negligible (adverse)	Slight (adverse)	Not significant
Surface waters (reens and rivers)	Low to Very High*	Migration of contaminants in soil, perched groundwater and surface water runoff into surface waters.	Short term	Moderate (adverse)	Slight (adverse) to large (adverse)	Negligible (adverse)	Slight (adverse)	Not significant
Surface waters (reens and rivers)	Low to Very High*	Piling and band drain installation allowing saline or contaminated groundwater entering surface water.	Short term	Moderate (adverse)	Slight (adverse) to large (adverse)	Negligible (adverse)	Slight (adverse)	Not significant
Surface waters (reens) – CL-6	Very High	Contaminants in aquifer connecting perched groundwaters (and surface waters) during band drain installation.	Short term	Moderate (adverse)	Large (adverse)	Negligible (adverse)	Slight (adverse)	Not significant
Construction workers – CL-13	High	Exposure to waste/Made Ground with potentially elevated levels of soil contamination and asbestos. Inhalation of ground gases with elevated concentrations.	Short to long term	Major (adverse)	Large (adverse)	Negligible (adverse)	Slight (adverse)	Not significant
Surface waters (River Ebbw) – CL-13	High	Contaminants in perched groundwater and leaching of contaminants from Made Ground migrating into surface waters.	Short term	Moderate (adverse)	Moderate (adverse)	Minor (adverse)	Slight (adverse)	Not significant

Receptor	Sensitivity of receptor	Description of impact	Short / medium / long term	Magnitude of impact (without mitigation)	Significance of effect (without mitigation)	Magnitude of impact (with mitigation)	Significance of effect (with mitigation)	Significant / Not significant
Aquifers – CL-13	Medium	Migration of impacted perched groundwaters to aquifer including pathways created by piles and band drains.	Short term	Moderate (adverse)	Moderate (adverse)	Minor (adverse)	Slight (adverse)	Not significant
Construction workers - CL-14	High	Exposure to Made Ground with potential soil contamination.	Short term	Moderate (adverse)	Moderate (adverse)	Negligible (adverse)	Slight (adverse)	Not significant
Construction workers - CL-17	High	Widespread soil contamination and soil derived dusts. Exposure to ground gas.	Short to long term	Major (adverse)	Large (adverse)	Negligible (adverse)	Slight (adverse)	Not significant
Construction workers and adjacent land users including general public- CL-17	Very High	Exposure to soil derived dusts.	Short to long term	Major (adverse)	Very large (adverse)	Negligible (adverse)	Slight (adverse)	Not significant
Surface waters (reens) – CL17	Very High	Contaminants in perched groundwater and leaching of contaminants from Made Ground migrating into surface waters. Piling and band drains may increase this risk.	Short term	Moderate (adverse)	Large (adverse)	Negligible (adverse)	Slight (adverse)	Not significant
Aquifers - CL-17.	Low	Migration of contamination within Made Ground and perched groundwaters during piling.	Short term	Moderate (adverse)	Slight (adverse)	Minor (adverse)	Slight (adverse)	Not significant
Construction workers - CL-18.	High	Exposure to groundwater contamination	Short term	Major (adverse)	Large (adverse)	Negligible (adverse)	Slight (adverse)	Not significant

Receptor	Sensitivity of receptor	Description of impact	Short / medium / long term	Magnitude of impact (without mitigation)	Significance of effect (without mitigation)	Magnitude of impact (with mitigation)	Significance of effect (with mitigation)	Significant / Not significant
Surface waters (reens) - CL-18.	Very High	Contaminants in groundwaters potentially mobilised during dewatering impacting upon surface waters.	Short term	Moderate (adverse)	Large (adverse)	Negligible (adverse)	Slight (adverse)	Not significant
Construction workers - CL-26.	High	Construction workers exposed to contaminated soils and groundwater and ground gases.	Short to Long term	Major (adverse)	Large (adverse)	Negligible (adverse)	Slight (adverse)	Not significant
Construction Adjacent site users- CL-26.	Very High	Exposure to contaminated soil derived dusts.	Short to Long term	Moderate (adverse)	Large (adverse)	Negligible (adverse)	Slight (adverse)	Not significant
Surface water (reens) CL-26.	Very High	Migration of contaminants in lagoon wastes, soils and waters entering surface waters.	Short term	Major (adverse)	Very large (adverse)	Minor (adverse)	Moderate (adverse)	Significant
Aquifers - CL-26.	Low	Migration of contaminants in lagoon wastes, soils and water entering aquifer.	Short term	Moderate (adverse)	Slight (adverse)	Minor (adverse)	Neutral	Not significant
Surface water (reens) – CL27.	Very High	Contaminants in perched groundwater and leaching of contaminants from Made Ground migrating into surface waters. Saline groundwater aquifer may connect surface waters via band drains and piles.	Short term	Moderate (adverse)	Large (adverse)	Negligible (adverse)	Slight (adverse)	Not significant
Operation								
Topsoils and subsoils	Medium	Pollution of soils immediately adjacent to carriage way due to traffic spray/airborne	Long term	Negligible (adverse)	Slight (adverse)	Negligible (adverse)	Neutral	Not significant

Receptor	Sensitivity of receptor	Description of impact	Short / medium / long term	Magnitude of impact (without mitigation)	Significance of effect (without mitigation)	Magnitude of impact (with mitigation)	Significance of effect (with mitigation)	Significant / Not significant
		pollutants.						
Adjacent land users including general public	Very High	Exposure through dermal contact, ingestion and inhalation of contaminated soil derived dusts. Ground gas migration and inhalation of gases.	Long term	Negligible (adverse)	Slight (adverse)	Negligible (beneficial)	Slight (beneficial)	Not significant
End users/ maintenance workers	High	Exposure through dermal contact, ingestion and inhalation of contaminated soil derived dusts. Ground gas migration and inhalation of gases.	Long term	Negligible (adverse)	Slight (adverse)	Negligible (beneficial)	Slight (beneficial)	Not significant
End users, adjacent site users and maintenance workers	Very High	Explosion from ground gases - human health hazard.	Long term	Negligible (adverse)	Slight (adverse)	Negligible (adverse)	Slight (adverse)	Not significant
Surface Waters (reens and rivers)	Low to Very High	Pollution of surface waters from surface water runoff, accidental spillages.	Long term	Negligible (adverse)	Slight (adverse)	Negligible (adverse)	Slight (adverse)	Not significant
Aquifers (superficial and bedrock)	Low to Medium	Pollution of groundwaters from surface water runoff, accidental spillages	Long term	Negligible (adverse)	Slight (adverse)	Negligible (adverse)	Neutral	Not significant
Surface waters (reens) – CL-6	Very High	Contaminants in aquifer have the potential to connect perched groundwaters (and surface waters) via band drains.	Medium term	Moderate (adverse)	Large (adverse)	Negligible (adverse)	Slight (adverse)	Not significant

Receptor	Sensitivity of receptor	Description of impact	Short / medium / long term	Magnitude of impact (without mitigation)	Significance of effect (without mitigation)	Magnitude of impact (with mitigation)	Significance of effect (with mitigation)	Significant / Not significant
Surface waters (River Ebbw) - CL-13	High	Impacted perched groundwaters/leachate may be intercepted by the land drainage ultimately discharging to the River Ebbw.	Medium term	Moderate (adverse)	Moderate (adverse)	Negligible (adverse)	Slight (adverse)	Not significant
End users and maintenance workers and adjacent users - CL-13	High	Exposure through dermal contact, ingestion and inhalation of contaminated soil derived dusts. Ground gas migration and inhalation of gases.	Long term	Minor (adverse)	Moderate (adverse)	Negligible (beneficial)	Slight (beneficial)	Not significant
Maintenance workers - CL-17	High	Exposure to soil contamination from Made Ground remaining on site.	Medium term	Moderate (adverse)	Moderate (adverse)	Negligible (adverse)	Slight (adverse)	Not significant
End users – CL-17	High	Exposure through dermal contact, ingestion and inhalation of contaminated soil derived dusts. Ground gas migration and inhalation of gases.	Long term	Minor (adverse)	Moderate (adverse)	Negligible (beneficial)	Slight (beneficial)	Not significant
Surface waters (reens) – CL-17	Very High	Hydrostatic pressure of aquifer near base of Made Ground may connect to aquifer and perched groundwaters (and surface waters) via piling.	Medium term	Moderate (adverse)	Large (adverse)	Negligible (adverse)	Slight (adverse)	Not significant

Receptor	Sensitivity of receptor	Description of impact	Short / medium / long term	Magnitude of impact (without mitigation)	Significance of effect (without mitigation)	Magnitude of impact (with mitigation)	Significance of effect (with mitigation)	Significant / Not significant
Aquifers – CL-17	Low	Contaminants within Made Ground and perched groundwaters migrating into aquifer during piling.	Medium term	Moderate (adverse)	Slight (adverse)	Negligible (adverse)	Neutral	Not significant
Surface waters (reens) – CL-26	Very High	Migration of contaminants in lagoon wastes, treated materials soils and water entering surface water.	Medium term	Major (adverse)	Very Large (adverse)	Negligible (adverse)	Slight (adverse)	Not significant
Aquifers – CL-26	Low	Migration of contaminants in lagoon wastes, treated materials soils and water entering aquifers.	Medium term	Moderate (adverse)	Slight (adverse)	Negligible (adverse)	Slight (adverse)	Not significant
End users and maintenance workers – CL-26	High	Exposure through dermal contact, ingestion and inhalation of contaminations soils and soil derived dusts. Ground gas migration and inhalation of gases.	Long term	Minor (adverse)	Moderate (adverse)	Negligible (beneficial)	Slight (beneficial)	Not significant
Surface waters (reens) -CL-27	Very High	Saline groundwater aquifer may connect surface waters via band drains and piles.	Medium term	Moderate (adverse)	Large (adverse)	Negligible (adverse)	Slight (adverse)	Not significant