Welsh Government

M4 Corridor around Newport

Environmental Statement Volume 1

Chapter 16: Road Drainage and the Water Environment

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16.1 Introduction

16.1.1 This chapter provides an assessment of effects on the water environment that may arise from the Scheme. For the purposes of this chapter, the water environment is considered to comprise the complex water system within the Gwent Levels, other surface watercourses within the study area, groundwater contained within aquifer units that underlie the study area and other waterbodies or water dependent features that may potentially be affected.

16.1.2 The assessment considers those effects that may arise during the construction phase and operational phase of the Scheme. This includes an assessment of likely significant effects on water quality as a result of construction, the operational road drainage and potential accidental spillages that would be captured by such drainage. This assessment focuses on chemical quality, but also considers possible effects on levels and flow where appropriate. Any associated effects on ecology are considered in Chapter 10: Ecology and Nature Conservation of the ES. This assessment also includes an evaluation of flood risk. A Flood Consequences Assessment has been undertaken for the Scheme (see Appendix 16.1).

16.1.3 The assessment of potential effects on the water environment is underpinned by an understanding of the existing baseline conditions within the water environment within the study area and conforms to the methodology outlined in guidance provided in the Design Manual for Roads and Bridges (DMRB) HD 45/09 (Highways Agency *et al.,* 2009).

16.2 Legislation and Policy Context

Relevant Legislation

16.2.1 Chapter 6 of this ES provides an overarching and strategic legislative context for the Scheme from an environmental perspective. There has been considerable development in the legislation relevant to the consideration of effects on the water environment. The principal legislation regarding the protection of specific water resources, water quality standards and policy relevant to the Scheme is set out in the following primary European legislation.

- Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy (Water Framework Directive).
- Directive 2006/118/EC of the European Parliament and of the Council of 12 December 2006 on the protection of groundwater against pollution and deterioration (daughter to 2000/60/EC) (Groundwater Daughter Directive).
- Directive 2013/39/EU of the European Parliament and of the Council of 12 August 2013, amending Directives 2000/60/EC and 2008/105/EC as regards priority substances in the field of water policy.
- Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and wildlife and fauna (the Habitats Directive).

16.2.2 The implementation of the Water Framework Directive (WFD) has resulted in the repeal and/or replacement of other European legislation of relevance to consideration of the water environment. Most notably, this includes the following.

- The Groundwater Directive (80/68/EEC), repealed in 2013.
- The Dangerous Substances Directive (76/464/EEC), repealed in 2013.
- The Freshwater Fish Directive (2006/44/EC) repealed in 2013.
- The EC Shellfish Waters Directive (2006/113/EEC) repealed in 2013.

16.2.3 European legislation is implemented in the UK through specific Regulations. Welsh Government is responsible for all aspects of water policy in Wales, with the management and enforcement of water policy being the responsibility of Natural Resources Wales (NRW). The following national legislation is considered relevant to this chapter.

- Environmental Protection Act (1990).
- The Water Resources Act (1991).
- Water Industry Act (1991) (as amended).
- Environment Act (1995).
- The Water Supply (Water Quality) Regulations 2000 (as amended).
- Water Act (2003).
- Water Environment (Water Framework Directive) (England and Wales) Regulations 2003.
- Groundwater (England and Wales) Regulations (2009).
- The Water Resources Act 1991 (Amendment) (England and Wales) Regulations 2009.
- Water Industry Act (1991) (Amendment) (England and Wales) Regulations (2009).
- Environmental Damage (Prevention and Remediation) Regulations (2009).
- The Environmental Permitting (England and Wales) Regulations 2010 (as amended).

16.2.4 The aim of water policy in Wales is to protect both public health and the environment by maintaining and improving the quality of natural waters. These include surface waterbodies (e.g. rivers, streams, lakes, ponds) and groundwater.

16.2.5 To consider effects on water quality within the study area, it is necessary to have due regard to the methodologies and legislation that relate to the management of contaminated land within the UK. This includes the following.

- Part IIA of the Environment Protection Act (EPA) (1990).
- Contaminated Land (England) Regulations (2006).

Planning Policy Context

16.2.6 Chapter 6 of this ES provides an overarching policy context for the Scheme from an environmental perspective. In addition, 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.

National Planning Policy

16.2.7 Planning Policy Wales (Welsh Government, 2016) provides general guidance and information with regard to development planning throughout Wales. Planning Policy Wales discusses the general approach to 'Minimising and Managing Environmental Risks and Pollution', specifically with respect to water quality, contaminated land and flood risk.

16.2.8 Technical Advice Note 5 (TAN 5): Nature Conservation and Planning (Welsh Assembly Government, 2009) gives advice as to the consideration of impacts on designated sites in relation to the water environment.

16.2.9 Technical Advice Note 15 (TAN 15): Development and Flood Risk (Welsh Assembly Government, 2004) provides technical guidance which supplements the policy set out in Planning Policy Wales in relation to development and flooding.

16.2.10 The Gwent Levels: the Severn Estuary Flood Risk Management Strategy (SEFRMS) (Environment Agency, 2014a) is to protect the area against a 0.1% (1 in 1000) Annual Event Probability (AEP) tide, keeping pace with climate change into the future (see Table 16.1).

Local Policy

16.2.11 The Local Development Plan for Newport was adopted on 27th January 2015 (Newport City Council, 2015). The Plan sets out a number of objectives to achieve the overall goals of the Plan. Objective 2 relates to climate change and aims to ensure that development and land uses in Newport make a positive contribution to minimising, adapting to or mitigation against the causes and impacts of climate change. This includes reference to managing the risks and consequences of flooding. General Development Principle 1 also relates to climate change and requires development proposals to be designed to reduce the risk of flooding on site and elsewhere.

16.2.12 Objective 6 relates to the conservation of the natural environment, including protection of controlled waters.

16.2.13 General Development Principle 5 relates to the natural environment and includes reference to the importance of geological sites.

16.2.14 Policy SP1 relates to sustainability, including a requirement to assess the potential contribution of development to conserving, enhancing and linking the natural environment and to conserving and ensuring the efficient use of water.

16.2.15 Policy SP3 relates to flood risk, setting out the need for development to be directed away from areas where flood risk is identified as a constraint and for technical assessment to be undertaken to ensure that development is designed to cope with the consequences of flooding.

16.2.16 The supporting text to Policy SP3 requires developers to consider effects in relation to fluvial and tidal flood risk and the effect on surface, groundwater and flood risk from artificial sources. Guidance is provided in relation to prevention of effects on the reen system within the Gwent Levels, including avoiding culverting and providing buffer zones to reens and field ditches.

16.2.17 Policy SP4 relates to water resources and requires developments to minimise water consumption, protect water quality and result in no net increase in surface water runoff.

16.2.18 Policy CE9 relates to the coastal zone. This policy states that development will not be permitted in the coastal area or adjoining the tidal river unless:

'i) in the undeveloped coastal area such development is required to be on the coast to meet an exceptional need which cannot reasonably be accommodated elsewhere;

ii) the area is not itself at risk nor will the proposed development exacerbate risks from erosion, flooding or land instability.'

16.2.19 The Monmouthshire Local Development Plan 2011-2021 was adopted in February 2014 (Monmouthshire County Council, 2014). The objectives of the Local Development Plan include reference to the need to avoid inappropriate development in areas at risk of flooding and the need to design development to manage surface water runoff.

16.2.20 Relevant policies include the following.

- EP1: Amenity and Environmental Protection.
- EP2: Protection of Water Sources and Water Environment.
- S12: Efficient Resource Use and Flood Risk.
- SD3: Flood Risk.
- SD4: Sustainable Drainage.

16.3 Assessment Methodology

Prediction and Evaluation of Effects

16.3.1 The water environment assessment considers effects on water quality, physical hydrology, hydrogeology, geology and flood risk. The nature of effects on the water environment is determined in relation to the baseline conditions of the water environment.

16.3.2 The principal effects considered as part of this assessment include the following.

- The effect on surface water from routine runoff and accidental spillages as part of operational highway drainage.
- The effect on surface water from runoff during highway construction, particularly in the vicinity of areas of contaminated land identified along the proposed new section of motorway.
- The effect of construction on water quality and the current function of the reen system with respect to flood risk (i.e. in terms of flow and water conveyance).

- The effect on groundwater and surface water from the highway construction methodology and proposed material reuse within highway design.
- The effect of groundwater dewatering, particularly in areas of proposed cutting and proposed use of band drains for achieving settlement of embankments.
- The effect on tidal, fluvial and pluvial flood risk from the construction of new structures, particularly within the Gwent Levels.

16.3.3 Effects during the construction phase have been assessed qualitatively and addressed through the development of suitable mitigation measures. The effect of routine highway runoff and accidental spillage has been assessed using the quantitative methodology described in the DMRB Volume 11, Section 3, Part 10 (HD45/09) (Highways Agency *et al.,* 2009). This prescribes assessment methods for determining impacts on surface water (methods A, B and D), groundwater (methods C and D) and flood risk (methods E and F) as follows.

- Method A – Simple Assessment of Pollution Impacts from Routine Runoff to Surface Waters.
- Method B – Complex Assessment of Pollution Impacts from Routine Runoff to Surface Waters.
- Method C – Assessment of Pollution Impacts from Routine Runoff on Groundwaters.
- Method D – Assessment of Pollution Impacts from Spillages.
- Method E – Hydrological Assessment of Design Floods.
- Method F – Hydraulic Assessment.

16.3.4 A Flood Consequences Assessment (FCA) has been produced for the Scheme (Appendix 16.1) and provides an assessment of the flood risk to the new section of motorway for a range of potential flood scenarios up to the 0.1% (1 in 1000) Annual Event Probability.

Relevant Guidance

16.3.5 The assessment has been undertaken taking into account the following regulatory and industry guidance.

- DMRB Volume 11, Section 3, Part 10 HD45/09 - Road Drainage and the Water Environment (Highways Agency *et al,,* 2009).
- DMRB Volume 11 Section 2, Part 5 HA 205/08 - Environmental Impact Assessment (Highways Agency *et al.,* 2008).
- Groundwater Protection: Principles and Practice (GP3) (Environment Agency 2013).
- Pollution Prevention Guideline (PPG) Series (including PPG1 (Environment Agency *et al*., 2013), PPG5 (Environment Agency *et al.,* 2007) and PPG6 (Environment Agency *et al.,* 2012).
- Model Procedures for the Management of Land Contamination (CLR11) (Environment Agency and Defra, 2004).

- Remedial Targets Methodology: Hydrogeological Risk Assessment for Land Contamination (Environment Agency, 2006).
- Methodology for the Derivation of Remedial Targets for Soil and Groundwater to Protect Water Resources (R and D Publication 20) (Environment Agency, 1999).
- H1 Environmental Risk Assessment Framework: Annex D1 Assessment of Hazardous Pollutants within Surface Water Discharges, Issue 2.0 (Environment Agency, 2014b).
- Construction Industry Research and Information Association (CIRIA) (2006) Technical Guidance C648: Control of Water Pollution from Linear Construction Projects.

Study Area

16.3.6 The baseline characterisation and supporting technical assessments focus on a corridor situated along the proposed new section of motorway. A nominal corridor of 250 metres radial width from the main highway alignment has been used. A larger area has been considered where effects have the potential to extend outside of this corridor and/or the understanding of baseline conditions is dependent on wider appreciation of conditions within the system. This is most relevant to the consideration of continuous groundwater catchment areas that extend laterally outside of the study area, watercourses crossing potentially contaminated sites and/or major reens within the area of potential influence of the new section of motorway.

Approach to Identification of Baseline Conditions

16.3.7 The baseline characterisation and technical assessments undertaken for the water environment are described in detail in the Baseline Water Environment (BWE) Report provided in Appendix 16.2. The characterisation of baseline conditions within the study area has been based on a review and synthesis of the following data sources relevant to the water environment.

- Historical reporting relating to the area, most notably the Preliminary Sources Study Report (PSSR) undertaken for the routes assessed at DMRB Stage 2 (Arup, 2014).
- Previous factual ground investigation data, and additional investigations local to the Scheme available in the archives of the British Geological Survey.
- Results of historical ground investigations.
- Published geological information, principally from the British Geological Survey.
- Relevant scientific literature, most notably in relation to geology and water quality.
- Ordnance Survey data for the Scheme.
- Aerial photography provided by Welsh Government.
- Datasets obtained from key stakeholders most notably Natural Resources Wales, the former Caldicot and Wentlooge Levels Internal Drainage Board (CWLIDB) and Newport City Council (NCC).

- Statutory and non-statutory consultation with key stakeholders, that include land owners / tenants within the Scheme corridor.
- Environmental monitoring datasets collected for the study area that relate to controlled waters (surface water and groundwater) and ground gas.
- The results of site walkover surveys undertaken in 2015.

16.3.8 For a complete description of each data source the reader should refer to the Baseline Water Environment Report at Appendix 16.2. With the exception of the quantitative datasets, the majority of data sources identified above have been incorporated in a GIS database to facilitate management and visual presentation of the complex data sources.

16.3.9 Based on the review of the baseline information sources, a Conceptual Hydrogeological Model (CHM) has been developed for the Scheme that defines the baseline characteristics of the system.

16.3.10 Surface water and groundwater monitoring data underpin the baseline characterisation of the water environment. Quantitative data have been obtained from the following sources.

- Completion of water monitoring as outlined in the Baseline Water Environment Report (Appendix 16.2).
- The result of historical intrusive investigations and associated monitoring undertaken in support of the Scheme.
- Recent and historical surface water quality monitoring undertaken within the Scheme corridor.
- Quantitative data collected by other organisations, most notably NRW but including other private companies (e.g. Tata Steel in the area around Llanwern).

16.3.11 The data are included within Appendix 16.2 and the Land Contamination Assessment Report in Appendix 11.1.

16.3.12 Surface water quality monitoring data has been collected within the Gwent Levels in three phases, with the baseline characterisation and assessment of effects placing particular reliance on the third phase.

- Titan Environmental Surveys Limited (TESL, 2008) – 22 Monitoring Locations, typically 4 Rounds (2007 / 2008).
- Supplementary Ground Investigation for the Welsh Government (Hyder, 2015) – 10 Monitoring Locations, 3 Rounds (2015).
- RPS Water and Ground Gas Monitoring 2015/2016 – Four Quarterly Rounds.

16.3.13 The technical report associated with each phase of water quality monitoring is provided as part of the Baseline Water Environment Report in Appendix 16.2.

16.3.14 Baseline conditions with respect to water quality have been defined by a statistical description of the quantitative dataset and high level water quality screening assessment. By screening observed water quality data against appropriate Assessment Criteria (AC), an evaluation of baseline quality can be made. The selection of AC depends on the conceptual model and in particular the nature and sensitivity of controlled water receptors for which active pollutant

linkages are considered likely to exist. Three sources of statutory and non-statutory water quality AC have been used herein.

- National Environmental Quality Standards (EQSs) defined for the protection of the ecology of surface water environments.
- Former CCW Trigger Levels developed at the local level for the Gwent Levels Sites of Special Scientific Interest (SSSIs).
- Drinking Water Standards (DWS) defined on the basis of health for water intended for human consumption.

16.3.15 The screening assessment is described in detail in the Baseline Water Environment Report at Appendix 16.2.

Approach to Flood Modelling

16.3.16 The FCA considers whether mitigation is required to ensure that the Scheme does not cause adverse consequences with respect to flood risk. The report has been produced in accordance with Planning Policy Wales (Welsh Government, 2016) and Technical Advice Note 15: Development and Flood Risk (Welsh Assembly Government, 2004).

16.3.17 The FCA is separated into a number of sections. These deal with overall flood risk to the Scheme and the flood consequences of constructing the new section of motorway (including the raised embankment across the Gwent Levels). The report has been informed by hydraulic modelling.

16.3.18 A one dimensional (1D)/two dimensional (2D) hydraulic model has been developed for the Gwent Levels (both the Wentlooge and Caldicot Levels) using the TUFLOW/ESTRY packages. The model allows for 1D/2D dynamic linking that simulates flood and tidal wave propagation (www.tuflow.com). This allows for open channels and structures to be modelled in 1D with all overland flow paths to be represented within the 2D model. The software is based on a fixed grid model that forms the basis for the 2D calculations. TUFLOW is industry standard software that has been benchmarked by the Environment Agency.

16.3.19 The modelling has been used to confirm fluvial flood risk to the new section of motorway by updating the baseline model to include the with-Scheme scenarios (including new road embankment, the reen mitigation strategy and sustainable drainage (SuDS) options).

16.3.20 The impacts of the proposed works have been considered against the baseline flood map. Where required, a series of mitigation measures have been developed to ensure that the Scheme would not increase flood risk.

16.3.21 Sensitivity testing of the Scheme has been undertaken against:

- varying siltation levels within the main reens;
- impacts of pump failure;
- impacts of tidal outfall failure; and
- culvert blockage.

16.3.22 The modelling has formed the basis of the assessment of the fluvial consequences of the with-Scheme scenarios. The flood modelling has also been

used to determine the impacts of the construction of a raised embankment across the Gwent Levels and the effectiveness of the proposed mitigation strategy in providing adequate flow conveyance.

16.3.23 The risk from tidal flooding has not been considered, apart from the impacts of tidal surcharge on the outfalls of the reen system. This reflects the expectation that the Gwent Levels are protected from tidal inundation by sea defences maintained by NRW to a 1 in 1000 year plus climate change standard.

16.3.24 In conjunction with NRW's improvements to the Gwent Levels sea defences, the proposed new section of motorway would be compliant with current Welsh Government planning policy with respect to tidal flood risk up to the year 2030. Continued improvements to sea defences beyond 2030, in line with Welsh Government policy to 'Hold the Line' would ensure that the proposed new section of motorway would remain compliant into the future.

Consultation

16.3.25 A brief overview of the consultation undertaken to date is provided in Table 16.1 below. This includes an overview of consultation undertaken prior to route selection, consultation undertaken during the formal scoping exercise and subsequent consultation and dialogue with key stakeholders.

Table 16.1: Consultation Responses Relevant to this Chapter

Date	Consultee and Issue Raised	How/Where Addressed
Draft Plan consultation response (Welsh Government 2014)	Public Response: Concern about Scheme acting as a barrier across Gwent Levels and effects on water movement. Concerns regarding potential pollution of reens. Concern about Scheme running through an area liable to flooding and effect on capacity of Gwent Levels to serve as flood plain.	Conveyance of water through the system has been considered through detailed design and reen mitigation measures have been evaluated in this ES. A Flood Consequences Assessment has been included (Appendix 16.1).
	Natural Resources Wales: Request assessment in relation to flood risk.	Flood Consequences Assessment has been provided as part of this ES (Appendix 16.1).
	Wildlife Trust: Concern regarding land lost from the Gwent Levels and effects of pollution on remaining areas.	Assessments undertaken to determine effects on water quality and summarised in this chapter. Consideration of contaminated land sites provided in Chapter 11 of this ES.
Environmental Liaison Group meetings	Natural Resources Wales: Requirement to provide replacement reens as part of Scheme, with no net decrease in capacity or water quality. Greenfield runoff rates will be a requirement, to ensure that capacity and flows are not exceeded.	Reen mitigation strategy has been agreed with NRW (Appendix 2.3). Greenfield runoff rates have been applied to discharges associated with the proposed Scheme.
Environmental Liaison Group meetings	Internal Drainage Board (now part of Natural Resources Wales): Will be important to consider drainage design to ensure reens are connected.	Agreed. NRW key consultee through design development.
23/07/2015	Natural Resources Wales: Dialogue to resolve potential discrepancy between Gwent Levels SSSI water quality trigger levels and WFD compliance requirements	Agreed to use former CCW Trigger Levels as compliance targets with the Gwent Levels SSSIs owing to the natural characteristics of the water system within the reen system. Agreed trigger levels provided in Appendix 16.2.
August 2015	Landowners / Tenants Dialogue regarding water abstraction / use within scheme corridor particularly on Gwent Levels	Abstractions assessed for impact from Scheme.
July 2015	NRW Discussion regarding aquifers/aquifer status for geological units	Correspondence summarised in Appendix 16.2.
July 2015	Monmouthshire County Council	Abstractions assessed for impact from Scheme.
July 2015	Newport City Council	Abstractions assessed for impact from Scheme.
18th September 2015 (Natural Resources Wales Response to Scoping	Indirect impacts on the Gwent Levels SSSI as a result of changes to the pattern of drainage, and changes to available water quantity and quality	Effects on water quality and flood risk are considered in this chapter with supporting information provided in the Drainage Strategy, FCA and DMRB Assessment (Appendices 2.2, 16.1 and 16.3 respectively).

Date	Consultee and Issue Raised	How/Where Addressed
Report)	Possible discharge of contaminated surface water into the River Usk during the construction and operation of the road.	Effects on water quality in the Usk are considered in this chapter and in WFD assessment (Appendix 16.4).
	Must demonstrate how every effort has been made to move the alignment through the Gwent Levels to the north to minimise adverse impacts on the Gwent Levels SSSIs and similarly that water treatment areas are moved to the north side of the proposed road alignment, again to minimise overall impacts on the Gwent Levels SSSIs, Internal Drainage District and Landscape of Outstanding Historic Importance in Wales	Chapter 4 of this ES sets out the alternative route alignments and design options considered. A number of water treatment areas have been relocated to the north of the alignment following preliminary design in order to minimise such impacts..
	Recommend that the Association of Drainage Authorities (ADA) be consulted.	Dialogue with the ADA undertaken. ADA happy for NRW to act as main consultee unless specifically requested otherwise by NRW.
	The attenuation of surface water should be for the 1% (1 in 100 year) storm rainfall event plus climate change event. The climate change factor for Rainfall Intensity is currently 30%, however, the final design must incorporate the latest adopted climate change guidance	The FCA (Appendix 16.1) is based on this approach.
	NRW need to be assured that proposed mitigation works will provide the necessary level of connectivity, be capable of being managed and have an appropriate water quality and water quantity to enable them to support the SSSI features of interest, and be viable in the long term	This is addressed in the Drainage Strategy, FCA and DMRB Assessment (Appendices 2.2, 16.1 and 16.3 respectively).
13th October 2015 (NCC Response to Scoping Report)	No mention is made of the obtaining of Ordinary Watercourse Consents.	The Scheme would require a number of Ordinary Watercourse Consents. Ordinary Watercourse consents would be obtained from the Lead Local Authority. A permitting strategy has been produced detailing all consents (Appendix 11.3)
	It must be ensured that the existing drainage systems on county roads are not impacted by the proposed work.	Scheme has been designed to convey and discharge without impacting existing road network drainage. This is set out in the Drainage Strategy (Appendix 2.2).
	The impact on private water supplies must be considered and the details of appropriate mitigation measures submitted to NCC	The potential effects on private water supplies and associated mitigation considered in this chapter.
	Highway drainage must be designed to capture and attenuate a 1:100 flood return period +30% climate change.	Considered in FCA (Appendix 16.1)
	It is strongly assumed that Welsh Government shall be responsible for the ownership and maintenance of Water Treatment Areas	Water treatment areas are within permanent land take boundary and would be managed on behalf of Welsh Government.

Assessment Criteria and Assignment of Significance

16.3.26 The DMRB methodology requires the significance of an effect to be assessed through consideration of the sensitivity (i.e. value or importance) of the receptor affected and the magnitude of the anticipated impact upon that receptor. The criteria for determining the sensitivity of the receptor, magnitude of impact and significance of effect are based on the qualitative approach outlined in DMRB Volume 11, Section 3, Part 10 (HD45/09) (Highways Agency *et al*., 2009) and DMRB Volume 11, Section 2, Part 5 (HA205/08) (Highways Agency *et al.,* 2008). The detailed quantitative and/or qualitative approach used to assign receptor sensitivity is presented in the Baseline Water Environment Report provided in Appendix 16.2. The criteria used are described below with examples relevant to the water environment assessment provided.

Receptor Sensitivity

16.3.27 The sensitivity or value of a receptor is dependent on its importance (at a local, national or European scale), its rarity and its potential for substitution. The value of each receptor identified during the baseline characterisation and presented in the CHM has been defined using the terms set out in Table 2.1 of HA205/08 and taking into account the guidance provided in Table A4.3 of HD45/09 and summarised in Table 16.2 below.

Table 16.2: Criteria and DMRB Definitions of Sensitivity or Value

Value (sensitivity)	Examples for Water Environment
Very high	**Surface water:** - European Community (EC) Designated Salmonid/ Cyprinid fishery - 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. **Groundwater:** - Principal aquifer providing a regionally important resource or supporting site protected under EC and UK Habitat legislation. - Groundwater Source Protection Zone (SPZ1). **Flood Risk:** - Floodplain or defence protecting more than 100 residential properties from flooding.
High	**Surface water:** - WFD Class 'Good'. - Major Cyprinid Fishery. Species protected under EU or UK habitat legislation. **Groundwater**: - Principal aquifer providing locally important resource or supporting river ecosystem - SPZ 2. **Flood Risk:** - Floodplain or defence protecting between 1 and 100 residential properties or industrial premises from flooding.
Medium	**Surface water:** - WFD Class 'Moderate'. **Groundwater:** - Aquifer providing water for agricultural or industrial use with limited connection to surface water - SPZ 3.

Value (sensitivity)	Examples for Water Environment
	Flood risk: - Floodplain or defence protecting 10 or fewer industrial properties from flooding.
Low (or Lower)	**Surface water:** - WFD Class 'Poor'. **Groundwater:** - Unproductive strata. **Flood Risk:** - Floodplain with limited constraints and a low probability of flooding of residential and industrial properties.

Source: Table A4.3: DMRB HD 45/09 (Highways Agency *et al.,* 2009)

Magnitude of Impact

16.3.28 The magnitude of a predicted impact is dependent on its size (scale/extent), duration, timing (e.g. seasonality) and frequency (permanent, seasonal etc.). These aspects of impact magnitude can be defined quantitatively or qualitatively, using the criteria outlined in Table 16.3.

Table 16.3: Criteria and DMRB Definitions of Impact Magnitude

Magnitude of Impact	Criteria Descriptor	Examples
Major	Results in loss of attribute and/or quality and integrity of the attribute (Adverse).	**Surface Water:** - Failure of both soluble and sediment-bound pollutants in HAWRAT (Method A) and compliance failure with EQS values (Method B). - Calculated risk of pollution from a spillage > 2% annually (Spillage Risk Assessment, Method D). - Loss or extensive change to a fishery. - Loss or extensive change to a designated Nature Conservation Site. **Groundwater:** - Loss of or extensive change to an aquifer. - Risk score >250 (Groundwater Assessment, Method C). - Calculated risk of pollution from spillages > 2% annually (Spillage Risk Assessment, Method D). - Loss of, or extensive change to, groundwater supported designated wetland. **Flood Risk:** - Increase in peak flood level of (1% annual probability)>100mm (Hydrological Assessment of Design Floods and Hydraulic Assessment, Methods E and F).
	Results in major improvement in attribute quality (Beneficial).	**Surface Water:** - Removal of existing polluting discharge, or removing the likelihood of polluting discharges occurring to a watercourse. **Groundwater:** - Removal of existing polluting discharge to an aquifer or removing the likelihood of polluting discharges occurring. - Recharge of an aquifer. **Flood Risk:** - Reduction in peak flood levels (1% annual probability)>100mm

Magnitude of Impact	Criteria Descriptor	Examples
Moderate	Results in effect on integrity of the attribute or loss of part of attribute (Adverse).	**Surface Water:** - Failure of both soluble and sediment-bound pollutants in HAWRAT (Method A) but compliance with EQS values (Method B). - Calculated risk of pollution from spillages > 1 % annually and <2% annually. - Partial loss in productivity of a fishery. **Groundwater:** - Partial loss or change to an aquifer. - Potential medium risk of pollution to groundwater from routine runoff - risk score 150-250. - Calculated risk of pollution from spillages >1% annually and <2% annually. - Partial loss of the integrity of groundwater supported designated wetlands. **Flood Risk:** - Increase in peak flood level (1% annual probability)>50mm
	Result in moderate improvement of attribute quality (Beneficial).	**Surface Water:** - HAWRAT assessment of both soluble and sediment-bound pollutants becomes Pass from an existing site where the baseline was a Fail condition. - Calculated reduction in existing spillage risk by 50% or more (when existing spillage risk > 1% annually). **Groundwater:** - Calculated reduction in existing spillage risk by 50% or more (when existing spillage risk is > 1% annually). **Flood Risk:** - Reduction in peak flood levels (1% annual probability) >50mm.
Minor	Results in some measurable change in attribute quality or vulnerability (Adverse).	**Surface Water:** - Failure of either soluble or sediment-bound pollutants in HAWRAT. - Calculated risk of pollution from spillages > 0.5% annually and <1% annually. **Groundwater:** - Potential low risk of pollution to groundwater from routine runoff – risk score <150. - Calculated risk of pollution from spillages > 0.5% annually and <1% annually. - Minor effects on groundwater supported wetlands. **Flood Risk:** - Increase in peak flood level (1% annual probability) >10mm.
	Results in some beneficial effect on attribute or a reduced risk of negative effect occurring (Beneficial).	**Surface Water:** - HAWRAT assessment of either soluble or sediment bound pollutants becomes Pass from an existing site where the baseline was a Fail condition. - Calculated reduction in existing spillage risk by 50% or more (when existing spillage risk is <1% annually). **Groundwater:** - Calculated reduction in existing spillage risk by 50% or more to an aquifer (when existing spillage risk is <1% annually) **Flood Risk:** - Reduction in peak flood level (1% annual probability) >10mm

Magnitude of Impact	Criteria Descriptor	Examples
Negligible	Very minor loss or detrimental alteration to one or more characteristics, features or elements (Adverse).	The scheme is unlikely to affect the integrity of the water environment. **Surface Water:** - No risk identified by HAWRAT (Pass both soluble and sediment-bound pollutants) - Risk of pollution from accidental spillages <0.5%. **Groundwater:** - No measurable impact upon an aquifer and risk of pollution from spillages <0.5%. **Flood Risk:** - Negligible change in peak flood level (1% annual probability) <+/- 10mm
	Very minor benefit to or positive addition of one or more characteristics, features or elements (Beneficial).	

Source: Table A4.4: DMRB HD 45/09 (Highways Agency *et al.,* 2009)

Significance of Effect

16.3.29 The consequence of an impact (expressed as 'significance of effect'), is determined by considering the magnitude of the impact and the importance, or sensitivity, of the receptor or resource. The assessment of significance has been based on the following table (Table A4.5 of HD 45/09).

Table 16.4: Approach to Evaluating Significance of Effect

Value / Sensitivity	Magnitude of Impact			
	Negligible	**Minor**	**Moderate**	**Major**
Low	Neutral	Neutral	Slight	Slight or Moderate
Medium	Neutral	Slight	Moderate	Large
High	Neutral	Slight or Moderate	Moderate or Large	Large or Very Large
Very high	Neutral	Moderate or Large	Large or Very Large	Very Large

Source: Table A4.5 of HD 45/09 (Highways Agency *et al.,* 2009).

16.3.30 The significance of effect has been described using the terms very large, large, moderate, slight and neutral. Table 16.5 defines these terms, taking into account the guidance provided in Table A4.5 of HD 45/09. For the purposes of this assessment effects of moderate and above are considered to be significant in terms of the EIA Regulations.

Table 16.5: DMRB Descriptors of Significance of Effect Categories

Significance	Typical Descriptors of Effect
Very large adverse	Where the proposal would result in degradation of the water environment, because it results in predicted very significant adverse impacts on at least one water attribute. More than one attribute may be affected by a single project and each should be assessed and reported separately. For example: **Surface Water** Potential failure of both soluble or sediment bound pollutants in a High or Good watercourse OR in an EC Designated Salmonid fishery for both short term and long term assessments (Methods A and B); Loss or extensive change to a site/habitat protected under EC or UK legislation (SAC, SPA, Ramsar site, SSSI, WPZ, salmonid waters); Calculated risk of pollution from spillages is >2% when discharging into a Good watercourse, > 1% for a High watercourse*. **Groundwater** Potential high risk (risk score > 250) of pollution in Method C (Annex I) to a principal aquifer providing a regionally important resource or supporting a site protected under habitat legislation OR a medium to high risk (score>150) to an SPZ1; Calculated risk of pollution from an accidental spillage is >1% when discharging into an SPZ 1 or principle aquifer; Potential loss or extensive change to a site/habitat protected under EC or UK legislation (SAC, SPA , Ramsar site, SSSI, WPZ, salmonid water) through interception of groundwater flow or significant change to groundwater level. **Flood Risk** An increase in peak flood levels (1% annual probability) > 100mm increasing the risk of flooding to > 100 residential properties.
Large adverse	Where the proposal would result in a degradation of the water environment, because it results in predicted highly significant adverse impacts on a water attribute. More than one attribute may be affected by a single project and each should be assessed and reported separately. For example: **Surface Waters** Potential short-term (HAWRAT) failure of both soluble and sediment-bound pollutants in a High or Good watercourse OR in an EC Designated Salmonid fishery. Calculated risk of pollution from spillages is > 1% for a Good watercourse (or one of lower ecological class) and >0.5% for a High watercourse; Loss or extensive change to a cyprinid fishery; Loss or extensive change to a Local Nature Reserve. **Groundwater** Potential high risk (risk score >250) of pollution to a secondary aquifer providing water for a small number of dwellings, agricultural or industrial use and/or supporting Local Nature Reserves aquifer OR medium risk (Score 150-250) of pollution of a principal aquifer providing a locally important resource or supporting or supporting a site protected under habitat legislation, OR medium to high risk (score>150) to a SPZ2, OR potential low risk (score <150) to a SPZ1; Calculated risk of pollution from spillages is >0.5% when discharging to a principal aquifer or SPZ 1; Loss or extensive change to a Local Nature Reserve through interception of groundwater flow or change to groundwater level. **Flood Risk** An increase in peak flood levels (1% annual probability) > 50mm increasing the risk of flooding to > 100 residential properties OR an increase of >100mm increasing the risk of flooding to 1-100 residential properties.

Significance	Typical Descriptors of Effect
Moderate adverse	Where the proposal may result in the degradation of the water environment because it results in predicted moderate adverse impacts on at least one attribute. More than one attribute may be affected by a single project and each should be assessed and reported separately. For example: **Surface Waters** Potential short-term (HAWRAT) failure of either soluble or sediment-bound pollutants in a High or Good watercourse; Calculated risk of pollution from spillages is > 0.5% for a Good watercourse OR >1% for a Moderate or Poor watercourse; Partial loss or change to a fishery; Effect on the integrity of the existing flora and fauna. **Groundwater** Potential medium risk (risk score 150-250) to a secondary aquifer providing water for a small number of dwellings, agricultural or industrial use and/or supporting Local Nature Reserves OR potential low risk (risk score < 150) of pollution to a principal aquifer providing a regionally important resource or supporting a river ecosystem OR medium to high risk score (>150) to a SPZ3 , OR potential low risk (score<150) to a SPZ2, OR high risk (>250) for a discharge to unproductive strata Calculated risk of pollution from spillages is > 1% for an aquifer or SPZ3; Effect on the integrity of the existing flora and fauna through interception of groundwater flow or change to groundwater level. **Flood Risk** An increase in peak flood level (1% annual probability) > 10mm resulting in an increased risk of flooding to > 100 residential properties OR an increase of > 50mm resulting in an increased risk of flooding to 1-100 residential properties.
Slight adverse	Where the proposal may result in a degradation of the water environment because it results in a predicted slight impact on one or more attributes. More than one attribute may be affected by a single project and each should be assessed and reported separately. For example: **Surface Waters** Potential short-term (HAWRAT) failure of either soluble or sediment-bound pollutants in a Moderate or Poor watercourse; Calculated risk of pollution from spillages is > 0.5% for an Moderate or Poor watercourse; Temporary loss to, or loss in productivity of, a fishery; **Groundwater** Potential low risk of pollution (risk score < 150) to a secondary aquifer with limited agricultural use and connectivity to surface waters and local ecology OR low to medium risk (risk score <250) for a discharge to unproductive strata, OR low risk (score<150) to a SPZ3; Calculated risk of pollution from spillages is > 0.5% for an aquifer or SPZ3. **Flood Risk** An increase in peak flood level (1% annual probability) > 10mm resulting in an increased risk of flooding to a fewer than 10 industrial properties.
Neutral	Where the net impact of the proposals is neutral, because it results in no appreciable effect, either positive or negative, on the identified attributes. More than one attribute may be affected by a single project and each should be assessed and reported separately. For example: **Surface Waters** No risk identified by Method A or Method B assessment (Pass both soluble and sediment-bound pollutants); Calculated risk of pollution from accidental spillages < 0.5% annually. **Groundwater** No predicted change in quality of any type of aquifer and/or its use as a resource;

Significance	Typical Descriptors of Effect
	Calculated risk of pollution from accidental spillages < 0.5% annually. **Flood Risk** Negligible change in peak flood (1% annual probability) < +/- 10mm.
Slight beneficial	All other situations where the proposal provides an opportunity to enhance the water environment or provide an improved level of protection to an attribute. More than one attribute may be affected by a single project and each should be assessed and reported separately. For example: **Surface Waters** Method A assessment of either soluble or sediment-bound pollutants becomes a pass from previous Fail conditions for existing discharges; Reduction by 50% or more in existing pollution risk from accidental spillages into High to Poor watercourses (when existing spillage risk is < 1%). **Groundwater** Reduction by 50% or more in existing pollution risk from spillages into an aquifer (when existing spillage risk is <1%). **Flood Risk** A reduction in peak flood level (1% annual probability) > 10mm resulting in a reduced risk of flooding to 1-100 residential properties.
Moderate beneficial	Where the proposal provides an opportunity to enhance the water environment, because it results in a moderate improvement for an attribute. More than one attribute may be affected by a single project and each should be assessed and reported separately. For example: **Surface Waters** Method A assessment of both soluble and sediment-bound pollutants becomes Pass from previous Refer or Fail condition for existing discharges; Reduction by 50% or more in likelihood of pollution to watercourses from spillages from existing discharges through retrofitting of pollution control to outfalls into a High to Poor watercourse* (existing risk > 1%); Recharge of aquifer through provision of treated discharges to ground resulting in measurable improvements to a connected site/habitat of local nature conservation value i.e. Local Nature Reserve. **Groundwater** Reduction by 50% or more in existing likelihood of pollution arising from a spillage to an aquifer through retrofitting of pollution control (existing risk > 1%). **Flood Risk:** A reduction in peak flood level (1% annual probability) > 10mm resulting in a reduced risk of flooding to > 100 residential properties OR a reduction of > 50mm resulting in a reduced risk of flooding to 1-100 residential properties.
Large beneficial	It is extremely unlikely that any proposal incorporating the construction of a new or improved trunk road would fit into this category. However, proposals could have a large positive impact if it is predicted that it would result in a 'very' or 'highly' significant improvement to a water attribute(s), with insignificant adverse impacts on other water attributes. More than one attribute may be affected by a single project and each should be assessed and reported separately. For example: **Surface Water** Removal of an existing polluting discharge through provision of pollution prevention measures, or any other measure, affecting a site/habitat protected under EC or UK legislation (SAC, SPA, Ramsar site, SSS, WPZ, Salmonid waters); Reduction by 50% or more in the existing likelihood of pollution arising from a spillage affecting a site/habitat protected under EC or UK legislation (SAC, SPA, Ramsar site, SSSI, WPZ, Salmonid water) where existing risk > 1%.

Significance	Typical Descriptors of Effect
	Groundwater Removal of an existing polluting discharge within Zone 1 and 2 of a SPZ and/or a principal aquifer; Reduction by 50% or more in the existing likelihood of pollution arising from a spillage at discharge points within Zone 1 or 2 of a SPZ, principal aquifer and/or a site supporting a habitat protected under habitat legislation (existing risk > 1%); Recharge of aquifer through provision of treated discharges to ground resulting in measurable improvements to a connected site/habitat protected under EC or UK legislation (SAC, SPA, Ramsar site, SSSI, WPZ, Salmonid water). **Flood Risk** A reduction in peak flood levels (1% annual probability) >50mm reducing the risk of flooding to >100 residential properties OR a reduction of > 100mm resulting in a reduced risk of flooding to 1-100 residential properties.

Source: Table A4.6 of HD 45/09 (Highways Agency *et al.,* 2009).

Limitations of the Assessment

16.3.31 Welsh Government is committed to the policy of maintaining sea defences to the Gwent Levels through the Severn Estuary Shoreline Management Plan. The proposed new section of motorway can only have adverse effects on tidal flooding if the sea defences are breached by wave action or overtopped.

16.3.32 NRW's proposed flood defence improvements provide the required level of protection up to 2030 to comply with current planning policy guidance with respect to flood risk. Assuming these defences are built, the proposals for the new section of motorway would compliant with TAN15 up to 2030.

16.3.33 Continued improvements to sea defences beyond 2030, which is consistent with Welsh Government policy to 'Hold the Line' and the SEFRMS, would ensure that the proposed new section of motorway would remain compliant into the future.

16.3.34 The Gwent Levels Sites of Special Scientific Interest are designated because they support a range of qualifying features (wetland plants and freshwater invertebrates) which are able to survive and/or thrive in the prevalent eutrophic conditions. Water quality trigger levels have been derived (historically by CCW but now used by NRW) to assist developers in designing their projects and in undertaking their water quality monitoring. The trigger levels indicate the concentration above which damage could occur to the features of the Sites of Special Scientific Interest and which therefore need to trigger follow up monitoring and potential remedial action. These levels have been derived locally but have come from expert knowledge of the Gwent Levels environment as well as evidence and lessons learnt from major developments in the area over the past 25 years.

16.3.35 The assessment has been based on available information and established assessment techniques. It is therefore considered that it provides a robust basis for assessment for EIA purposes.

16.4 Baseline Environment

Geology and Topography

16.4.1 The new section of motorway would cross three distinct topographic zones.

- High elevation, Devonian Hills in the west around Castleton (Junction 29) (elevation of up to approximately 60 metres 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 (J23A) (elevation of up to approximately 60 metres AOD).

16.4.2 The geology encountered within the study area is shown on Figures 16.2 and 16.3 and summarised in Table 16.6 below.

Table 16.6: 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)
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)

16.4.3 Further details in relation to geology are provided in Appendix 11.1 of Chapter 11: Geology and Soils.

Hydrology

16.4.4 The route of the proposed new section of motorway would cross high ground in the east and west around existing junctions/interchanges at Magor and Castleton respectively.

16.4.5 In its mid-section, the study area crosses the River Ebbw and River Usk, to the south of Newport. The study area also includes the Alexandra Docks, between the Usk and the Ebbw. Collectively this central section of the new motorway is referred to as the 'new bridged section of motorway' (Chainage 8,400 to 11,400).

16.4.6 To the west and east of the River Usk are the Wentlooge Levels and Caldicot Levels (forming part of the Gwent Levels) respectively.

16.4.7 The principal water features located within the study area are shown on Figure 16.1 and Figure 16.4. These include the complex reen system of the Gwent Levels, the tidal estuaries of the River Usk and River Ebbw and the other watercourses. The main water features within the study area are summarised in Table 16.7.

Table 16.7: Main Water Features within Study Area

Chainage (m)	Name	Management	Additional Notes
Castleton			
5,100 – 5,300	Nant-y-Moor Reen	Former Internal Drainage Board (IDB)	Reen crosses alignment and runs parallel to the alignment between 5100 – 5300 before flowing eastwards.
5,600 – 5,700	SDR East Reen New	Former IDB	Alignment intersects the reen and subsequently joins Percoed Reen at the point of alignment intersection
5,600 – 5,700	Percoed Reen	Former IDB	Surrounding Percoed Reen, a number of other IDB reens and field drains join this reen. Flowing southwest.
Wentlooge Levels			
6,800 – 6,900	Morfa Gronw Reen	Former IDB	Connected with Percoed Reen
7,700 – 7,800	Old Dairy Reen	Former IDB	Connects with Pont-y-Cwcw Reen (NRW Reen)
7,900 – 8,000	Pont-y-Cwcw Reen	NRW	Multiple branch reens associated with Pont-y-Cwcw Reen.
8,400 – 8,500	Sea Wall Reen	NRW	Connected with Pont-y-Cwcw Reen.
New Bridged Section of Motorway			
c. 8,500	River Ebbw	NRW	
c. 9,600	Alexandra Docks	ABP	
c. 10,100	River Usk	NRW	
Caldicot Levels			
12,300 – 12,400	Lakes Reen	Former IDB	Joins Julians Reen south of alignment.
13,000	Julians Reen	Former IDB and NRW	Large reen that is joined by a number of other reens and field drains as it flows South. Becomes NRW main reen south of alignment.
14,300 – 14,400	Ellen Reen	Former IDB	Alignment intersects Ellen Reen just south of head of Ellen Reen.
14,700	Middle Road Reen	Former IDB	Short reen. Joins Blackwall Reen just south of alignment.
14,900	Blackwall Reen	Former IDB	Joins Ellen Reen south of alignment
14,900 – 15,000	Monk's Ditch	NRW	Intersected by alignment and associated junction.
16,600	Elver Pill Reen	NRW	Head of Elever Pill Reen just north of alignment.
17,900	Middle Road Reen Diversion	NRW	Joins from 100 Perches Reen and Greenmoor Reen. Intersected by alignment and associated junction.
18,450	Cock Street Reen	Former IDB	Possibly joins Rush Wall South Reen south of alignment.
19,300	Petty Reen	NRW	
Magor			
19,700	Stutwall East Reen & Bareland Street Reen East	Former IDB	Joins Blackwall West Reen

Gwent Levels

16.4.8 Approximately two thirds of the route for the proposed new section of motorway would cross the Gwent Levels. The Gwent Levels are an area of flat reclaimed coastal marshes that extend up to the Severn Estuary and comprise the Wentlooge Levels and Caldicot Levels to the west and east of Newport respectively. The Gwent Levels are low lying with an elevation of typically between 5 – 6 metres AOD. The Gwent Levels are split into a complex mosaic of small scale landowners, with small scale agricultural/livestock activities being the principal land use.

Environmental Sensitivity

16.4.9 The Gwent Levels are an area of high environmental sensitivity at a national level. The Gwent Levels are almost entirely designated as Sites of Special Scientific Interest (SSSIs) that include (from west to east): Rumney and Peterstone SSSI; St Brides SSSI; Nash and Goldcliff SSSI; Whitson SSSI; Redwick and Llandevenny SSSI; and Magor and Undy SSSI.

16.4.10 The Gwent Levels extend up to the Severn Estuary, which is designated at a national and European level as a Special Protection Area, Special Area of Conservation, Ramsar site and SSSI. They are also registered as a Landscape of Outstanding Historic Importance in Wales.

Drainage System

16.4.11 The Gwent Levels are a rainfall dominated system that conveys surface runoff to the Severn Estuary, principally through the complex network of tide locked freshwater drains, locally known as reens. The Levels are first drained by grips, small gullies which run parallel to each other through agricultural land and drain into the network of field ditches. Field ditches enclose most parcels of land on the Levels and convey water to the larger reens. Responsibility for the maintenance of field ditches rests with the riparian land owners. The ditches drain a complex array of smaller internal field drains and field grips. The Gwent Levels are also crossed by eight 'NRW watercourses' (that lie outside of the responsibility of the former Internal Drainage Board) shown in Figure 16.4 and summarised in Table 16.8.

16.4.12 The Gwent Levels were formerly under the management of Caldicot and Wentlooge Levels Internal Drainage Board (CWLIDB) with the exception of the NRW watercourses and the system under the management of Tata Steel, situated immediately south of the A4810 that crosses the former Llanwern site. The CWLIDB now forms part of NRW.

16.4.13 The water level within the Gwent Levels is controlled by a series of tidal sluice gates situated along the Severn Estuary, River Usk and River Ebbw, and approximately 200 internal sluices. The distribution of sluice structures within the study area is shown on Figure 16.4.

16.4.14 The Gwent Levels are managed to maintain agreed summer and winter 'penning levels'. The change to winter (low) penning levels occurs in October, with water levels then raised to summer penning levels in July. In addition to maintaining water levels through the system of sluice gates, an annual programme of dredging and clearance of the main reens is also undertaken.

16.4.15 The reen system is characterised by extremely low flow and apparently stagnant areas. During the winter and spring, lower levels are maintained to facilitate elevated flows to convey flood waters to the Estuary.

Water Use by Riparian Land Owners

16.4.16 Typically riparian land owners require the Gwent Levels to be drained to enable agricultural use and stock grazing. Surface water use within the Gwent Levels is therefore largely restricted to stock watering, with no NRW abstraction licences issued within the Gwent Levels in the study area.

Baseline Water Quality

16.4.17 The water quality within the reen system of the Gwent Levels is considered to reflect the low flow and significant organic loading associated with the setting. During the summer months, natural organic degradation results in significant nutrient enrichment. The high productivity and low/absent flow also result in low levels of dissolved oxygen and elevated Biological Oxygen Demand (BOD) compared to other rivers. Although highway drainage from existing roads is discharged to main watercourses, the reen system is generally considered to be characterised by the absence of heavy metals and other anthropogenic organic contaminants.

16.4.18 The baseline water quality within the reen system of the Gwent Levels has been determined from environmental monitoring undertaken as part of the assessment. The water quality dataset is presented and described in the Baseline Water Environment (BWE) Report provided in Appendix 16.2.

16.4.19 The inorganic chemistry of the reen system can generally be considered to be characterised by:

- neutral to mildly alkaline pH;
- moderate dissolved oxygen concentration, that rarely approaches saturation;
- freshwater chemistry of moderate mineralisation in terms of alkalinity, hardness and major ion chemistry (e.g. calcium, chloride and sulphate);
- common presence of key nutrients in oxidised and reduced forms;
- routine presence of the metals arsenic, boron, zinc, selenium and nickel; and
- occasional presence of other metals that include cadmium, chromium, copper, lead and mercury.

16.4.20 The reen system within the Gwent Levels is shown to contain freshwater with a chloride concentration typically below 100 mg/l and commonly below 50 mg/l. The notable exceptions to this include survey locations 17.2 and 17.3 and location SW05 (see Appendix 16.2). Location SW05 had a mean concentration of 260 mg/l and is located within the central area of the Tata Steel site, towards the southern boundary. Locations 17.2 and 17.3 are located in small reens adjacent to but outside of the Tata Steel site and had a concentration of 248 mg/l and 785 mg/l in March 2015.

16.4.21 A total of approximately 220 organic parameters were analysed in surface water samples, including total petroleum hydrocarbon (TPH) fractions, benzene, toluene, ethylbenzene and xylene (BTEX) compounds, volatile organic

compounds (VOCs) and semi-volatile organic compounds (SVOCs). With the exception of the occasional occurrence of Polycyclic Aromatic Hydrocarbons (PAH) (in up to four samples), no other organic contaminants were found in surface waters. It can therefore be concluded that water within the reen system is typically free from contamination by organic substances.

16.4.22 The water quality dataset has been screened against the most stringent Environmental Quality Standards and is presented in Appendix 16.2. The key findings include the following.

- A low dissolved oxygen concentration that often falls below the standard for 'good' status under the Water Framework Directive.
- The presence of nutrients at concentrations in excess of their respective Environmental Quality Standards.
- Occasional presence of metals, most notably cadmium, chromium and lead in surface water although they generally occur as spikes as opposed to routine occurrences in consecutive monitoring rounds.
- Rare occurrence of Polycyclic Aromatic Hydrocarbons at concentrations in excess of their respective Environmental Quality Standards.

16.4.23 When the water quality dataset is screened against the former CCW Trigger Levels it can be seen that some general parameters (pH and dissolved oxygen) and nutrient concentrations do exceed the Trigger Levels, but metals and organic constituents do not (Appendix 16.2). This indicates a general water quality status consistent with the hydrological setting of the system that is characterised by little flow and elevated nutrient concentrations.

NRW Watercourses

16.4.24 NRW has historically been responsible for the principal watercourses within the study area and a number of smaller watercourses that cross the Gwent Levels, but were outside of the control of the former CWLIDB. The former CWLIDB now forms part of NRW.

Principal Watercourses

16.4.25 The study area includes two principal watercourses, namely the River Usk and River Ebbw. These two estuaries are subject to large tidal fluctuations that commonly exceed six metres and are characterised by saline waters.

Water Framework Directive Status

16.4.26 The Water Framework Directive status of watercourses with the study area, as defined by NRW, is summarised in Table 16.8. The watercourses are generally considered to be of moderate status with the potential of becoming good by 2027.

Table 16.8: WFD Waterbodies

Waterbody Name and ID	Waterbody Length /Area. Hydro-morphological Designation	Current Overall Status / Potential	Current Ecological / Quantitative Status / Potential and Certainty[1]	Current Chemical Status /Potential and Certainty	Protected Area Designations	Status Objective and Justification if not 'Good' by 2015
Riverine Waterbodies						
Mill Reen - source to the R Severn Estuary (GB109056026860)	Length N/A Artificial	Moderate Potential	Moderate Potential (Certainty N/A) Supporting Conditions: Mitigation Measures – Moderate Quantity and Dynamics of Flow – Supports Good	Does Not Require Assessment	Habitats Directive	Good Overall Status by 2027 Good Ecological Potential by 2027 Justifications: Disproportionately Expensive Technically Unfeasible
Monks Ditch - Wainbridge to mouth (GB109056026810)	Length N/A Artificial	Moderate Potential	Moderate Potential (Very Certain) Supporting Conditions: Mitigation Measures – Moderate Quantity and Dynamics of Flow – Supports Good	Does Not Require Assessment	Habitats Directive	Good Overall Status by 2027 Good Ecological Potential by 2027 Justifications: Disproportionately Expensive Technically Unfeasible
Monks Ditch - source to Wainbridge (GB109056026850)	Length N/A Artificial	Moderate Potential	Moderate Potential (Certainty N/A) Supporting Conditions: Mitigation Measures – Moderate Quantity and Dynamics of Flow – Supports Good	Does Not Require Assessment	None	Good Overall Status by 2027 Good Ecological Potential by 2027 Justifications: Technically Unfeasible
Broadway Reen - source to R Severn Estuary (GB109056073370)	Length N/A Artificial	Moderate Potential	Moderate Potential (Very Certain) Supporting Conditions: Mitigation Measures – Moderate Quantity and Dynamics of Flow – Supports Good	Does Not Require Assessment	Habitats Directive	Good Overall Status by 2027 Good Ecological Potential by 2027 Justifications: Disproportionately Expensive Technically Unfeasible
Ebbw R – conf Ebbw Fach R to	Length N/A Heavily Modified	Moderate Potential	Moderate Potential (Uncertain - WoE[2])	Fail (Quite	Freshwater Fish Directive	Good Overall Status by 2027 Good Ecological Potential by

[1] For both riverine and transitional waterbodies, ecological status/potential is measured whereas for groundwater quantitative status is measured.
[2] Weight of Evidence – This notation is used where multiple elements are classed as 'Uncertain', however the data supporting these elements may all point to the same conclusion and therefore the current status/potential is classed as 'Uncertain' overall due to the 'Weight of Evidence' (Environment Agency, 2009).

Waterbody Name and ID	Waterbody Length /Area. Hydro-morphological Designation	Current Overall Status / Potential	Current Ecological / Quantitative Status / Potential and Certainty[1]	Current Chemical Status /Potential and Certainty	Protected Area Designations	Status Objective and Justification if not 'Good' by 2015
Maes-glas (GB109056026910)	Waterbody		Supporting Conditions: Mitigation Measures – Moderate Quantity and Dynamics of Flow – Supports Good	Certain)		2027 Good Chemical Status by 2027 Justifications: Disproportionately Expensive Technically Unfeasible
Unnamed trib - source to conf Ebbw R (GB109056026780)	Length N/A Artificial	Good Potential	Good Potential (Certainty N/A) Supporting Conditions: Mitigation Measures – Good Quantity and Dynamics of Flow – Supports Good	Does Not Require Assessment	None	Good Overall Status by 2015 Good Ecological Potential by 2015 Justifications: None
Transitional Waterbodies						
Usk (GB530905415404)	Area N/A Heavily Modified Waterbody	Moderate Potential	Moderate Potential (Certainty N/A) Supporting Conditions: Mitigation Measures – Moderate Tidal Regime and Freshwater Flow – Supports Good	Good Status	Freshwater Fish Directive Habitats Directive Birds Directive	Good Overall Status by 2027 Good Ecological Potential by 2027 Good Chemical Status by 2015 Justifications: Technically Unfeasible
Severn Lower (GB530905415401)	Area N/A Heavily Modified Waterbody	Moderate Potential	Moderate Potential (Uncertain) Supporting Conditions: Mitigation Measures – Moderate	Good Status	Bathing Water Directive Freshwater Fish Directive Birds Directive Urban Waste Water Treatment Directive	Good Overall Status by 2027 Good Ecological Potential by 2027 Good Chemical Status by 2015 Justifications: Disproportionately Expensive Technically Unfeasible

16.4.27 The Gwent Levels SSSIs are designated because they support a range of qualifying features (wetland plants and freshwater invertebrates) which are able to survive and/or thrive in the prevalent eutrophic conditions. Under the Water Framework Directive, the Gwent Levels waterbodies are defined as artificial and heavily modified. In practice this means that water quality criteria are not used as part of the routine classification of these waterbodies. In addition, environmental quality standards specific to an environment such as the Gwent Levels (a lowland, grazing marsh, drainage system) have not been drawn up. Regular water quality monitoring across the Gwent Levels undertaken by NRW occurs primarily to detect any gross pollution events. However, aspects of the Water Framework Directive water quality standards are relevant; including the Environmental Quality Standards for Priority Substances, as set out in Table 1 of Part 3 of the WFD Directions 2015. Of relevance to this Scheme are cadmium and lead (as well as standards for specific pollutants which could have eco-toxicity, as set out in Table 1 of Part 2 of the same Directions – those substances of relevance here include copper and zinc).

Baseline Water Quality

16.4.28 NRW monitoring data have been reviewed to determine water quality in the NRW watercourses. The entire dataset and detailed summary is presented in Appendix 16.2.

16.4.29 For the purposes of the baseline characterisation, the data collected for the following locations was reviewed.

- Broadway Reen.
- Haws Reen.
- Seven locations within the 'Newport Wetlands' (part of the Caldicot Levels).
- Windmill Pill Reen.
- Three locations on Monks Ditch.
- River Usk, downstream of the Transporter Bridge.

16.4.30 The water quality data for NRW watercourses confirm their freshwater nature, generally neutral pH, variable dissolved oxygen concentration, with the presence of some nutrients. Low concentrations of the metals zinc and copper were present within the reens, with a mean concentration of 16.6 µg/l and 2.6 µg/l respectively.

16.4.31 The water quality monitoring data for Monks Ditch confirm its freshwater status, with similar concentrations of nitrogen compounds, copper and zinc as seen in the reens. Dissolved oxygen concentrations are typically high and orthophosphate concentrations are low relative to the reens.

16.4.32 The water quality monitoring data for the River Usk are characterised by a high salinity, neutral pH and the presence of a variety of heavy metals most commonly nickel, lead and zinc. However, other heavy metals are also observed less frequently and include mercury, chromium and cadmium (less than 50% of analyses).

Alexandra Docks

16.4.33 The study area includes the Alexandra Docks in Newport. The docks are managed by Associated British Ports (ABP). Navigation in and out of the dock is facilitated via lock gates located at the south west corner, directly into the River Usk. The water level within the dock is maintained at approximately 12.9 metres Chart Datum (CD), which is around the level of a mean high water spring tide within the Usk Estuary.

16.4.34 There are no significant surface water inflows to the dock. The principal components of the water budget for the dock are therefore considered to be:

- direct rainfall to the dock;
- runoff from the dockside catchment area (including consented discharges from peripheral land users);
- direct surface water evaporation;
- leakage through lock gates;
- net transfer during gate operation; and
- compensation pumping by ABP to maintain levels in the dock.

16.4.35 The water contained in the Alexandra Dock is saline, although more dilute than expected in the estuary of the River Usk to which it is connected. The water quality in the dock is expected to reflect the water quality of the Usk Estuary, consented discharges and surface water dilution.

Tata Steel/Llanwern

16.4.36 Tata Steel currently operates a consent that permits a dry weather daily discharge of 28,000 m^3 of water to the Severn Estuary (Environmental Permit reference EPR/BR9715IB). This includes surface water runoff (both onsite and offsite), treated effluents and runoff from urban areas to the north of the Llanwern site. The Tata Steel water management area is principally situated between the A4810 and the Caldicot Levels, as shown on Figure 16.3, immediately south of the east-west ditch which is the key watercourse associated with the system.

16.4.37 The system is operated to maintain the lowest water levels within the local area, thus ensuring that no water flows from the Llanwern/Tata site to the surrounding reen system. During times of high rainfall, flood waters have been known to flow onto the Tata site and be processed through their water management system.

16.4.38 Waters within these areas are generally circulated around the system and discharge via the two reed beds, through the interceptor, to the outfall reen. The east-west ditch is the principal receiving watercourse that ultimately flows through the interceptor before discharge to the permitted discharge point. Water is discharged from a single point into the north-south discharge reen. This reen is approximately two metres deep and flows up to the pumping station where water is pumped to the outfall within the Severn Estuary.

16.4.39 The water quality at the point of discharge is controlled by the consent. Tata Steel monitors water quality at the discharge point. Historically, water quality samples have also been taken at a point prior to entry to the long sea outfall

discharge pipe. Surface water quality was monitored at ten locations around the Tata Steel water management area at the points shown in Figure 16.4.

Hydrogeology

16.4.40 A detailed description of the hydrogeology including geology within the study area is provided in the BWE Report in Appendix 16.2, with a summary provided below.

16.4.41 The WFD status of the groundwater within the route corridor are summarised in Table 16.9 below.

16.4.42 All the groundwater bodies have been assigned current good potential with an expected objective of both 'good overall' and 'good quantitative' status by 2015.

Aquifer Designations

16.4.43 The general hydrogeological status of each of the geological units identified within the study area is summarised in Table 16.10. This includes the NRW aquifer designation for each unit and associated British Geological Survey (BGS) hydrogeological description.

16.4.44 Where Glaciofluvial Deposits are exposed at the ground surface along the inland boundary with the Gwent Levels they are designated as a Secondary aquifer unit. NRW provides no formal aquifer designation for the Glaciofluvial Deposits that underlie the Tidal Flat Deposits within the centre of the study area and form a laterally continuous saturated granular unit (see Figure 16.3).

16.4.45 The study area is predominantly underlain by argillaceous bedrock of the Mercia Mudstone Group or St Maughans Formation. NRW considers these geological units to be Secondary B or Secondary A aquifers, reflecting the generally low productivity of these units.

16.4.46 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 within the study area, being largely restricted to the east.

Table 16.9: WFD Waterbodies – Groundwater

Waterbody Name and ID	Waterbody Length/ Area and Hydro-morphological Designation	Current Overall Status / Potential	Current Ecological / Quantitative Status / Potential and Certainty[3]	Current Chemical Status / Potential and Certainty	Protected Area Designations	Status Objective and Justification if not 'Good' by 2015
Usk and Wye Southern Carboniferous Limestone (GB40901G206300)	Area N/A No Hydro-morphological Designation	Good Status	Good Status (Low Certainty) Quantitative Elements: Impact on Wetlands – Good (Low) Impact on Surface Waters – Good (Low) Saline intrusion – Good (Low) Water Balance – Good (High)	Good Status (Low Certainty) Chemical Elements: DrWPA Test – Good (Low) Chemical Test – Good (Low) Impact on Wetlands – Good (Low) Impact on Surface Waters – Good (Low) Saline Intrusion – Good (Low)	Drinking Water Directive Nitrates Directive	Good Overall Status by 2015 Good Quantitative Status by 2015 Good Chemical Status by 2015 Justifications: None
Usk Devonian Old Red Sandstone (GB40902G201700)	Area N/A No Hydro-morphological Designation	Good Status	Good Status (Low Certainty) Quantitative Elements: Impact on Wetlands – Good (Low) Impact on Surface Waters – Good (High) Saline intrusion – Good (High) Water Balance – Good (High)	Good Status (Low Certainty) Chemical Elements: DrWPA Test – Good (High) Chemical Test – Good (High) Impact on Wetlands – Good (Low) Impact on Surface Waters – Good (High) Saline Intrusion – Good (High)	Drinking Water Directive Nitrates Directive	Good Overall Status by 2015 Good Quantitative Status by 2015 Good Chemical Status by 2015 Justifications: None

[3] For both Riverine and Transitional waterbodies, Ecological Status/Potential is measured whereas for Groundwater Quantitative Status is measured.

Waterbody Name and ID	Waterbody Length/ Area and Hydro-morphological Designation	Current Overall Status / Potential	Current Ecological / Quantitative Status / Potential and Certainty[3]	Current Chemical Status / Potential and Certainty	Protected Area Designations	Status Objective and Justification if not 'Good' by 2015
SE Valleys Southern Devonian Old Red Sandstone and Triassic Mercia Mudstone (GB40902G201500)	Area N/A No Hydro-morphological Designation	Good Status	Good Status (High Certainty) Quantitative Elements: Impact on Wetlands – Good (High) Impact on Surface Waters – Good (High) Saline intrusion – Good (High) Water Balance – Good (High)	Good Status (Low Certainty) Chemical Elements: DrWPA Test – Good (Low) Chemical Test – Good (Low) Impact on Wetlands – Good (Low) Impact on Surface Waters – Good (Low) Saline Intrusion – Good (High)	Drinking Water Directive	Good Overall Status by 2015 Good Quantitative Status by 2015 Good Chemical Status by 2015 Justifications: None

Table 16.10: Hydrogeological Status of Geological Units

Unit (Reference)	NRW Aquifer Designation	BGS Hydrogeological Description	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 Deposits (RTD)	Secondary A	-	Aquifer
Tidal Flat Deposits (TFD)	Unproductive strata in east. No designation in west.	-	Aquitard
Glaciofluvial Deposits (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 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 Maughans Formation (SMF)	Secondary A	Low productivity aquifer. Local sandstone and conglomerate aquifers yield small supplies.	Aquifer Unit
Raglan Mudstone Formation (RMF)	Secondary A	Low productivity aquifer. Highly indurated argillaceous rocks with limited groundwater.	Aquifer Unit

Groundwater Flow System

Bedrock

16.4.47 Groundwater flow within the bedrock beneath inland areas of higher elevation is expected to follow topography towards the Gwent Levels and/or local surface watercourses, particularly where superficial deposits are granular or absent. The principal receptor of groundwater flow is therefore expected to be either the saturated bedrock beneath the Gwent Levels; springs or spring-lines associated with local watercourses and the inland margin with the Gwent Levels; and/or surface watercourses that are in hydraulic continuity with underlying groundwater.

16.4.48 Ordnance Survey base mapping identifies many headwater springs that feed into the numerous small watercourses at the Castleton end of the new section of motorway. These features and watercourses rise on the flanks of the local topographic high point centred around Pen-y-lan approximately 1 km north of Castleton. A largely schematic cross section through this hydrogeologically active, western end of the study area is provided in Figure 16.5. This figure provides little clear hydrogeological basis for the occurrence of observed springs at different elevations, although this is presumed to relate to discrete groundwater bearing horizons within layered bedrock.

16.4.49 The lateral flow of groundwater is expected within bedrock concealed by the Tidal Flat Deposits of the Gwent Levels. This flow is expected to be orientated towards the Severn Estuary and/or major watercourses (i.e. the Rivers Ebbw and Usk). Little hydraulic continuity is expected between groundwater in bedrock and the reen system and watercourses of the Gwent Levels owing to the low permeability of the intervening Tidal Flat Deposits. Observations of groundwater levels and geology suggest this flow system may be more dynamic beneath the Wentlooge Levels compared to the Caldicot Levels in the east.

16.4.50 More significant groundwater flow can be expected to occur in limestone units of the Carboniferous Limestone Series that are present in elevated areas at the eastern end of the study area. Groundwater flow will principally occur through the solution enhanced secondary (fracture) permeability developed in the limestone. Groundwater flow directions are uncertain, although a general flow to the Gwent Levels is expected. Despite the presence of limestone, sandstone and marginal facies of the Mercia Mudstone Group in the east, very few springs are identified on baseline mapping in this part of the study area (See Figure 16.4).

Superficial Deposits

16.4.51 The silty clays that dominate the Tidal Flat Deposits of the Gwent Levels typically confine the underlying Glaciofluvial Deposits and/or Bedrock at depth. The low permeability expected for the Tidal Flat Deposits will inhibit vertical transfer of water between the ground surface and aquifer units at depth. The Tidal Flat Deposits are considered likely to promote lateral flows towards the surrounding reen system dominating the local system, either through surface water runoff or through saturated groundwater pathways in granular Made Ground or other overlying granular deposits.

16.4.52 Where present, the Glaciofluvial Deposits form a laterally continuous groundwater bearing unit beneath the Tidal Flat Deposits in the centre of the

study area, becoming progressively more discontinuous with distance to the east and west. Groundwater flow within the concealed Glaciofluvial Deposits is expected to be lateral, orientated towards the Severn Estuary or principal watercourses (e.g. the River Ebbw or River Usk).

16.4.53 Little groundwater is expected in the glacial till, although tortuous vertical flow pathways are expected to dominate in this unit.

Groundwater /Surface water Catchment Areas

16.4.54 OS base mapping identifies four small groundwater/surface water sub-catchments that surround the local topographic high point (of approximately 125 metres AOD) centred around Pen-y-lan approximately 1 km north of Castleton. These catchments are characterised by significant groundwater emergence in the form of springs, wells and wetland features that mark the source of the local watercourses. This area also corresponds with the location of much of the groundwater utilisation that has been identified within the study area. These sub-catchments include the following.

- Southerly/south easterly flowing watercourses, that rise immediately to the north of Castleton, and flow onto the Gwent Levels principally via Pwll Bargoed Reen and Church Reen.
- Easterly/south easterly flowing tributaries of Nanty-y-moor Brook, that flow onto the Gwent Levels, principally via Nant-y-Moor Reen.
- Westerly flowing tributaries of the Afon Rhymni that rise to the west of Michaelstone-y-Fedw.
- North westerly flowing tributary streams of the Afon Rhymni that rise in the area around Clearwell.

16.4.55 The seemingly significant emergence of groundwater within these catchments is surprising considering the local geology, which is dominated by bedrock of the St Maughan's Formation and Raglan Mudstone Formation, with a variable cover of Glacial Till. A north-south orientated cross section that passes from north of Pen-y-lan to the Gwent Levels is provided in Figure 16.10 and includes the existing M4 and proposed new section of motorway alignment in this area. The springs on these watercourses rise at various elevations with no obvious geological control on their emergence.

16.4.56 Areas of higher elevation at the eastern end of the study area around Magor are characterised by less evidence of groundwater emergence and southerly flow towards the Levels. This is consistent with the limited number of groundwater abstractions sources identified at this end of the study area, despite the generally more productive nature of the bedrock geology and absence of superficial deposits in this area.

Groundwater Receptors

16.4.57 The principal groundwater receptors identified within the local area include the following.

- Inland surface watercourses (i.e. away from the Gwent Levels) that receive active groundwater discharge principally via springs and seepages.
- River Ebbw and River Usk.

- Severn Estuary.
- Alexandra Docks.

16.4.58 The groundwater levels shown in Appendix 16.2 for the Gwent Levels suggest a degree of hydraulic continuity between bedrock/Glaciofluvial Deposits and tidal waterbodies in the vicinity of the Rivers Ebbw and Usk, particularly in association with the Wentlooge Levels. This implies potentially long (> 1 km) flow paths in the saturated Glaciofluvial Deposits/Bedrock before discharge to these tidal waterbodies can occur.

16.4.59 Although the reen system of the Gwent Levels represents a potential receptor for groundwater, the low permeability of the Tidal Flat Deposits is consistent with limited groundwater-reen interaction. It is considered that outside of the influence of tidal waterbodies, the Tidal Flat Deposits promote the lateral flow of groundwater towards the Severn Estuary.

Tidal Effects on Groundwater

16.4.60 Tidal influence of groundwater in the bedrock and Glaciofluvial Deposits is expected in the vicinity of the River Ebbw and River Usk. Tidal effects are not anticipated elsewhere within the study area considering the distance between these watercourses and the Severn Estuary.

Groundwater Utilisation

Abstraction Sources

16.4.61 The locations of groundwater abstraction sources are identified in Figure 16.4 and summarised in Table 16.11.

16.4.62 Groundwater utilisation is largely restricted to bedrock sources or spring sources located on higher ground around Castleton and Magor in the east and west respectively. Abstraction sources are typically for small domestic or agricultural supplies. There are no documented abstractions taken from the Glaciofluvial Deposits or bedrock beneath the Tidal Flat Deposits of the Gwent Levels within the study area.

Source Protection Zones

16.4.63 Source Protection Zones are designated around important groundwater supplies for the purpose of groundwater protection. No source protection zones have been defined within the study area. This reflects the limited resource potential of the groundwater bearing units in the area.

Groundwater Recharge

16.4.64 Groundwater recharge to the aquifer units identified within the study area is derived from the infiltration of precipitation to the ground surface within the inland catchment area to the north of the Gwent Levels themselves. The Tidal Flat Deposits are considered to be of low permeability and will not allow quantitatively significant vertical transfer of water between the surface and underlying aquifer units.

16.4.65 The continuity of granular Glaciofluvial Deposits identified beneath the Tidal Flat Deposits with inland granular deposits, where present, is likely to be of little

significance in the study area considering the general predominance of more cohesive superficial deposits overlying the Glaciofluvial Deposits inland of the Gwent Levels. Recharge to the Glaciofluvial Deposits is therefore considered to be controlled by its hydraulic relationship with the underlying bedrock that extends inland to the north and not localised surface exposures of inland granular deposits.

Hydraulic Properties and Aquifer Parameters

16.4.66 The result of permeability testing undertaken in boreholes within the study area is provided in Appendix 16.2. Hydraulic conductivity typically varies between 10^{-8} m/s and 10^{-4} m/s. Some data have been obtained for most geological units. The bedrock of the St Maughans Formation and Mercia Mudstone Group typically has a low permeability determined for the bedrock (10^{-8} m/s to 10^{-7} m/s) but with occasional high conductivities of up to 10^{-4} m/s. The Tidal Flat Deposits are interpreted as having variable hydraulic conductivity, as 'no analysis' was frequently possible from the permeability testing dataset, but with hydraulic conductivities of up to 10^{-5} m/s being observed.

Groundwater Salinity

16.4.67 The chloride concentrations plots provided in Appendix 16.2 indicate the following.

- Groundwater, principally in bedrock, in areas of higher elevation inland from the Gwent Levels (in the east and west) is typically fresh being characterised by a chloride concentration of below 250 mg/l.
- Shallow and deep groundwater with the Wentlooge Levels is typically fresh. This includes the bedrock beneath the Tidal Flat Deposits.
- Shallow and deep groundwater near the Usk and Ebbw is significantly more saline and non-potable in nature, being characterised by a chloride concentration typically in excess of 1000 mg/l.
- Within the Caldicot Levels to the east of the River Usk, shallow groundwater (typically perched above the Tidal Flat Deposits) is typically fresh whereas groundwater from the Tidal Flat Deposits and underlying Glaciofluvial Deposits and/or bedrock typically has a high chloride concentration in excess of 1000 mg/l.

16.4.68 The results of chloride analyses imply that groundwater encountered across much of the Gwent Levels does not constitute a potable water resource. Considering the fresh water nature of the surface reen system, the elevated salinity of deep groundwater supports the assumption that interchange between surface water system and deeper groundwater is limited, based on the expected hydraulic properties of the various water bearing units and their presumed hydrogeological status.

Table 16.11: Groundwater Abstraction

Ref.	Name / Location	Type	Data Source	Licence Nr	In Use	Notes
Western Section (Castleton)						
1.1 1.2 1.3	New Park Farm & Cottage, Penylan Road, Michaelstone-y-Fedw.	Spring West (issue) East (spring)	NCC, Arup 2008 Arup 2008 Arup 2008	NA NA NA	Yes - -	
2	Former Amgeki Abstraction Borehole	Borehole	Arup 2008	formerly 20/56/71/0012	No	
3	Walk Farm, Castleton.	Shallow Borehole	Arup 2008	NA	Yes	Garden Watering
4.1 4.2 4.3	Spring Court Farm, Cardiff Road, Coedkernew.	Spring Abstraction Tyn-y-nant Cottage Lower House	NCC, Arup 2008	NA NA NA	Yes	Piped from Spring at Spring Court Farm Piped from Spring at Spring Court Farm
5	Clearwell Farm, Pentre Poeth Road, Michaelstone-y-Fedw.	Spring	NCC	NA	Yes	Farmhouse and also shared with Barns converted into 6 residential units.
6	Colscote, Michaelstone-y-Fedw.	Spring	NCC	NA	Yes	Spring in garden
7	Richards & Partners Agriculture	Groundwater (presumed borehole)		21/57/12/0100	Yes	General Agriculture, Spray Irrigation.
8.1 8.2 8.3	Fairwater Farm, near Michaelstone-y-Fedw	Springs Springs near reservoir Spring at Five Oaks	Arup 2008	NA NA NA		
9	Pen-y-groes-fach	Disused well	Arup 2008	NA	No	
10	Pant-rhiw-gôch Farm	Abandoned well and spring fed stream	Arup 2008	NA	No	
11	Gelli Ber	Spring	Arup 2008	NA	No	Spring used as bog garden.
12	Gwaunshonbrown Farm	Abandoned well at residential dwelling.	Arup 2008	NA	No	
13	Cefn logell	Spring	Arup 2008	NA	No	
14.1	Pen-sidan	Issue at Pen-sidan farm yard used to serve the farm house	Arup 2008	NA	No	

Ref.	Name / Location	Type	Data Source	Licence Nr	In Use	Notes
14.2		Spring at Pen-sidan-fâch (old farm house).		NA	No	No evidence of spring found in 2008
14.3		Spring east of Pen-sidan fach		NA	No	Dry spring to east of Pen-sidan-fâch. Depth of channel suggests significant flows in wet season.
Eastern Section (Magor)						
15	Green Farm, Rogiet.	Borehole	NCC, NRW, ARUP 2008	20/56/72/0029 (Philips Agriculture)	Yes	General Agriculture, General Farming & Domestic EAW
16.1	Knollbury Barn, Magor	Borehole	MCC	NA	Yes	Single supply to domestic property
16.2	Knollbury Cottage / Knollbury	Unknown	Arup 2008			
17	Upper Grange Farm, St Brides, Netherwent.	Borehole	MCC	NA	Yes	Single supply to dairy farm
18	Lower Minnetts, Rogiet.	Borehole	MCC	NA		Single supply to domestic property
19.1 19.2 19.3	Church Farm, Wilcrick.	Well Spring Spring	Arup 2008	NA	No No No	
20	Rose Cottage, Knollbury	Abandoned Well	Arup 2008		No	

Groundwater Quality

Baseline Groundwater Quality: Bedrock

16.4.69 The baseline quality of groundwater in bedrock is characterised by the following.

- Frequently high chloride concentration that routinely exceed the Drinking Water Standards and Environmental Quality Standards of 250 mg/l (i.e. 60% of analyses).
- Neutral to mildly alkaline pH, that is within Drinking Water Standards and Environmental Quality Standards limits.
- Routine presence of many metals within groundwater, most notably arsenic, boron, chromium, copper, nickel, selenium and zinc (i.e. present in more than 70% of analyses undertaken).
- Mercury present in 25.9% of samples analysed at concentrations that all exceed the respective freshwater Environmental Quality Standards and 8% of samples exceeding the Drinking Water Standards.
- The DWS for arsenic, boron, chromium and selenium (approximately 27 to 50% of analyses) are routinely exceeded. The Environmental Quality Standards for copper, nickel and mercury are also exceeded routinely (i.e. 26% to 43% of samples).
- Infrequent occurrence of lead (5.9% of analyses), cadmium (7.1% of analyses) and mercury (25.9% of analyses) in bedrock groundwater and infrequent occurrence at concentrations above their respective Assessment Criteria.
- Generally elevated concentrations of Total Ammoniacal Nitrogen, with a mean concentration of 7.3 mg/l, that commonly exceeds the UK Drinking Water Standards for ammonium (following correction for temperature and pH) and the Environmental Quality Standards for ammonia (uncorrected).
- Infrequent occurrence of petroleum hydrocarbons (typically in less than 10% of samples analysed). Where present petroleum hydrocarbons are typically characterised by long-chain fractions, with the absence of benzene, toluene, ethylbenzene and xylene hydrocarbons.
- General absence of other organic compounds.
- Absence of cyanide (free and total).

16.4.70 There is significant difference in groundwater quality encountered within the bedrock at different points within the study area. Bedrock groundwater in the vicinity of the Rivers Ebbw and Usk is the most saline, reflecting the proximity and presumed continuity with local tidal waterbodies (i.e. River Usk, River Ebbw and Alexandra Docks).

16.4.71 The Caldicot Levels and areas close to the Rivers Usk and Ebbw are characterised by elevated chloride, sulphate and Total Ammoniacal Nitrogen concentrations, with the ubiquitous presence of metals that commonly exceed the Drinking Water Standards for arsenic, boron, chromium and selenium and the Environmental Quality Standards for nickel and copper. Although the common presence of metals in groundwater represents an anthropogenic source, the pathway is unclear.

16.4.72 Elsewhere the bedrock groundwater is fresh in nature and largely free of organic contaminants. Although the concentration of metals infrequently exceeds their respective Drinking Water Standards or Environmental Quality Standards, a number of metals are routinely found in bedrock groundwater, most notably arsenic, boron, chromium, nickel and selenium. Thus baseline groundwater quality in bedrock is characterised by background concentrations of these metals, although their source is uncertain.

16.4.73 Organic contamination is not commonly observed often in the groundwater, but is observed most frequently in the Caldicot Levels.

Baseline Groundwater Quality: Tidal Flat Deposits

16.4.74 The groundwater quality in the Tidal Flat Deposits is characterised by the following.

- Frequently high chloride concentration that routinely exceeds 250 mg/l (approximately 73% of samples).
- Neutral to mildly alkaline pH.
- Elevated Ammoniacal Nitrogen, with a mean concentration of 12.2 mg/l. Concentrations routinely exceeds the Drinking Water Standard for ammonium (following correction for temperature and pH) and the Environmental Quality Standard for ammonia.
- Routine presence of heavy metals in groundwater. The Drinking Water Standards for arsenic, boron and selenium are commonly exceeded. The concentration of chromium and manganese exceed their respective Drinking Water Standard less frequently and only occasionally exceed the Drinking Water Standard for other metals.
- Infrequent occurrence of cyanide (Free and Total).
- The occasional occurrence of petroleum hydrocarbons (typically in less than 10% to 13% of samples of samples), where it occurs more commonly as longer chain fractions.
- Rare occurrence of benzene, toluene, ethylbenzene and xylene hydrocarbons.
- General absence of other organic compounds.

Baseline Groundwater Quality: Glaciofluvial Deposits

16.4.75 The groundwater quality in the Glaciofluvial Deposits is characterised by the following.

- Frequently high chloride concentration that routinely exceeds 250 mg/l (approximately 70% of samples).
- Neutral to mildly alkaline pH (with a mean of 7.84).
- Elevated Ammoniacal Nitrogen, with a mean concentration of 6.7 mg/l. Concentrations routinely exceeds the Drinking Water Standard for ammonium (following correction for temperature and pH) and the Environmental Quality Standard for ammonia.
- Routine presence of heavy metals in groundwater. The Drinking Water Standard for arsenic, boron and selenium is commonly exceeded

(approximately 50% of analyses). The concentration of chromium exceeds the Drinking Water Standard less frequently and the Drinking Water Standards for mercury and manganese are only occasionally exceeded.

- Absence of cyanide (Free and Total).
- The occasional occurrence of petroleum hydrocarbons (typically in less than 10% of samples), where it occurs more commonly as longer chain fractions.
- Rare occurrence of benzene, toluene, ethylbenzene and xylene hydrocarbons.
- Absence of other organic compounds.

Baseline Groundwater Quality: River Terrace Deposits and Glacial Till

16.4.76 An extremely small number of analytical results were available for these inland units (four and two samples for River Terrace Deposits and Glacial Till respectively), hence the representativeness of these datasets is questionable. Metals are identified in groundwater from these units but Drinking Water Standards are not exceeded, with the exception of boron. pH is neutral to mildly alkaline. Cyanide is absent. Organic parameters, including petroleum hydrocarbons, are absent.

Conceptual Hydrogeological Model

16.4.77 The key aspects of the baseline water environment are summarised in Figure 16.4. By combining geological data (taken from BGS mapping and site-specific geological logs) with the hydrological and hydrogeological information described above, a Conceptual Hydrogeological Model (CHM) has been developed that provides a description of the baseline water environment. The CHM is provided in Figure 16.5.

Receptor Sensitivity/Value

16.4.78 The various receptors relevant to the consideration of the water environment are summarised in Table 16.12. This table also provides the sensitivity/value designated to each receptor used in the assessment of effects and provides the justification for this value.

Table 16.12: DMRB Receptor Sensitivity

Receptor Details		Sensitivity / Value	Justification
Surface Water	Gwent Levels Drainage System	Very High	Reen system of Gwent Levels is designated as a SSSI of national importance
	Inland Watercourses (non-SSSI)	High	WFD Status Good
	Tidal Waterbodies - Designated (i.e. River Usk / Severn)	Very High	Usk and Severn WFD transitional water designated as a SAC
	Tidal Waterbodies - Non-designated (River Ebbw)	Medium	Non-designated, WFD waterbody with a status that currently has moderate potential
	Surface Water Users / Livestock	Low	Non potable water resource principally used for local stock watering

Receptor Details		Sensitivity / Value	Justification
Groundwater	Groundwater Users	Medium	Generally small private water abstractions serving individual properties or tied properties from secondary aquifer
	Bedrock - Inland Bedrock (Castleton / Magor)	Medium	WFD Groundwater. Typically a Secondary aquifer of limited resource potential, localised Principal. Active groundwater utilisation typically for small abstractions
	Bedrock & Glaciofluvial Deposits - Wentlooge Levels	Medium	WFD Groundwater Typically a Secondary Aquifer of limited resource potential
	Bedrock & Glaciofluvial Deposits - New bridged section of motorway	Low	Non-potable Secondary Aquifer
	Bedrock & Glaciofluvial Deposits - Caldicot Levels	Low	Generally non-potable Secondary Aquifer
	Non-designated Groundwater Dependent Receptors (Castleton / Wentlooge Levels)	Medium	This includes non-designated groundwater fed wetlands, streams and springs. Absence of groundwater dependence within the Gwent Levels, only really significant around Castleton in the west of the scheme.

Flood Risk

Introduction

16.4.79 The study area includes the Wentlooge and Caldicot Levels, alongside the banks of the Severn Estuary.

16.4.80 The Caldicot and Wentlooge Levels are two areas of low lying estuarine alluvial wetland and intertidal mudflats adjoining the north bank of the Severn, either side of the River Usk estuary near Newport. They are also known collectively as the Monmouthshire Levels or Gwent Levels.

16.4.81 The Caldicot Levels lie to the south east of Newport (between the River Usk and River Wye) and consist of 17,500 acres (71 km^2). the area is home to the Newport Wetlands Reserve.

16.4.82 The Wentlooge Levels lie to the south west (between the River Usk and Rhymney River) and consists of 8,500 acres (34 km^2).

16.4.83 There is an extensive network of reens and drainage channels within the low lying area. The reens are intensively managed and serve an important dual function: to store runoff during tide-locked periods in the winter and to supply water for livestock in the summer.

16.4.84 The route of the new section of motorway passes 11 catchments defined by Flood Estimation Handbook (FEH) CD-ROM and is protected from tidal inundation by the existing sea defences. The Flood Estimation Handbook

software suite implements the Centre for Ecology and Hydrology (CEH) national design standards for rainfall and river flood frequency estimation in the UK.

Existing Tidal Defences

16.4.85 The Levels are defended from the tidal impacts of the Severn through a continuous raised embankment. This embankment is of mixed construction and offers a varied level of service against overtopping. These defences protect approximately 25,000 commercial and residential properties from flooding within Newport and the wider Gwent Levels.

16.4.86 The Levels are drained through a network of reens, being lowland drains which outfall to the tidal estuary though a series of tide gates and sluices. Most of the area lies below extreme tide levels, and so during high tides, the reen network is tide-locked and unable to discharge. The result is that the tidal waters are prevented from entering the reens and the levels.

16.4.87 It is acknowledged that under certain extreme conditions, there is an existing risk that the existing tidal defences will be overtopped and that both spray and overtopping water will pass over the defences and into the system.

Extreme Water Levels and Waves

16.4.88 The Severn Estuary Flood Risk Management Strategy (SEFRMS) generated Severn Estuary specific Joint Probability Assessment (JPA) data in 2008. This covered individual and combined Extreme Water Levels (EWL) and waves between the 1 year and 1,000 year return period (100%-0.1% Annual Exceedance Probability - AEP). The relevant data and locations are provided in the FCA in Appendix 16.1.

16.4.89 Subsequent to this, in 2011, the Environment Agency (England and Wales) generated a national EWL dataset (including information on confidence intervals). The relevant data and locations are shown in the FCA at Appendix 16.1. The Environment Agency (2011) dataset does not extend upstream beyond the Second Severn Crossing.

16.4.90 The SEFRMS wave and JPA analyses remain the only estuary-wide analyses across the Severn Estuary. It is apparent that the Environment Agency (2011) dataset has different EWLs than the SEFRMS dataset. This indicates that (with confidence intervals included) for less extreme events the SEFRMS EWLs are higher than Environment Agency EWLs, and for more extreme events vice versa. The two datasets agree most closely around the 100 year return period (1% AEP) event, although this agreement also varies spatially.

16.4.91 The Environment Agency has issued climate change advice (Environment Agency, 2011), drawn from UK Climate Change Projections (UKCP09) and the Intergovernmental Panel on Climate Change Fourth Assessment Report (IPCC AR4). This advises consideration of the low 50%ile, medium 95%ile, upper end (plus surge), and if necessary high impact range (high-plus-plus) scenarios.

16.4.92 Detailed values for sea level rise are given, but the Environment Agency (2011) did not give a clear view on wave height changes.

Existing Coastal FRM Asset Performance

16.4.93 A topographic survey of the coastal Flood Risk Management (FRM) assets was undertaken in 2010, as part of the SEFRMS.

16.4.94 The River Rhymney and River Usk geometry was not based on detailed survey at the time (instead it was based on National Flood and Coastal Defence Database, LiDAR and localised survey elevation data).

16.4.95 The SEFRMS also undertook a performance assessment of the coastal Flood Risk Management (FRM) assets, defining the Standard of Protection for tidal weiring, wave overtopping, damage and breach.

16.4.96 In overview, this indicates that large lengths of the coastal FRM assets have at least 1 in 1,000 year (0.1% AEP) Standards of Protection against breach, with localised lower sections near Sluice Farm and Chapel Farm, and along the rivers Rhymney and Usk. Consideration of the Environment Agency (2011) and SEFRMS EWL differences indicates the following.

- For locations with quoted Standards of Protection of less than 100 years (1% AEP), the Standard of Protection would increase using the Environment Agency (2011) dataset.
- For locations with quoted Standards of Protection of greater than 100 years (1% AEP) (especially on the Caldicot Levels), the Standard of Protection may decrease slightly using the Environment Agency (2011) dataset but still remain above 100 years (1% AEP).

Future Baseline Conditions

16.4.97 The Welsh Government report 'Climate Change Risk Assessment for Wales' (Welsh Government, 2012) presents a national assessment of potential risks (and opportunities) from climate change facing Wales for the period to 2100.

16.4.98 From the results, the potentially most significant risks for Wales from climate change to the water environment appear to be:

- changes in soil conditions, biodiversity and landscape due to warmer, drier summers;
- reductions in river flows and water availability during the summer, affecting water supplies and the natural environment;
- increases in flooding on the coast and inland, affecting people, property and infrastructure; and

  changes in coastal evolution including erosion and coastal squeeze, affecting beaches, intertidal areas and other coastal features.

Current and Future FRM Strategy for Wentlooge and Caldicot Levels

16.4.99 The SEFRMS is still undergoing final agreement with NRW's Large Project Review Group and Integrated Regional Operational Programme sign off with Defra/Welsh Government. However, it is understood the SEFRMS is being used as a technical document to guide the future management of FRM assets.

16.4.100 The strategy recommendations for the Wentlooge and Caldicot Levels contained within SEFRMS are:

'At the Wentlooge Levels, River Ebbw to River Usk, and Caldicot Levels (all Wales), all Sustain or Improve options return high benefit-cost ratios (BCRs), with the highest BCR for Sustain or Improve defences in current form with 2%AEP SoS [1 in 50 year standard of service]. As iBCRs are well above unity for all %AEP, the economically preferred option is Improve defences in current form with 0.1%AEP SoS keeping pace with climate change [1 in 1000 year standard of service into the future].

The environmentally preferred option is Improve, as a reduction in flood risk will benefit people, property, infrastructure and historic assets. All Sustain or Improve options would continue to cause intertidal habitat loss by coastal squeeze and direct footprint increase impacts within the Severn Estuary SPA, SAC and Ramsar.

The selected option for Wentlooge Levels, River Ebbw to River Usk, and Caldicot Levels is Improve defences in current form with 0.1%AEP SoS keeping pace with climate change [1 in 1000 year standard of service into the future], recommended as priority schemes within 5 years due to their strong economic case. Scheme level business cases are currently underway for the Wentlooge Levels and Caldicot Levels locations.'

16.5 Mitigation Measures Forming Part of the Scheme Design

16.5.1 Design measures have been incorporated into design of the new section of motorway in order to minimise potential impacts on the water environment. Details of the proposed drainage strategy and reen mitigation strategy are provided in Chapter 2: Scheme Description and in Appendices 2.2 and 2.3.

16.5.2 Following consultation and review undertaken during the preliminary design process, a set of design criteria for drainage was developed which promote sustainable drainage and meet the requirements of Natural Resources Wales and South Wales Trunk Road Agency (SWTRA) and the Design Manual for Roads and Bridges (DMRB) guidelines. These design criteria reflect the unique hydrological environment of the Gwent Levels.

16.5.3 The normal design standards for trunk roads and motorways are that drainage pipework is designed to accommodate a 1 year return period storm within the pipework and to ensure that a 5 year return period storm does not result in surface flooding.

16.5.4 This was recognised as being an inappropriate standard for the proposed new section of motorway due to the risk of potentially contaminated surface water finding its way into the reen system on the Gwent Levels. Consequently, the highway drainage systems have been designed to contain all flows up to a 100 year storm, including a 30% increase in precipitation to account for climate change. Such an event could be expected to be exceeded, on average, only once every 100 years. The drainage systems are capable of conveying this flow to the water treatment areas for attenuation and treatment.

16.5.5 A Drainage Strategy Report has been produced and is provided at Appendix 2.2. The content of the Drainage Strategy Report has been discussed and agreed in principle with NRW. In summary, the specification for the proposed drainage

considerably exceeds that required by the standards normally adopted for trunk roads and motorways.

16.5.6 With respect to water treatment, the Scheme includes the following measures.

- The detailed design of the full treatment train at water treatment areas.
- The derivation of re-use criteria (RTCs) that are protective of controlled waters (both surface waters and groundwater) for site won soils and/or stabilised materials from the former Llanwern steekworks site to be used as general embankment fill.

16.5.7 It is proposed to intercept the runoff from the new section of motorway into grassed channels in the road verge. These channels would transfer the runoff to water treatment and attenuation areas. The grassed channels would be lined with a geosynthetic clay liner (and topsoil) to contain pollutants. The use of grassed channels would reduce the flow rate and would allow for some sediment to be deposited and oily residues and organic matter to be retained and broken down. Where the use of grassed channels is not possible, concrete channels would be utilised.

16.5.8 With the exception of discharges to the River Usk and the River Ebbw, all drainage would be treated through the identified water treatment areas. These would typically include provision for capture of hydrocarbons and grit prior to runoff entering the main attenuation lagoons. Discharges to the Usk and Ebbw being tidal do not require flood compensation lagoons but will be provided with oil interceptors. Given the Usk Estuary comprises a Special Area of Conservation, additional protection would be provided in the form of a pollution retention basin to protect the river in the event of a serious pollution event on the carriageway.

16.5.9 The detailed design of water treatment area is described in the Drainage Strategy (Appendix 2.2) and includes for separate elements that provide pollutant-removal methods these include the following.

- Grass lined channels that provide pollution removal whilst conveying high runoff to other treatment elements.
- Pollution control lagoon capable of separating oil via a baffle plate.
- Wet balancing pond providing a bunded volume of up to 1.1 metre above existing ground level to retain the 1 in 100 year plus 30% climate change rainfall event and to allow dilution as an important attenuation process for inorganic pollutants, principally comprising chloride and sulphate.
- Reed beds to provided dedicated wetland area for the treatment of residual soluble and suspended pollutants.

16.5.10 Each water treatment area has been designed to ensure that it provides sufficient treatment capacity to ensure the discharge would meet DMRB requirements and regulatory requirements for the protection of the Gwent Levels SSSIs, most notably with respect to heavy metals, organic contaminants associated fuels, oils and hydrocarbon combustion and major ions principally associated with de-icing. Each water treatment area would include a sediment trap, oil interceptor, pollution bypass lagoon, permanently wet flood attenuation and dilution lagoon and a substantial area of reed bed. Discharge water would be released at the Greenfield runoff rate. The detailed water treatment area design is described in the Drainage Strategy (Appendix 2.2).

16.5.11 Grass lined channels are a widely recognised sustainable drainage solution and offer substantial benefits over concrete channels in retaining and breaking down pollutants within road runoff as well as reducing the transport of suspended sediments. The grass channels also act to slow and temporality store runoff thus contributing to the reduction in flood risk.

16.5.12 It is accepted that there is a strong dependence between the biodiversity of the Sites of Special Scientific Interest and surface water quality within the Gwent Levels. However, given the Gwent Levels are defined under the Water Framework Directive as artificial and heavily modified waterbodies, water quality criteria are not used as part of the routine classification of surface watercourses.

16.5.13 Additionally, given the acknowledged high uncertainty regarding the effect of changes in water quality in relation to the conservation objectives of the Sites of Special Scientific Interest, the Scheme design has aimed to preserve existing water quality within the reens. To achieve this, bespoke water treatment areas have been incorporated into the Scheme design capable of attenuating 1 in 100 year (plus climate change) rain events, as well as reducing concentrations of highway derived chemical constituents to ambient levels.

16.5.14 These ambient pollutant levels have been delineated at the proposed water treatment area reen discharge points through the four quarterly monitoring rounds capturing both summer and winter penning levels.

16.5.15 Water quality would continue to be monitored for at least 12 months of operational use of the new section of motorway to demonstrate acceptable quality of the water treatment area discharges.

16.5.16 A Reen Mitigation Strategy has been produced and is provided at Appendix 2.3. The content of the Reen Mitigation Strategy has been discussed and agreed in principle with NRW.

16.5.17 The proposed new section of motorway would cross reens and field ditches at a series of locations, which would be infilled. The estimated length of reens that would be infilled and culverted is approximately 2,570 metres. The estimated length of field ditch crossings that would be infilled as part of the Scheme is approximately 9,150 metres. Details are provided in Appendix 2.3.

16.5.18 In order to replace the loss in length of reen and field ditch, new reens would be provided along the north of the highway in areas in which existing reens are being infilled. These reens would be excavated to a depth of 2 metres with 1 in 1 side slopes, a 0.7 metre berm and a width of approximately 5.7 metres at the surface.

16.5.19 Replacement reens would generally be provided on the north side of the new section of motorway to provide improved connectivity with the cross flow culverts.

16.5.20 On the south side, smaller field ditches would be used to connect the existing field ditches to the nearest main reens. These would be 2.5 metres wide with 1 in 1 slopes and 1 metre deep. These would connect to the nearest main reens to provide connectivity and offset losses.

16.5.21 Figure 2.5 shows the current proposals for the reen mitigation. Reens and field ditches would be replaced at a ratio of greater than 1:1. It is proposed to provide

2,657 metres of new reen and 9,771 metres of new field ditches. Further details are provided in Appendix 2.3.

16.5.22 All of the above measures have been included in the assessment of potential effects set out below in Sections 16.6 to 16.8.

16.6 Assessment of Potential Land Take Effects

16.6.1 No effects have been identified associated solely with land take. Impacts on the water environment are therefore considered in Sections 16.6 and 16.7 below.

16.7 Assessment of Potential Construction Effects

16.7.1 This section assesses the significance of potential effects on the water environment that may arise during the construction phase of the Scheme. The following potential effects are considered.

- Changes to surface water quality.
- Changes to groundwater in terms of quality, resource potential and associated effects on non-designated groundwater dependent features (i.e. springs, wetlands and groundwater fed watercourses).
- Effects on private water supplies.
- Changes in flood risk and conveyance of drainage.

16.7.2 Potential effects associated with the construction phase are typically short to medium term in nature and of localised extent, although in some cases they can occur across a wider area.

16.7.3 The assessment presented in this section considers the potential magnitude of impact and significance of effects of construction before mitigation. The assessment for each of the receptors identified in Table 16.12 is summarised in Tables 16.13 to 16.16.

Proposed New Section of Motorway

Surface Water Quality

16.7.4 Many activities undertaken during the construction phase have the potential to affect surface water quality within the construction corridor for the new section of motorway. The significance of each these effects on surface water quality is summarised in Table 16.13 and described below.

Temporary Access Roads, Compounds and Storage/Laydown Area

16.7.5 All access roads, construction compounds and material laydown/storage areas would generate surface water runoff, which may affect surface water quality if allowed to enter surface watercourses directly during construction. Runoff generated during the construction phase has the potential to be characterised by a significant sediment load and may contain certain potentially polluting substances.

16.7.6 The storage, handling and use of potentially hazardous substances and heavy plant machinery in these areas during construction also represents a source of

contaminants that could be entrained in runoff or involved in a direct release to ground and/or surface water.

16.7.7 The locations of temporary site compounds are described in Chapter 3 and shown on Figure 2.16/Appendix 3.2. Compounds are located outside of the Gwent Levels at the western (Castleton) end of the new section of motorway, to the east and west of the River Usk and in several locations around the existing Magor Interchange in the east. In addition to runoff generation, the handling and storage of potentially hazardous materials in these areas has the potential to impact groundwater and surface water quality.

Borrow Pits

16.7.8 Borrow pits are proposed outside of the Gwent Levels SSSIs at the eastern and western ends of the new section of motorway (see Figure 16.1). The excavation of natural materials from borrow pits may generate runoff that has the potential to be contaminated and is likely to be characterised by a high sediment load. Uncontrolled runoff from the borrow pit areas therefore has the potential to affect water quality in the inland watercourses adjacent to the excavation sites. These watercourses then flow on to the Gwent Levels principally via Nant-y-Moor Reen in the west.

16.7.9 Groundwater dewatering may be required in borrow pits to facilitate excavation. The resulting groundwater would be discharged to local watercourses. Although the baseline groundwater quality in the inland bedrock aquifer is typically expected to be good, the resulting water is likely to be characterised by a significant sediment load. There is also the potential for contaminated groundwater to be encountered that relates to currently unknown sources of contamination. The discharge of groundwater of lower quality to surface watercourses may therefore potentially affect surface water quality.

Construction of Embankments

16.7.10 The design and methodology for embankment and associated haul road construction is described in the Buildability Report (Appendix 3.1). The proposed design of embankments is summarised in the schematic conceptual pathway drawings provided at Figures 16.6 to 16.9.

16.7.11 It is intended that all embankments would be constructed using a fill material composed of site won materials and/or stabilised soils derived from the former Llanwern steelworks site situated on the Caldicot Levels (i.e. re-used materials). Additionally, some haul roads may be constructed on cement stabilised ground to improve bearing conditions. As shown on Figures 16.6 to 16.7, the depth of re-used fill material within an embankment (i.e. general embankment fill) would depend on the height of the engineered basal layers (e.g. working platform, drainage blanket etc.) and the depth of the surface cover required on the top and sides of the embankment. When laid, the general embankment fill would be compacted to Welsh Government specifications and would therefore be characterised by low porosity and low permeability.

16.7.12 Embankments within the Gwent Levels would be constructed directly on the Tidal Flat Deposits. No excavation works would therefore be required during construction, with the following exceptions.

- Known areas of existing contamination that require remediation, most notably around Solutia and Llanwern to the east of Newport (described in the Contamination Land Assessment Report (Appendix 11.1) and summarised in Chapter 11 of this ES: Geology and Soils).
- Areas where contamination is discovered, through pre-construction investigations works and/or activities.

16.7.13 Embankments with a design height of less than 5 metres require the Tidal Flat Deposits upon which they are constructed to be dewatered and compacted to prevent settlement during the operational lifespan of the highway. Dewatering would be achieved by the installation of vertical, porous band drains that enable porewater within the Tidal Flat Deposits to be drained and discharged to the underlying Glaciofluvial Deposits/bedrock aquifer or to the overlying drainage blanket during a period of surcharging (Figure 16.6). During surcharging, the surface embankment would be built using compacted clean soils to a sufficient height to ensure that runoff is maintained throughout settlement and the embankment fill remains largely dry.

16.7.14 Porewater dewatered from the Tidal Flat Deposits during surcharging is likely to be brackish, with elevated ammoniacal nitrogen concentrations and the presence of a variety of metals. Due to downward vertical gradients (see Baseline Water Environment Report at Appendix 16.2), porewater from the Tidal Flat Deposits is likely to flow downwards through the band drains to the underlying bedrock or Glaciofluvial Deposits, as opposed to an upward flow to the drainage blanket and subsequent lateral flow which could appear as seepages within the Gwent Levels. A short term temporary effect on water quality in receiving watercourses in the Gwent Levels could be observed should upward vertical flow occur and be quantitatively significant. For conservativism, a minor magnitude of impact on the surrounding reen system is assumed for the unmitigated scenario presented in Table 16.13. For an effect on tidal waterbodies to be observed, downward flow through band drains and lateral flow in groundwater would be required. However, a measurable effect on water quality at these receptors is not expected, considering the distance of these receptors, the quantity of flow expected and short term nature of this effect as presented in Table 16.13.

16.7.15 Dewatering of Tidal Flat Deposits by band drains would not be required for embankments that are greater than 5 metres in height, which would instead be supported by piles driven into competent bedrock (Figure 16.8). Piled embankments would be constructed on a basal layer and piling platform situated directly on the Tidal Flat Deposits. These layers would be composed of clean, compacted, granular materials which would behave in a similar manner to the drainage blanket used in lower embankments.

16.7.16 The potential pathways for water movement associated with rainfall onto embankments during construction would be as follows.

- Direct runoff from the embankment surface to adjacent land and watercourses.
- Vertical infiltration through embankment fill into the drainage blanket that would discharge via band drains to groundwater in the underlying Glaciofluvial Deposits or bedrock.
- Vertical infiltration through the embankment fill with leakage down the sides of

piles to the underlying aquifer.

- Vertical infiltration through the embankment into the drainage blanket or into the piling base layer that would then flow laterally through this granular layer and emerge as small seepages along the embankment edge that may enter into compensatory reens or field drains by lateral overland flow.

16.7.17 Direct runoff from the embankment surface during construction/surcharging could have a high sediment load, a potentially elevated pH and may contain certain potentially polluting substances. The uncontrolled discharge of this runoff therefore has the potential to affect surface water quality within the Gwent Levels SSSIs and other inland watercourses, depending on the position of the embankment.

16.7.18 Water that infiltrates through general embankment fill has the potential to affect surface water quality within the Gwent Levels SSSIs by lateral discharges from the drainage blanket or granular basal layers in piled embankments (Figure 16.6 and Figure 16.8). The significance of this effect would be dependent on the flux of infiltration through embankment fill, the quality of the infiltrating water and the time taken to reach the drainage blanket/basal layer. The quality of water that infiltrates through the embankment fill to the drainage blanket would be dependent on the quality and leachability of the materials used as general embankment fill.

16.7.19 Estimates of the likely infiltration rate through embankment fill are based on research reported by TRL (2006). The following outcomes are expected.

- Infiltration through embankment fill would be extremely low (approximately. 0.5% average rainfall).
- Infiltration would be so slow that infiltrating waters are unlikely to break through into the drainage blanket/basal layers during the duration of the construction phase.
- Infiltration rates would be significantly smaller than surface runoff rates and/or evapotranspiration rates expected on the Gwent Levels.
- Infiltration rates would be so low that where band drains are present there would be a tendency for downward vertical flow to underlying groundwater as opposed to lateral flow via the drainage blanket towards receptors on the Gwent Levels SSSIs.

16.7.20 These observations suggest that infiltration through the embankment does not have the potential to have a measurable effect on surface water quality during the construction phase. Although these waters may ultimately reach groundwater, there would be no measurable impact on the tidal surface waterbodies that are the ultimate receptor of groundwater.

Road Cuttings

16.7.21 In the elevated areas situated inland of the Gwent Levels at the eastern and western end of the new section of motorway, additional cut would be required. The most significant areas would be situated immediately north of the existing Castleton Interchange at the western end of the new section of motorway.

16.7.22 The general design of new or extended cuts is presented schematically on Figure 16.9, with a filter drain to be installed along the northern boundary of the cut that

may intercept groundwater. This may require active dewatering during the construction of the new highway and installation of filter drains. The resulting groundwater would be discharged to local inland watercourses. Although groundwater quality in the inland bedrock aquifer is expected to be good, the resulting water may be characterised by a significant sediment load. There is also the potential for contaminated groundwater to be encountered that relates to currently unknown sources of contamination. The discharge of groundwater of low quality to surface watercourses may potentially affect surface water quality.

Culverting of Reens and Construction of Compensatory Reens and Field Drains

16.7.23 The construction of the new section of motorway across the Gwent Levels would require the culverting of existing main reens to maintain hydraulic continuity within the Gwent Levels and facilitate the continued conveyance of flood waters. The proposed design includes the culverting of reens and ditches.

16.7.24 The construction of highway embankments, water treatment areas, road junctions and access roads upon the Gwent Levels SSSIs also requires the provision of compensatory reens and field drains to replace those lost beneath the footprint of the development. These compensatory watercourses would ensure the integrity of the drainage system, in terms of water conveyance and flood risk, is maintained.

16.7.25 All temporary works undertaken on existing reens and/or the construction of new reens have the potential to directly affect surface water quality within the existing system, principally by the generation of low quality runoff.

New Bridged Section of Motorway (Chainage 7,980 to 11,400)

16.7.26 The new bridged section of motorway that includes the crossings of the River Ebbw and River Usk would be supported by piled piers and piled towers.

16.7.27 A commitment has been made to ensure piers are kept outside of the wetted channel of the River Usk. Only the eastern tower of the River Usk bridged section would be situated on natural saltmarsh, but would remain outside of the wetted channel for that tidal waterbody. The construction of piled tower foundations may require the use of dewatered cofferdams to facilitate safe excavation in these areas. The construction of bridge tower foundations therefore has the potential to generate a considerable amount of potentially contaminated sediments/soils, which could have an impact on the tidal waterbodies crossed, either directly or via the surface water drainage system potentially affected.

16.7.28 Any works within the River Usk have the potential to affect water quality therein during the construction phase. Excavation works and dewatering required outside of the tidal channel may also affect surface water quality through the management of runoff and/or abstracted groundwater.

16.7.29 The construction of piers outside of the River Usk also has the potential to affect water quality in the River Ebbw and Alexandra Docks through the uncontrolled runoff of potentially contaminated waters. The discharge of any groundwater from dewatering during construction also has the potential to affect water quality within these waterbodies.

Dust Generation

16.7.30 The use of heavy machinery during construction and material handling also has the potential to generate dust which can affect water environment. The issue of dust is considered in Chapter 7: Air Quality of this ES.

Table 16.13: Assessment of Unmitigated Potential Construction Effects on Surface Water Quality

Construction Activity	Works Element	Potential Effects	Receptor	Receptor Sensitivity	Magnitude of Impact	Significance	General pathway notes &/or incorporated mitigations
Borrow Pits	Excavation and runoff	Generation of potentially contaminated, silt laden runoff during excavation	Gwent Levels drainage system (SSSI)	Very High	Moderate Adverse	Very Large Adverse	-
			Inland watercourses (non-SSSI)	High	Moderate Adverse	Large Adverse	-
			Tidal waterbodies - Designated (Usk, Severn)	Very High	Minor Adverse	Large Adverse	-
			Tidal waterbodies - Non-designated (Ebbw)	Medium	Minor Adverse	Slight Adverse	-
	Groundwater dewatering during excavation	Abstraction and discharge of low quality groundwater during dewatering, resulting in a direct impact on receiving surface waterbody	Gwent Levels drainage system (SSSI)	Very High	Moderate Adverse	Very Large Adverse	-
			Inland watercourses (non-SSSI)	High	Moderate Adverse	Large Adverse	-
			Tidal waterbodies - Designated (Usk, Severn)	Very High	N/A	N/A	No borrow pits near tidal waterbodies
			Tidal waterbodies - Non-designated (Ebbw)	Medium	N/A	N/A	No borrow pits near tidal waterbodies
Highway Embankments including Haul Roads	Dewatering of Tidal Flat Deposits on Gwent Levels using band drains in embankments less than 5 m high	Impact on surface watercourses	Gwent Levels drainage system (SSSI)	Very High	Minor Adverse	Moderate Adverse	Upward vertical flow in band drains. Lateral transport of drainage waters from Tidal Flat Deposits via drainage blanket.
			Tidal Waterbodies - Designated (i.e. Usk / Severn)	Very High	Negligible	Neutral	Downward vertical leakage through band drains. Lateral transport in groundwater beneath Tidal Flat Deposits to surrounding tidal waterbodies.

Construction Activity	Works Element	Potential Effects	Receptor	Receptor Sensitivity	Magnitude of Impact	Significance	General pathway notes &/or incorporated mitigations
			Tidal Waterbodies - Non-designated (Ebbw)	Medium	Negligible	Neutral	Downward vertical leakage through band drains. Lateral transport in groundwater beneath Tidal Flat Deposits to surrounding tidal waterbodies.
	Use of cement ground stabilisation and re-used materials as general embankment fill in embankments that utilise band drains to facilitate settlement of Tidal Flat Deposits on Gwent Levels	Generation of potentially contaminated leachate by infiltration through general embankment fill during surcharging period, before highway surface completed. Lateral or vertical flows to surface water receptors	Tidal Waterbodies - Designated (i.e. Usk / Severn)	Very High	Negligible	Neutral	Vertical leakage through band drains. Lateral transport in groundwater beneath Tidal Flat Deposits to surrounding tidal waterbodies.
			Tidal Waterbodies - Non-designated (Ebbw)	Medium	Negligible	Neutral	Vertical leakage through band drains. Lateral transport in groundwater beneath Tidal Flat Deposits to surrounding tidal waterbodies.
			Gwent Levels drainage system (SSSI)	Very High	Moderate Adverse	Large Adverse	Lateral flow via drainage blanket, that could enter surrounding reen system.
	Use of cement ground stabilisation and re-used materials as general embankment fill in embankments that utilise piled foundations without need	Generation of potentially contaminated leachate by infiltration through general embankment fill during surcharging period, before highway surface completed. Lateral or	Tidal Waterbodies - Designated (i.e. Usk / Severn)	Very High	Negligible	Neutral	Vertical leakage through pathways created by piles. Lateral transport in groundwater beneath Tidal Flat Deposits to surrounding tidal waterbodies.
			Tidal Waterbodies - Non-designated (Ebbw)	Medium	Negligible	Neutral	Vertical leakage through pathways created by piles. Lateral transport in groundwater beneath Tidal Flat Deposits to surrounding tidal

Construction Activity	Works Element	Potential Effects	Receptor	Receptor Sensitivity	Magnitude of Impact	Significance	General pathway notes &/or incorporated mitigations
	for band drains to facilitate settlement of Tidal Flat Deposits on Gwent Levels	vertical flows to surface water receptors					waterbodies.
			Gwent Levels drainage system (SSSI)	Very High	Moderate Adverse	Large Adverse	Lateral flow via drainage blanket, that could enter surrounding reen system.
	Surface runoff from embankments during construction and surcharging period	Generation of potentially contaminated, silt laden runoff during construction phase	Gwent Levels drainage system (SSSI)	Very High	Moderate Adverse	Very Large Adverse	-
			Inland watercourses (non-SSSI)	High	Moderate Adverse	Large Adverse	-
			Tidal waterbodies - Designated (Usk, Severn)	Very High	Minor Adverse	Large Adverse	--
			Tidal waterbodies - Non-designated (Ebbw)	Medium	Minor Adverse	Slight Adverse	-
Road Cuttings	Construction of road cuttings in the vicinity of the Castleton and Magor junctions. Generally extensions of exiting cut rather than new cuts	Interception of contaminated waters emanating from known areas of contamination (CL Sites) or unknown sources of groundwater contamination. Potential impact on receiving waters	Inland watercourses (non-SSSI)	High	Moderate Adverse	Large Adverse	Direct impact on inland waterbodies. Known areas of contamination considered in Chapter 11
			Gwent Levels drainage system (SSSI)	Very High	Minor Adverse	Moderate Adverse	No discharges direct to Gwent Levels SSSI, therefore dilution and attenuation would occur. Known areas of contamination considered in Chapter 11
Construction of Mitigation Reens / Field Drain	-	Direct impact on reen system, principally by sediment generated during culverting	Gwent Levels drainage system (SSSI)	Very High	Moderate Adverse	Very Large Adverse	-

Construction Activity	Works Element	Potential Effects	Receptor	Receptor Sensitivity	Magnitude of Impact	Significance	General pathway notes &/or incorporated mitigations
Bridge Towers and Viaduct Piers	Construction of bridge piers that may involve construction of coffer dams and dewatering	Generation, management and handling of contaminated sediments &/or groundwater during construction.	Gwent Levels drainage system (SSSIs)	Very High	N/A	N/A	None constructed in Gwent Levels
			Inland watercourses (non-SSSI)	High	N/A	N/A	None constructed near inland surface watercourses
			Tidal waterbodies - Designated (Usk & Severn)	Very High	Moderate Adverse	Very Large Adverse	-
			Tidal waterbodies - Non-designated (Ebbw)	Medium	Moderate Adverse	Moderate Adverse	-
	Installation of piled foundations for piers and towers	Creation of pathways that allow contaminated groundwater enter bedrock / Glaciofluvial Deposits beneath Tidal Flat Deposits.	Tidal Waterbodies - Designated (i.e. Usk / Severn)	Very High	Minor Adverse	Large Adverse	Lateral transport in groundwater to tidal waterbody
			Tidal Waterbodies - Non-designated (Ebbw)	Medium	Minor Adverse	Slight Adverse	Lateral transport in groundwater to tidal waterbody
Construction and use of temporary access roads, compounds and laydown areas	Generation of potentially contaminated, silt laden runoff during excavation.		Gwent Levels drainage system (SSSI)	Very High	Moderate Adverse	Very Large Adverse	-
Use and Storage of Materials	Accidental spillage of hazardous substances to ground or direct to surface water		Gwent Levels drainage system (SSSI)	Very High	Major Adverse	Very Large Adverse	-
			Inland Watercourses (non-SSSI)	High	Major Adverse	Large Adverse	-
			Tidal Waterbodies - Designated (i.e. Usk / Severn)	Very High	Moderate Adverse	Very Large Adverse	-

Construction Activity	Works Element	Potential Effects	Receptor	Receptor Sensitivity	Magnitude of Impact	Significance	General pathway notes &/or incorporated mitigations
			Tidal Waterbodies - Non-designated (Ebbw)	Medium	Moderate Adverse	Moderate Adverse	-

Groundwater

16.7.31 The following aspects of the groundwater system may be affected during the construction phase.

- Groundwater quality.
- Groundwater resource potential and/or availability.
- Groundwater dependent receptors.

16.7.32 Existing groundwater abstractions have been considered as part of the Private Water User assessment provided below.

Groundwater Quality

16.7.33 The greatest risk to groundwater quality during the construction phase relates to proposed activities within areas of known contamination along the proposed new section of motorway. All contaminated land sites identified along the proposed alignment have been assessed with respect to the proposed activities at those locations in the Contaminated Land Assessment Report (Appendix 11.1). The remediation measures to be undertaken at each site to mitigate risk associated with ground and groundwater quality are outlined within the Outline Remediation Strategy (Appendix 11.2) and summarised in Chapter 11 of this ES: Geology and Soils.

16.7.34 Outside of areas of known contamination, groundwater quality may be affected by the following mechanisms during construction.

- Accidental emissions/releases of potentially hazardous substances to ground associated with construction activities, movements on temporary access roads, compounds and storage/laydown areas.
- Disturbance of areas of currently unknown contamination, particularly in areas where intrusive works are required most notably pile foundations and/or bridge piers.
- Leakage or infiltration through embankments, via band drains or piled foundations into the bedrock/Glaciofluvial Deposits on the Wentlooge Levels, Caldicot Levels and the River Usk Crossing.

16.7.35 The magnitude of potential impacts on groundwater quality that may result from surface activities would be dependent on the degree of protection afforded to the principal groundwater bearing units by the overlying geology. Groundwater within the Gwent Levels is afforded protection by the low permeability Tidal Flat Deposits. Similarly, the bedrock aquifer at the western (Castleton) end of the new section of motorway is generally afforded protection by the presence of glacial till. As a result, small accidental releases and/or disturbance of currently unknown areas of contamination during construction within these areas are not considered likely to represent a significant risk to groundwater quality in these areas.

16.7.36 In contrast, the absence of protective strata above the bedrock at the eastern (Magor) end of the new section of motorway suggests that groundwater quality could be at potential risk from surface activities.

16.7.37 Estimated infiltration rates through general embankment fill are extremely low (see the Drainage Strategy Report in Appendix 2.2). This indicates that these infiltrating waters would travel vertically down band drains or piles and be mixed with the groundwater in the bedrock or Glaciofluvial Deposits. However, the very small volumes of infiltration expected and delayed breakthrough suggests that this impact would not be measurable during the construction phase.

16.7.38 However, the porewater generated from the Tidal Flat Deposits during surcharging may have a short term effect on groundwater quality within the underlying bedrock, where the principal flow direction is downward. Although this could theoretically have a measurable impact on groundwater quality in the bedrock or Glaciofluvial Deposits, this is likely to be minor at worst.

Groundwater Resources and Resource Potential

16.7.39 Dewatering and groundwater control measures have the potential to reduce the groundwater resource availability and resource potential in those areas affected. Long term, extensive dewatering is not a feature of the Scheme. The most significant effects would occur in those areas of major cut, principally at the Castleton end of the new section of motorway although short term effects may be associated with any dewatering of the borrow pits.

Groundwater Dependent Receptors

16.7.40 Within the Gwent Levels SSSIs, groundwater contained within bedrock and/or Glaciofluvial Deposits is considered to be hydraulically isolated from the surface water system by low permeability Tidal Flat Deposits. Thus the surface water system within the Gwent Levels is not characterised by any groundwater dependence. However, a number of groundwater fed watercourses are encountered near the land-marsh boundary, most notably on the Wentlooge Levels. The inland area around Castleton is also characterised by numerous surface water features with an important groundwater dependence and these non-designated features could be affected by construction, depending on their location relative to the construction activities.

16.7.41 With the exception of spring fed watercourses that feed in to Pwll Bargoed Reen at the western end of the new section of motorway, these groundwater dependent features are typically situated in different groundwater catchments and/or significantly up-gradient of the proposed construction activities.

Table 16.14: Assessment of Unmitigated Potential Construction Effects on Groundwater

Construction Activity	Works Element	Potential Effects	Receptor	Receptor Sensitivity	Magnitude of Impact	Significance	General pathway notes &/or incorporated mitigations
Borrow Pits	Groundwater dewatering during excavation.	Local reduction of groundwater level and/or groundwater flow	Bedrock - Inland Bedrock (Castleton / Magor)	Medium	Minor Adverse	Slight Adverse	
			Bedrock & Glaciofluvial Deposits (GFD) - Wentlooge Levels	Medium	N/A	N/A	No borrow pits in this area
			Bedrock & GFD - New bridged section of motorway	Low	N/A	N/A	
			Bedrock & GFD - Caldicot Levels	Low	N/A	N/A	
			Non-designated Groundwater Dependent Receptors (Castleton / Wentlooge Levels)	Medium	Minor Adverse	Slight Adverse	
	Excavation or runoff	Disturbance of previously unknown contamination sources result in deterioration in groundwater quality	Bedrock - Inland Bedrock (Castleton / Magor)	Medium	Moderate Adverse	Moderate Adverse	
			Bedrock & GFD - Wentlooge Levels	Medium	N/A	N/A	No borrow pits in this area
			Bedrock & GFD - New bridged section of motorway	Low	N/A	N/A	
			Bedrock & GFD - Caldicot Levels	Low	N/A	N/A	
			Non-designated Groundwater Dependent Receptors (Castleton / Wentlooge Levels)	Medium	Minor Adverse	Slight Adverse	
Highway Embankments including Haul	Dewatering of TFD on Gwent Levels using	Impact on groundwater quality	Bedrock - Inland Bedrock (Castleton / Magor)	Medium	N/A	N/A	No dewatering of TDF.

Construction Activity	Works Element	Potential Effects	Receptor	Receptor Sensitivity	Magnitude of Impact	Significance	General pathway notes &/or incorporated mitigations
Roads	band drains in embankments less than 5 m high		Bedrock & GFD - New bridged section of motorway	Low	N/A	N/A	No dewatering of TDF.
			Bedrock & GFD - Wentlooge Levels	Medium	Minor Adverse	Slight Adverse	
			Bedrock & GFD - Caldicot Levels	Low	Minor Adverse	Neutral	
			Non-designated Groundwater Dependent Receptors (Castleton / Wentlooge Levels	Medium	Negligible	Neutral	No pathway identified
	Use of cement ground improvement and re-used materials as general embankment fill in embankments that utilise band drains to facilitate settlement of TFD on Gwent Levels	Generation of potentially contaminated leachate by infiltration through general embankment fill during surcharging period, before highway surface completed. Vertical flows to groundwater in bedrock / GFD.	Bedrock - Inland Bedrock (Castleton / Magor)	Medium	Minor Adverse	Slight Adverse	Conservative assessment of potential magnitude
			Bedrock & GFD - New bridged section of motorway	Low	N/A	N/A	No band drains proposed
			Bedrock & GFD - Wentlooge Levels	Medium	Negligible	Neutral	RTCs for embankment fill. No breakthrough during construction.
			Bedrock & GFD - Caldicot Levels	Low	Negligible	Neutral	
	Use of cement ground improvement and re-used materials as general embankment fill in embankments that utilise	Generation of potentially contaminated leachate by infiltration through general embankment fill during surcharging period, before	Bedrock & GFD - New bridged section of motorway	Low	N/A	N/A	No piled embankments proposed.
			Bedrock - Inland Bedrock (Castleton / Magor)	Medium	Minor Adverse	Slight Adverse	Moderate to high polluting potential of some re-used site won fill materials.
			Bedrock & GFD - Wentlooge Levels	Medium	Minor Adverse	Slight Adverse	
			Bedrock & GFD -	Low	Minor	Slight	

Construction Activity	Works Element	Potential Effects	Receptor	Receptor Sensitivity	Magnitude of Impact	Significance	General pathway notes &/or incorporated mitigations
	piled foundations without need for band drains to facilitate settlement of TFD on Gwent Levels	highway surface completed. Lateral or vertical flows to surface water receptors	Caldicot Levels		Adverse	Adverse	
Road Cuttings	Construction of road cuttings in the vicinity of the Castleton and Magor junctions. Generally extensions of exiting cut rather than new cuts	Disturbance of previously unknown contamination sources	Bedrock - Inland Bedrock (Castleton / Magor)	Medium	Minor Adverse	Slight Adverse	
		Adverse impact on non-designated groundwater dependent features by localised lowering of groundwater levels and alterations to groundwater flow field. Potential loss of source, reduced reliability or changed quality.	Non-designated Groundwater Dependent Receptors (Castleton / Wentlooge Levels)	Medium	Minor Adverse	Slight Adverse	
Bridge Towers and Viaduct Piers	Construction of bridge support structures than may involve construction of	Local reduction of groundwater level and/or groundwater flow	Bedrock & GFD - New bridged section of motorway	Low	Minor Adverse	Neutral	-
			Non-designated Groundwater Dependent Receptors (Castleton /	Medium	N/A	N/A	No features within Newport crossing

Construction Activity	Works Element	Potential Effects	Receptor	Receptor Sensitivity	Magnitude of Impact	Significance	General pathway notes &/or incorporated mitigations
	coffer dams and dewatering		Wentlooge Levels)				
	Installation of piled piers.	Creation of pathways and transport of contaminants to groundwater	Bedrock & GFD - New bridged section of motorway	Low	Moderate Adverse	Slight Adverse	-
Use & Storage Materials	Accidental spillage of hazardous substances to ground / water		Bedrock - Inland Bedrock (Magor)	Medium	Moderate Adverse	Moderate Adverse	
			Bedrock - Inland Bedrock (Castleton)	Medium	Minor Adverse	Slight Adverse	
			Bedrock & GFD - Wentlooge Levels	Medium	N/A	N/A	No pathway through TFD
			Bedrock & GFD - New bridged section of motorway	Low	N/A	N/A	No pathway through TFD
			Bedrock & GFD - Caldicot Levels	Low	N/A	N/A	No pathway through TFD
			Non-designated Groundwater Dependent Receptors (Castleton / Wentlooge Levels)	Medium	Minor Adverse	Slight Adverse	Principally in Castleton.

Private Water Users

16.7.42 Existing groundwater users may be affected by the following activities undertaken during the construction phase.

- Groundwater dewatering associated with new or extended areas of highway cut, most notably around the existing Castleton Interchange.
- Groundwater dewatering associated with the borrow pits at the eastern and western ends of the new section of motorway.

16.7.43 New or extended road cuttings that intercept groundwater represent a potential long term risk to the reliability of groundwater abstraction sources in terms of yield reliability. In contrast, the temporary dewatering of borrow pits represents a short term risk to yield reliability for any groundwater abstraction located in close proximity, but could represent a long term risk with respect to water quality depending on the material used to backfill the excavation. Water quality issues would, however, only represent a risk to groundwater abstraction sources situated down hydraulic gradient of borrow pits.

16.7.44 A qualitative evaluation of the potential risk to known groundwater abstraction sources is provided in Table 16.15. The assessment identifies those sources at greatest risk of possible effects from supply derogation. At the existing Castleton Interchange a single spring source is identified as being potentially at high risk and four sources at moderate risk of being affected by the proposed excavations. Three sources, principally around Knollbury, have been identified as being at moderate or high risk at the Magor end of the existing motorway.

Table 16.15: Private Groundwater Abstractor Source Assessment

Ref.	Type	In Use	Near Cut or Borrow Pit	Up or Down Hydraulic Gradient	Distance (m)*[1]	Change in Elevation (m)*[2]	Risk
Western Section (Castleton)							
1.1 1.2 1.3	Spring West (issue) East (spring)	Yes - -	Major cut & borrow pit Minor cut Major cut & borrow pit	Up gradient Up gradient Up gradient	175 (60) 100 325 (275)	5 (7.5) 0 37.5 (32.5)	High Moderate Moderate
2	Borehole	No	Cut & borrow pit	Different catchment?	750	-27.5	Negligible
3	Shallow Borehole	Yes	Cut & Borrow Pit but near WTA 1	Down gradient	390	-22.5	Moderate (WTA)
4.1 4.2 4.3	Spring Abstraction Tyn-y-nant Cottage Lower House	Yes - -	Major cut & borrow pit - -	Down gradient - -	230 600 430	-25 -37.5 -30	Moderate - -
5	Spring	Yes	-	Different catchment	965 (850)	+37.5 (+12.5)	Negligible
6	Spring	Yes	-	Different catchment	1,000	+20	Negligible
7	Groundwater (presumed borehole)	Yes	-	Different catchment	1,195	+2.5	Negligible
8.1 8.2 8.3	Springs Springs (reservoir) Spring at Five Oaks		- - -	Different catchment Different catchment	920 795 360	-27.5 -12.5 +2.5	Negligible Negligible Negligible
9	Disused well	No	Cut & borrow pit	Up gradient	700	+55	Negligible
10	Abandoned well and spring fed stream	No	Minor cut	Down gradient			Low
11	Spring	No	Cut & borrow pit	Different catchment?	1,115	-32.5	Negligible
12	Abandoned well at residential dwelling.	No	Major cut & borrow pit	Up gradient	185	+10	Moderate
13	Spring	No	Existing cut &borrow pit	Presumed different catchment	360	+22.5	Negligible
14.1 14.2 14.3	Issue at Pen-sidan Spring at Pen-sidan-fâch (old farmhouse)	No No No	Existing cut &borrow pit	Presumed different catchment	1,250 845 735	+40 (+20) +30 +5	Negligible
Eastern Section (Magor)							
15	Borehole	Yes	Cut &borrow pit	Up gradient	180	+12.5	Moderate
16.1	Borehole	Yes	Cut	Up gradient	200	+5	Moderate
16.2			Cut	Up gradient	110	+2.5	High
17	Borehole	Yes	Cut	Different Catchment	665	+2.5	Negligible

Ref.	Type	In Use	Near Cut or Borrow Pit	Up or Down Hydraulic Gradient	Distance (m)*[1]	Change in Elevation (m)*[2]	Risk
18	Borehole		Cut	Up gradient	595	+50	Negligible
19.1 19.2 19.3	Well Spring Spring	No No No	N/A	Different Catchment	855 1,060 1,320	-7.5 -10 -17.5	Negligible
20	Abandoned Well	No	Cut	Up gradient			Moderate

*1 Approximate distance from cut (approximate distance from borrow pit).
*2 Approximate elevation of source relative to elevation of the cut (elevation of Borrow Pit).

Flood Risk and Drainage

16.7.45 Uncontrolled runoff during construction is considered to represent a key risk to the water environment and in particular the conservation status of the Gwent Levels SSSIs.

16.7.46 The surface watercourses of the Gwent Levels, comprising reens and ditches, are of high water quality and being generally low flowing particularly during summer penning possess limited capacity to attenuate waterborne pollutants. Additionally, low flow conditions within surface watercourses result in heightened vulnerability to sudden and sustained excessive discharges generated by runoff from relatively impermeable surfaces present within the construction corridor.

16.7.47 Sources of water other than rainfall run-off requiring controlling also include porewater flowing from band drains as a consequence of Tidal Flat Deposit consolidation and other groundwater dewatering activities associated with excavation of borrow pits and cofferdams.

16.7.48 All reens bisected by the route would be conveyed through the proposed new section of motorway by appropriately sized culverts. These culverts are incorporated mitigation as are routine elements of DMRB highway drainage design.

Table 16.16: Assessment of Unmitigated Potential Construction Effects on Flood Risk and Drainage

Construction Activity	Works Element	Potential Effects	Receptor	Receptor Sensitivity	Magnitude of Impact	Significance	General pathway notes &/or incorporated mitigation
Construction of highway structures	Changes to conveyance of reens during construction	Impacts on reen system, land and property from changes to conveyance of flood waters through reen system during construction	Residential and commercial property	Very High	Negligible	Neutral	Provision of culverts to reens bisected by the new section of motorway (see Appendix 3.1)
	Changes to Flood Risk during construction	Impacts on property from changes to flood risk during construction	Residential and commercial property	Very High	Negligible	Neutral	

Complementary Measures

16.7.49 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 no significant predicted effects on hydrology or flood risk, over and above those assessed for the new section of motorway above.

16.8 Assessment of Potential Operational Effects

16.8.1 During operation, the principal effects of the Scheme would be related to routine road runoff, sediment transfer or movement, increased surface water runoff leading to fluvial flooding and mobilisation of contaminants. In addition, consideration has been given to the potential impact on surface water and groundwater quality that may result from the re-use of site won materials and/or stabilised waste from the former Llanwern steelworks as embankment fill.

16.8.2 The assessment for each of the receptors identified in Table 16.12 is summarised in Tables 16.17 to 16.20.

Proposed New Section of Motorway

Surface Water Quality

Routine Runoff and Accidental Spillages – Main Motorway Highway

16.8.3 Once operational, the principal mechanism by which the new section of motorway may have an impact on surface water quality relates to the management of routine runoff from the highway and the risk posed by accidental spillages associated with the operational highway.

16.8.4 As set out in Section 16.5 above, the proposed drainage for the new section of motorway is described in the Drainage Strategy (Appendix 2.2) and is based on the construction of water treatment areas to manage the runoff generated and any accidental releases related to road use. Each of the water treatment areas discharges to the reen system of the Gwent Levels.

16.8.5 To determine the potential magnitude of the impact on surface water quality, water quality tests have been undertaken using the Highways Agency Water Risk Assessment Tool (HAWRAT) and spillage risk tests outlined in Annex I of HD45/09 (Highways Agency *et al*., 2009). The HAWRAT test (Method A) considers routine runoff and the Method D test considers serious spillage risk. These tests relate to the highway following the construction of the road pavement. An assessment has therefore been undertaken for the new impermeable area of road to be drained and the highest traffic flow has been considered, which would equate to the largest pollutant loading.

16.8.6 Each water treatment area has been designed to ensure that it provides sufficient treatment capacity to ensure the discharge would meet DMRB requirements and regulatory requirements for the protection of the Gwent Levels SSSIs, most notably with respect to heavy metals, organic contaminants associated with fuels, oils and hydrocarbon combustion and major ions principally associated with de-icing. The detailed water treatment area design is described in the Drainage

Strategy (Appendix 2.2). The full treatment train has been considered, most notably the depth and volume of attenuation ponds and the area of reed beds.

16.8.7 A full description of the HAWRAT assessments is provided in the DMRB Assessment Report (Appendix 16.3), with a summary of key aspects of water treatment area design and qualitative assessment provided in Table 16.17. The test results using HAWRAT (routine runoff) show that all of the new proposed discharges would meet DMRB concentration limits and furthermore are likely preserve existing surface water quality, based on the design measures.

16.8.8 Highway runoff from the proposed bridged sections crossing the River Ebbw, River Usk and Alexandra Docks would be discharged to outfalls on the River Ebbw and River Usk. The Ebbw outfalls would not be flow attenuated but would benefit from treatment in the form of oil interceptors. The Usk outfall would not be flow attenuated but would include the provision of a pollution control lagoon to capture and retain significant pollution resulting from road accidents that may otherwise flow uncontrolled to the Usk Estuary. No significant effects would arise from chloride within road runoff due to the Rivers Usk and Ebbw being tidal and therefore already brackish or saline in nature. Furthermore, the risk associated with pollution from spillages would be mitigated to below 0.5% as prescribed by the DMRB and, as such, can be considered to have negligible magnitude of impact on both watercourses. The receiving water treatment area within the Wentlooge Levels to the west would also be designed to meet agreed water quality objectives for the receiving reen.

Routine Runoff and Accidental Spillages – Existing Drainage, New Junctions, Link Roads and Highway Crossings

16.8.9 The general discharge arrangements for existing drainage, new junctions, link roads and highway crossings is described in the Drainage Strategy report at Appendix 2.2.

16.8.10 The new highway crossings (including overbridges and underbridges) proposed along part of the new section of motorway are shown on Figure 2.4. The nature of the drainage proposed for each of the water treatment areas and crossings is summarised in Table 16.17 and comprises either: a discharge to new water treatment areas associated with main highway; discharge to new bespoke water treatment areas that comprise oil interceptors; or the direct discharge to the existing highway drainage system at the point of crossing. This represents an improvement in the existing drainage system that would result in improved water quality and reduction in pollution risk from accidents relative to the current baseline.

16.8.11 The new junctions and associated link roads at Docks Way Junction, Glan Llyn Junction and the new M48 roundabout are shown on Figure 2.4. The drainage proposed for these areas is summarised in Table 16.17.

Table 16.17: Drainage Outfall Characteristics

Outfall	Contributing Impermeable Area (Ha)	Drain Channel Type	Notes
1	9.3	Concrete	A48M / Existing M4 Junction
2	11.5	Concrete	New section of motorway / Existing M4 Junction
4a	4.3	Grass	Embankment in SSSI
4b	4.2	Grass	Embankment in SSSI
5	7.3	Grass	Embankment in SSSI
Ebbw West	1.3	Concrete	Embankment in SSSI
Ebbw East	11	Concrete	Docks Junction and River Usk Crossing (west)
Usk	2.9	Concrete	River Usk Crossing (east)
6	4.8	Concrete/ Grass	Super Elevated
Meadows Road (north)	0.34	Concrete	Side Road
Meadows Road (south)	0.34	Concrete	Side Road
7	4.1	Grass	Embankment in SSSI
8	9.0	Grass	Embankment in SSSI
8a	1.0	Concrete	Glan Llyn Junction
North Row (north)	0.31	Concrete	Side Road
North Row (south)	0.34	Concrete	Side Road
9	15.8	Grass	Embankment in SSSI
10	3.3	Concrete	Embankment in SSSI
11b	6.0	Concrete	Existing M4/New section of motorway junction
11c	5.0	Concrete	Existing M4/New section of motorway
12a	14.4	Concrete	Existing M4
12b	0.73	Concrete	M48/Existing M4 Gyratory

16.8.13 Drainage at the Castleton and Magor Interchanges at the western and eastern end of the motorway would discharge through new water treatment areas (i.e. 1, 2, 12 and 11). These water treatment areas are designed to meet DMRB standards and water quality criteria agreed with NRW. As such, this represents a potential improvement in water quality relative to the baseline conditions.

Re-use of Materials in Embankments

16.8.14 As outlined for the construction phase, site won materials and/or stabilised soils from the former Llanwern site would be used as general embankment fill where engineering constraints allow. Water infiltrating through embankment fill therefore has the potential to contain polluting substances depending on the quality and leachability of the embankment fill materials.

16.8.15 The drainage design of the highway is described in the Drainage Strategy (Appendix 2.2). The low permeability of the road surface and use of granular sub-base material with lateral fin drains would ensure that any water that passes through the highway surface would be collected and drained to the water treatment areas, effectively preventing infiltration through the embankment fill across the width of highway (TRL Limited, 2006). Infiltration is possible through

the inclined sides of the embankments. Infiltration rate through embankment sides is considered to be very low considering their gradient and the low permeability of the compacted embankment fill. To ensure that any water that does infiltrate through embankment sides does not have an unacceptable effect on controlled waters (i.e. surface water quality or groundwater quality) Reuse Target Concentrations (RTCs) have been developed.

16.8.16 To protect surface water quality within the Gwent Levels SSSIs, the potential for lateral flow through the drainage blanket/granular basal layer to the surrounding reen system has been considered. Reuse Target Concentrations have been developed that ensure Environmental Quality Standards agreed with NRW would be achieved on the basis of leachable concentrations in infiltrating water and mixing with runoff generated by the inclined embankment sides. The Reuse Target Concentrations for soils developed for the new section of motorway are presented in the Outline Remediation Strategy (Appendix 11.2 of the ES). This would ensure that infiltrating water would have a negligible impact on water quality if discharged to surface waterbodies within the Gwent Levels.

16.8.17 RTCs are non-statutory but agreed with NRW within a Code of Practice via a Material Management Plan (MMP). Non-compliance with the MMP would deem placed material as non-recovered waste and would therefore be considered to be a non-permitted waste activity. This would be in breach of Environmental Permitting Regulations 2010.

16.8.18 Sites currently regulated under Environmental Permitting Regulations 2010 that would be affected by the proposed new section of motorway would be managed under an Environmental Permitting Strategy agreed with and regulated by NRW. This strategy is contained within Appendix 11.3 of the ES.

Table 16.18: Assessment of Unmitigated Potential Operational Effects on Surface Water Quality

Aspect of Operational Design	Description	Potential Effects	Receptor	Receptor Sensitivity	Magnitude of Impact	Significance	General pathway notes &/or incorporated mitigations
Routine Highway Runoff	Runoff to new highway drainage system	Routine runoff directly to surface waterbodies receiving highway runoff from WTA	Gwent Levels drainage system (SSSI)	Very High	Negligible	Neutral	WTAs designed to meet EQSs at point of discharge (see DMRB Assessment – Appendix 16.3). See Table 16.19 below.
			Inland watercourses (non-SSSI)	High	Negligible	Neutral	WTAs designed to meet EQSs at point of discharge (see DMRB Assessment – Appendix 16.3). See Table 16.19 below.
		Serious pollution incidents arising as a result of a spillage resulting in direct impact on surface waterbodies receiving highway runoff from WTA	Gwent Levels drainage system (SSSI)	Very High	Negligible	Neutral	Below DMRB accident threshold of 0.5%
			Inland watercourses (non-SSSI)	High	Negligible	Neutral	Below DMRB accident threshold of 0.5%
	Routine runoff from Bridged Section	Discharge to tidal waterbodies	Tidal Waterbodies - Designated (i.e. Usk / Severn)	Very High	Negligible	Neutral	Pollution control lagoon and oil interceptor.
			Tidal Waterbodies - Non-designated (Ebbw)	Medium	Minor Adverse	Slight Adverse	Oil interceptor.
		Discharge to reen system within Gwent Levels	Surface Water - Gwent Levels reen system	Very High	Negligible	Neutral	
		Serious pollution incidents arising as a result of a spillage resulting in direct impact on Tidal	Surface Water - Tidal waterbodies	Very High	Negligible	Neutral	Below DMRB accident threshold of 0.5%
			Tidal waterbodies -	Medium	Negligible	Neutral	Below DMRB accident threshold of 0.5%

Aspect of Operational Design	Description	Potential Effects	Receptor	Receptor Sensitivity	Magnitude of Impact	Significance	General pathway notes &/or incorporated mitigations
		Waterbodies	Non-designated (Ebbw)				
		Discharge to reen system within Gwent Levels	Surface Water - Gwent Levels reen system	Very High	Negligible	Neutral	Below DMRB accident threshold of 0.5%
Embankment including Haul Roads	Completed embankments that use band drains (<5m). Completed highway that includes road surface and fin drains	Generation of potentially contaminated leachate by infiltration through embankment fill during operation of the highway.	Tidal waterbodies - Designated (i.e. Usk / Severn)	Very High	Negligible	Neutral	RTCs have been developed that are protective of surface water quality
			Tidal waterbodies - Non-designated (Ebbw)	Medium	Negligible	Neutral	RTCs have been developed that are protective of surface water quality
			Gwent Levels drainage system (SSSI)	Very High	Negligible	Neutral	RTCs have been developed that are protective of surface water quality
	Completed embankments that use piled foundations (>10m). Completed highway that includes road surface and fin drains	Generation of potentially contaminated leachate by infiltration through embankment fill during operation of the highway.	Tidal waterbodies - Designated (i.e. Usk / Severn)	Very High	Negligible	Neutral	RTCs have been developed that are protective of surface water quality
			Tidal waterbodies - Non-designated (Ebbw)	Medium	Negligible	Neutral	RTCs have been developed that are protective of surface water quality
			Gwent Levels drainage system (SSSI)	Very High	Negligible	Neutral	RTCs have been developed that are protective of surface water quality
Road Cuttings	Long term dewatering in area of new cutting	Long term discharge of water to surface water receptors	Gwent Levels drainage system (SSSI)	Very High	Minor Adverse	Moderate Adverse	Groundwater quality expected to be generally good.
			Inland watercourses (non-SSSI)	High	Minor Adverse	Slight Adverse	Groundwater quality expected to be generally good.

Aspect of Operational Design	Description	Potential Effects	Receptor	Receptor Sensitivity	Magnitude of Impact	Significance	General pathway notes &/or incorporated mitigations
Culverts Beneath Embankment		Alteration to water quality of reens in culverted areas	Gwent Levels drainage system (SSSI)	Very High	Minor Adverse	Moderate Adverse	
Borrow Pits	Restoration with materials unsuitable for use	Generation of contaminated groundwater, that discharges to lateral surface water features	Inland watercourses (non-SSSI)	High	Moderate Adverse	Moderate Adverse	
			Gwent Levels drainage system (SSSI)	Very High	Moderate Adverse	Large Adverse	

Table 16.19: Water Treatment Area Summary Table and Assessment

Potential Impact	Feature	Attribute	Quality	Importance	Mitigation	Magnitude	Significance
Water Quality	Pwll Bargoed Reen	SSSI Biodiversity	High	Very High	WTA1	Negligible	Neutral
Water Quality	Tyn-y-Brwyn Reen	SSSI Biodiversity	High	Very High	WTA2	Negligible	Neutral
Water Quality	Percoed Branch East	SSSI Biodiversity	High	Very High	WTA4a/4b	Negligible	Neutral
Water Quality	Morfa Gronw Reen	SSSI Biodiversity	High	Very High	WTA5	Negligible	Neutral
Water Quality	Lakes Reen	SSSI Biodiversity	High	Very High	WTA6	Negligible	Neutral
Water Quality	Julians Reen	SSSI Biodiversity	High	Very High	WTA7	Negligible	Neutral
Water Quality	Ellens Reen	SSSI Biodiversity	High	Very High	WTA8	Negligible	Neutral
Water Quality	Black Wall Reen	SSSI Biodiversity	High	Very High	WTA8a	Negligible	Neutral
Water Quality	Middle Road Reen Diversion	SSSI Biodiversity	High	Very High	WTA9	Negligible	Neutral
Water Quality	Rush Wall South Reen	SSSI Biodiversity	High	Very High	WTA10	Negligible	Neutral
Water Quality	St Bride's Brook	SSSI Biodiversity	High	Very High	WTA11b/11c	Negligible	Neutral
Water Quality	Prat Reen	SSSI Biodiversity	High	Very High	WTA12a	Negligible	Neutral
Water Quality	Vurlong Reen	SSSI Biodiversity	High	Very High	WTA12b	Negligible	Neutral
Water Quality	River USk	SAC Biodiversity	Good	Very High	Spill Lagoon	Negligible	Neutral
Water Quality	River Ebbw	Biodiversity	Good	High	-	Negligible	Neutral
Flooding from runoff	Pwll Bargoed Reen	Flow	High	Very High	WTA1	Negligible	Neutral
Flooding from runoff	Tyn-y-Brwyn Reen	Flow	High	Very High	WTA2	Negligible	Neutral
Flooding from runoff	Percoed Branch East	Flow	High	Very High	WTA4a/4b	Negligible	Neutral
Flooding from runoff	Morfa Gronw Reen	Flow	High	Very High	WTA5	Negligible	Neutral
Flooding from runoff	Lakes Reen	Flow	High	Very High	WTA6	Negligible	Neutral
Flooding from runoff	Julians Reen	Flow	High	Very High	WTA7	Negligible	Neutral
Flooding from runoff	Ellens Reen	Flow	High	Very High	WTA8	Negligible	Neutral
Flooding from runoff	Black Wall Reen	Flow	High	Very High	WTA8a	Negligible	Neutral
Flooding from runoff	Middle Road Reen Diversion	Flow	High	Very High	WTA9	Negligible	Neutral
Flooding from runoff	Rush Wall South Reen	Flow	High	Very High	WTA10	Negligible	Neutral
Flooding from runoff	St Bride's Brook	Flow	High	Very High	WTA11b/11c	Negligible	Neutral
Flooding from runoff	Prat Reen	Flow	High	Very High	WTA12a	Negligible	Neutral
Flooding from runoff	Vurlong Reen	Flow	High	Very High	WTA12b	Negligible	Neutral
Floodplain loss	Gwent Levels SSSIs	Flood water storage	High	Very High	New reens	Negligible	Neutral
Water Quality	Secondary Aquifer	Water Supply	Poor	Low	-	Negligible	Neutral

Groundwater

16.8.19 No direct discharges are proposed to groundwater as all drainage would be sealed or lined and discharged to surface watercourses principally through the water treatment areas. Therefore, no groundwater tests following the HD 45/09 Method C have been undertaken.

16.8.20 Table 16.20 summarises those activities proposed for the operational phase that have the potential to affect groundwater quality, resource potential and/or non-designated groundwater dependant features. The potential effect on private groundwater abstractors is considered separately.

16.8.21 The design of the highway is described in the Drainage Strategy (Appendix 2.2). The low permeability of the road surface and use of granular sub-base with lateral fin drains would ensure that any water that passes through the highway surface would be collected and drained to the water treatment areas, thus preventing infiltration through the embankment fill across the approximate 40 metre width of the highway. Infiltration would be possible through the inclined sides of the embankments. The infiltration through embankment sides would be very low considering their gradient and the low permeability of the compacted embankment fill. To ensure that any water that does infiltrate through embankment sides does not have an unacceptable effect on groundwater quality within the underlying bedrock or Glaciofluvial Deposit aquifer units, Reuse Target Concentrations have been developed that are protective of groundwater quality. The Reuse Target Concentrations would achieve Environmental Quality Standards agreed with NRW on the basis of leachable concentrations and mixing with groundwater flow within the underlying aquifer unit. By adopting these Reuse Target Concentrations it can be ensured that water quality in the bedrock aquifer would not be significantly affected. The Reuse Target Concentrations developed for the new section of motorway are provided in the Outline Remediation Strategy provided in Appendix 11.2.

16.8.22 It is proposed to backfill borrow pits with site won materials that cannot be used elsewhere on the alignment of the new section of motorway on the basis of their geotechnical and/or chemical properties. These materials may have the capacity to leach contaminants and therefore have the potential to result in an adverse impact on groundwater quality, through the infiltration of rainwater and possible direct saturation by groundwater. These effects would be most significant where borrow pits have been dewatered and post infilling groundwater recovery results in the saturation of the backfilled material. In an unmitigated scenario this has the potential to result in a measurable effect on groundwater quality, depending on the polluting potential of materials used as backfill. Lateral transport of groundwater of poor quality also has the potential to affect groundwater dependent receptors situated down hydraulic gradient from backfilled borrow pits.

Private Water Users

16.8.23 In the absence of any direct discharges to groundwater, the potential impacts on private groundwater users during the operational phase principally relate to the impact of long term dewatering in the vicinity of major road cuttings proposed as part of the new section of motorway, most notably at the western (Castleton) end. Effects on water quality are also possible, e.g. following backfilling of borrow pits with site won non construction soils. This has been considered in Table 16.15. Only two sources are considered to have the potential to require an alternative

source of supply to be provided as mitigation for potential effects associated with areas of cut at the Castleton and Magor junctions of the new section of motorway, however potentially measurable effects cannot be discounted at other sources.

Flood Risk

16.8.24 The incorporated operational routine highway drainage has been designed to capture, convey, attenuate and discharge runoff from a 1 in 100 year plus climate change design period storm. Flow attenuation would be achieved via roadside channels - grass lined within the majority of the Gwent Levels and concrete elsewhere - linked to water treatment areas containing appropriately dimensioned attenuation lagoons. Discharges from the water treatment areas would be flow controlled to be no greater than the equivalent greenfield runoff rate for the impermeable area of road drained, as agreed with NRW. This standard of drainage provision meets the DMRB and TAN15 requirements resulting in a negligible magnitude impact on flood risk.

16.8.25 A Flood Consequences Assessment has been undertaken for the Scheme and is provided at Appendix 16.1 of the ES. The Flood Consequences Assessment has assessed the impact on flood risk for both the 1 in 100 year plus climate change and 1 in 1,000 year plus climate change Annual Exceedance Probability (AEP). The modelling of flood depths as a consequence of these scenarios with and without the Scheme in place generates difference plots for comparison with the DMRB flood depth and property impact criteria.

16.8.26 The difference plots for both the Wentlooge and Caldicot Levels identify small areas of flood detriment above 10 mm. However, none of the affected areas contain either residential or commercial property.

Table 16.20: Assessment of Unmitigated Potential Operational Effects on Groundwater

Design Element	Description	Potential Effects	Receptor	Receptor Sensitivity	Magnitude of Impact	Significance	General pathway notes &/or incorporated mitigations
Groundwater Quality							
Embankments including Haul Roads	Completed embankments that use band drains (<5 metres). Completed highway that includes road surface and fin drains (See Chapter 3 and Appendix 3.1)	Generation of potentially contaminated leachate by infiltration through embankment fill during operation of the highway.	Bedrock - Inland Bedrock (Castleton / Magor)	Medium	Negligible	Neutral	RTCs have been developed that are protective of groundwater quality
			Bedrock & GFD - New bridged section of motorway	Low	Negligible	Neutral	RTCs have been developed that are protective of groundwater quality
			Bedrock & GFD - Wentlooge Levels	Medium	Negligible	Neutral	RTCs have been developed that are protective of groundwater quality
			Bedrock & GFD - Caldicot Levels	Low	Negligible	Neutral	RTCs have been developed that are protective of groundwater quality
	Completed embankments that use piled foundations (>10m). Completed highway that includes road surface and fin drains (See Chapter 3 and Appendix 3.1)	Generation of potentially contaminated leachate by infiltration through embankment fill during operation of the highway.	Bedrock - Inland Bedrock (Castleton / Magor)	Medium	Negligible	Neutral	RTCs have been developed that are protective of groundwater quality
			Bedrock & GFD - Wentlooge Levels	Medium	Negligible	Neutral	RTCs have been developed that are protective of groundwater quality
			Bedrock & GFD - Caldicot Levels	Low	Negligible	Neutral	RTCs have been developed that are protective of groundwater quality

Design Element	Description	Potential Effects	Receptor	Receptor Sensitivity	Magnitude of Impact	Significance	General pathway notes &/or incorporated mitigations
Borrow Pits	Restoration / backfill with potentially contaminated soils	Generation of contamination groundwater	Bedrock - Inland Bedrock (Castleton / Magor)	Medium	Moderate	Moderate Adverse	Use of contaminated materials as backfill
			Bedrock & GFD - Wentlooge Levels	Medium	Moderate	Moderate Adverse	Use of contaminated materials as backfill
			Bedrock & GFD - New bridged section of motorway	Low	Moderate	Slight Adverse	Use of contaminated materials as backfill
			Bedrock & GFD - Caldicot Levels	Low	Moderate	Slight Adverse	Use of contaminated materials as backfill
Groundwater Dependant Features (including non-designated sites)							
Road Cuttings	Long term dewatering in area of new cutting	Adverse impact on non-designated groundwater dependent features by localised lowering of groundwater levels and alterations to groundwater flow field. Potential loss of source, reduced reliability or changed quality.	Non-designated Groundwater Dependent Receptors Castleton / Wentlooge Levels	Medium	Minor	Slight Adverse	Possible measurable effect on flow or discharge at springs or seepages.
Borrow Pits	Restoration / backfill with potentially contaminated soils	Generation of contamination groundwater that is discharged at groundwater dependent feature.	Non-designated Groundwater Dependent Receptors Castleton / Wentlooge Levels	Medium	Moderate	Moderate Adverse	Possible measurable effect on flow or discharge at springs or seepages.

Table 16.21: Assessment of Unmitigated Potential Operational Effects on Flood Risk and Drainage

Design Element	Description	Potential Effects	Receptor	Receptor Sensitivity	Magnitude of Impact	Significance	Justification
Embankments including Haul Roads	Completed embankments that use band drains (<5m). Completed highway that includes road surface and fin drains	Changes to flood risk during construction, relating to conveyance of flood waters through reen system	Surface Water - Gwent Levels Reen System	Very High	Negligible	Neutral	Use of Greenfield runoff rates (see Drainage Strategy Report at Appendix 2.2)
	Completed embankments that use piled foundations (>10m). Completed highway that includes road surface and fin drains	Changes to flood risk during construction, relating to conveyance of flood waters through reen system	Surface Water - Gwent Levels Reen System	Very High	Negligible	Neutral	Use of Greenfield runoff rates (see Drainage Strategy Report at Appendix 2.2)
Culverts Beneath Embankments		Changes to flood risk, relating to conveyance of flood waters through reen system	Surface Water - Gwent Levels Reen System	Very High	Negligible	Neutral	FCA (Appendix 16.1)
Reen / Field Drain Creation		Changes to flood risk, relating to conveyance of flood waters through reen system	Surface Water - Gwent Levels Reen System	Very High	Negligible	Neutral	FCA (Appendix 16.1)
Highway structures	Changes to conveyance of reens during construction	Impacts on property from changes to conveyance of flood waters through reen system during construction	Residential and commercial property	Very High	Negligible	Neutral	FCA (Appendix 16.1)

Design Element	Description	Potential Effects	Receptor	Receptor Sensitivity	Magnitude of Impact	Significance	Justification
	Changes to Flood Risk during construction	Impacts on property from changes to flood risk during construction	Residential and commercial property	Very High	Negligible	Neutral	FCA (Appendix 16.1)

Complementary Measures

16.8.27 For the operational phase, the potential effects on routine highway runoff and accidental emissions have been considered. The Complementary Measures would include the reclassification of the existing M4, which would affect the pollutant loading associated with the existing highway. No improvement to the existing standard of routine road runoff treatment is proposed as part of the Complementary Measures.

16.8.28 Whilst details and performance of the 'as built' existing structures designed to mitigate routine runoff from the existing M4 corridor between Junctions 23A and 29 are not known in detail, a qualitative assessment can be made based on projected offset of Annual Average Daily Traffic (AADT) reductions on the M4 following operation of the Scheme. The DMRB assessment methodology uses AADT ranges within which impacts to surface water from runoff discharges remain constant with only drained areas informing the calculation of potential impact.

16.8.29 It is predicted from traffic modelling that, following the implementation of Complementary Measures, traffic for design year 2037 would result in the AADT magnitude falling into a lower assessment range than the existing range (without the Scheme). This would result in a lowering of HAWRAT predicted runoff pollutant loads, HGV accident spillage risks and associated impacts to the water environment at the current discharge locations.

16.8.30 Notwithstanding the outcome of the DMRB Assessment, a reduction in traffic AADT would result in associated reductions in contaminant loadings to the existing M4 carriageway and therefore reductions in concentrations of runoff entering surface watercourses. Whilst it is not possible to quantify the precise magnitude of such pollution reductions, a beneficial impact would occur.

16.9 Additional Mitigation and Monitoring

16.9.1 A wide range of mitigation and monitoring measures have been identified during the EIA process and are proposed for the construction and operational phases to mitigate the potential effects on the water environment presented above.

16.9.2 For the construction phase these include the following.

- Undertaking the works within an agreed Materials Management Plan underpinned by a regulator approved Remediation Strategy and associated re-use criteria for the protection of the water environment, validated during the works. An Outline Materials Management Plan and an Outline Remediation Strategy are provided within this ES (see Appendices 3.2 and 11.2).
- Undertaking regular surface water and groundwater monitoring to establish water environment conditions before and during construction works to demonstrate that impacts to surface water and groundwater are within accepted limits agreed with NRW.
- Construction of a flood resilient surface water runoff containment bund along both sides of the alignment to capture, convey and treat construction drainage water prior to release to the water environment. Treatment methods would include settlement, filtering and flocculation. Such discharges would

be limited to avoid pollution and water quality monitoring would be undertaken to demonstrate compliance. Waters unfit for discharge would be disposed off-site if required.

- Construction of replacement reens and ditches during construction to maintain connectivity of the features of the Gwent Levels and replacement of sections lost under the new section of motorway. Greater lengths of replacement reens and ditches are proposed than that lost due to construction.
- Placement of the River Usk Crossing bridge pier foundations outside the 'wetted channel' to avoid direct impacts to the Special Area of Conservation.
- Undertaking works within a framework of environmental protection practices defined and co-ordinated via a Construction Environmental Management Plan (CEMP). A Pre-CEMP is provided at Appendix 3.2 of this ES. This includes the provision of an Outline Pollution Control and Prevention Plan and an Outline Groundwater and Surface Water Management Plan.

16.9.3 For the operational phase, additional measures include the following.

- Undertaking of 5 years of aftercare monitoring following the completion of construction works to characterise the longer term environmental performance of the Scheme with particular focus on the water treatment areas and areas where site won materials have been re-used within the Scheme.

16.9.4 These additional mitigation measures would be developed in advance of works commencing, following agreement with the regulatory authorities and will be presented in the following documents.

- Pollution Control and Prevention Plan.
- Groundwater and Surface Water Management Plan.
- Remediation Strategy.

16.9.5 The reports will refer to all legislative requirements, industry best practice and key regulatory guidance that define good working practices during construction most notably the following.

- Model Procedures for the Management of Land Contamination (CLR11) (Environment Agency and Defra, 2004).
- Groundwater Protection: Principles and Practice (GP13) (Environment Agency, 2013).
- CIRIA Technical Guidance C648: Control of Water Pollution from Linear Construction Projects (CIRIA, 2006).
- NRW Pollution Prevention Guidelines (PPG), most notably:
  - PPG 1 General guide to the prevention of water pollution.
  - PPG 2 Above ground oil storage tanks.
  - PPG 3 Use and design of oil separators in surface water systems.
  - PPG 4 Treatment and disposal of sewage where no foul sewer is found.
  - PPG 5 Work in, near or liable to affect a Watercourse.

- PPG 6 Working at demolition and construction sites.
- PPG 22 Dealing with spillages on highways.
- PPG 23 Maintenance of structures over water.

16.9.6 The assessment of construction and operational effects following the adoption of the proposed mitigation and monitoring commitments is summarised in the residual assessment presented in Tables 16.22 to 16.26.

Pollution Control and Prevention Plan

16.9.7 The pollution prevention plan shall identify all measures to minimise risks of contamination during the construction phase over and above the protocols and measures outlined in the other strategies and management plans.

Groundwater and Surface Water Management Plan

16.9.8 With regard to surface water, the Groundwater and Surface Water Management Plan shall consider all drainage required during the construction phase and will reference all industry and regulatory pollution prevention guidelines. The plan shall describe the design of each element of surface water management system required to manage surface water runoff during construction and potential risks to surface waters. This shall include consideration of temporary storage and settlement requirements to manage sediment load of waters. The plan shall define the water quality criteria to ensure any discharge to receiving watercourses meets regulatory requirements. The plan shall also define an appropriate monitoring regime to ensure that water quality will be protected to the satisfaction of the regulatory authorities. The plan will have to consider discharges to the Gwent Levels, inland watercourses and tidal waterbodies as required. Additionally, a site-specific piling risk assessment shall be provided, to ensure the most appropriate piling approach and methodology is utilised for the construction of pile foundations for embankments (above 5 metres height) and bridge tower and viaduct pier foundations. The piling risk assessment shall minimise the potential for the creation of new pathways and hence the cross contamination of controlled water receptors (i.e. groundwater and surface water).

16.9.9 With regard to groundwater, the plan shall consider all activities to be undertaken during the construction phase that may require groundwater control through pumping. The plan will reference all relevant industry and regulatory pollution prevention guidelines. The plan shall consider excavations within borrow pits, structures required for managing groundwater in areas of cut, the excavations required for bridge tower and viaduct pier foundations (particularly those requiring cofferdam construction) and excavations required for subsurface structures/utilities that may encounter shallow groundwater. The plan shall define the nature and approach for groundwater management following its abstraction, including monitoring to determine the acceptability of chemical and physical quality with respect to discharge to the surface water system.

16.9.10 Potential effects on private groundwater abstractors considered to be at moderate or high risk as identified in Table 16.15 would be mitigated through measures to be set out in the Groundwater and Surface Water Management Plan, most notably the following.

- Preconstruction baseline monitoring (quality and flow).

- Construction and post construction monitoring with agreed contingency measures.

16.9.11 The plan shall outline the scope of monitoring required with respect to private groundwater abstractions. This shall include a summary of source specific contingency measures should the flow, reliability and or quality be affected during the period of monitoring.

Remediation Strategy

16.9.12 The Remediation Strategy shall identify the nature and extent of remediation works required in advance of the construction phase. A contamination discovery strategy shall define the approach to managing any land contamination that may be identified during the construction phases. This includes the discovery of contamination within the land take area. The discovery strategy shall outline the methodology to be adopted to determine the acceptability of land quality and the contingency measures required should land quality be shown to be unsuitable for remaining in-situ. The discovery strategy shall include appropriate characterisation and verification monitoring required to demonstrate that these works are complete.

16.9.13 The report shall also outline all chemical reuse criteria, also known as Re-use Target Concentrations, required for the construction phase, including monitoring/verification testing requirements. Precautionary Re-use Target Concentrations shall also be developed for the materials to be replaced on borrow pits to ensure groundwater quality and groundwater dependent receptors are not adversely affected by the backfilling of these structures. The Re-use Target Concentrations will be designed to ensure that the Environmental Quality Standards agreed with NRW are achieved, based on leachability results and mixing with the received in groundwater.

16.9.14 Further details of these documents are provided in the outline plans provided in Appendix 3.2 and Appendix 11.2 of this ES.

16.10 Assessment of Land Take Effects

16.10.1 No effects have been identified associated solely with land take. Impacts on the water environment are therefore considered in Section 16.11 and 16.12 below.

16.11 Assessment of Construction Effects

Proposed New Section of Motorway

16.11.1 The effects during construction have been assessed for particular construction activities and different watercourse receptors (taking into account the mitigation set out in Section 16.9). The significance of construction effects on surface water quality, groundwater quality, groundwater dependent waterbodies, abstractions and flood risk have been considered. The importance of the receiving water feature, the magnitude of impact of construction activity, including mitigation, and the significance of the effect is reported. The main pluvial risk during construction would be increased runoff.

Surface Water Quality

Temporary Access Roads, Compounds and Storage/Laydown Area

16.11.2 Through the implementation of the Groundwater and Surface Water Management Plan, potential effects associated with uncontrolled surface water runoff would be mitigated. The Groundwater and Surface Water Management Plan shall include the provision of runoff containment measures (e.g. temporary drainage and/or bunding) to prevent uncontrolled runoff from construction areas and the provision of sufficient storage to allow settlement of suspended load, before discharge back into the surface water system. The CEMP and the associated Pollution Control and Prevention Plan will outline measures to control the use and management of potentially hazardous substances within the construction phase to reduce the likelihood and potential magnitude of accidental emissions. This includes the selection of appropriate areas for material storage/handling, delivery of appropriate storage facilities (e.g. bunding and hardstanding) and development of appropriate protocols for material use/handling.

Borrow Pits

16.11.3 Through the implementation of the Groundwater and Surface Water Management Plan, potential effects associated with uncontrolled surface water runoff within borrow pits shall be mitigated. Any unforeseen soil and groundwater contamination that may be identified shall be managed through the protocols and measures outlined in the Remediation Strategy and the Groundwater and Surface Water Management Plan

16.11.4 Potential effects on surface watercourses that may result from the discharge of groundwater abstracted for the purpose of dewatering shall also be mitigated by measures outlined in the Groundwater and Surface Water Management Plan and Pollution Control and Prevention Plan should contaminated groundwater be encountered.

Construction of Embankments

16.11.5 Surface runoff from embankments shall be managed in accordance with the Groundwater and Surface Water Management Plan to ensure there are no adverse effects on receiving waterbodies.

Road Cuttings

16.11.6 Potential effects on surface watercourses that may result from the long term discharge of groundwater dewatering from areas of new or extended cut shall be mitigated through the Groundwater and Surface Water Management Plan and pollution prevention measures should contaminated groundwater be encountered. This would ensure that he water quality at the point of discharge to receiving surface waterbodies meets agreed water quality standards.

Culverting of Reens and Construction of Compensatory Reens and Field Drains

16.11.7 The potential for a direct impact on surface water quality through temporary works undertaken on existing reens and/or the construction of compensatory reens and field drains shall be managed through the Groundwater and Surface Water Management Plan and Remediation Strategy developed for the Scheme.

In the event that shallow groundwater control is required, the resulting groundwater shall be managed in accordance with the Outline Groundwater and Surface Water Management Plan. These measures shall mitigate these effects and consequently it is considered likely that adverse effects on water quality within the Gwent Levels SSSI can be avoided.

New Bridged Section of the Motorway

Any possible effects that may result from the construction of piled tower foundations, including groundwater control measures associated with the use of cofferdams shall be mitigated through the measures outlined in the and Groundwater and Surface Water Management Plan. By undertaking site-specific piling assessment the potential for creating new pathways with the potential to result in cross contamination shall be minimised. These mitigation measures would reduce the risk of any adverse effects on adjacent tidal waterbodies.

16.11.8 As set out above, further details of these plans is provided in Appendices 3.2 and 11.2 of this ES.

Table 16.22: Final Assessment of Construction Effects on Surface Water Quality

Construction Activity	Works Element	Potential Effects	Receptor	Receptor Sensitivity	Magnitude of Impact	Significance
Borrow Pits	Excavation and runoff	Generation of potentially contaminated, silt laden runoff during excavation	Gwent Levels drainage system (SSSI)	Very High	Negligible	Neutral
			Inland watercourses (non-SSSI)	High	Negligible	Neutral
			Tidal waterbodies - Designated (Usk, Severn)	Very High	Negligible	Neutral
			Tidal waterbodies - Non-Designated (Ebbw)	Medium	Negligible	Neutral
	Groundwater dewatering during excavation	Abstraction and discharge of low quality groundwater during dewatering, resulting in a direct impact on receiving surface waterbody	Gwent Levels drainage system (SSSI)	Very High	Negligible	Neutral
			Inland watercourses (non-SSSI)	High	Negligible	Neutral
			Tidal waterbodies - Designated (Usk, Severn)	Very High	N/A	N/A
			Tidal waterbodies - Non-Designated (Ebbw)	Medium	N/A	N/A
Highway Embankments including Haul Roads	Dewatering of TFD on Gwent Levels using band drains in embankments less than 5 m high	Direct impact on surface watercourses resulting from lateral flow through drainage blanket	Gwent Levels drainage system (SSSI)	Very High	Negligible	Neutral
			Tidal Waterbodies - Designated (i.e. Usk / Severn)	Very High	Negligible	Neutral
			Tidal Waterbodies - Non-designated (Ebbw)	Medium	Negligible	Neutral
	Use of cement ground stabilisation and re-used materials as general embankment fill in embankments the utilise band drains to	Generation of potentially contaminated leachate by infiltration through general embankment fill during surcharging period, before highway surface	Tidal Waterbodies - Designated (i.e. Usk / Severn)	Very High	Negligible	Neutral
			Tidal Waterbodies - Non-designated (Ebbw)	Medium	Negligible	Neutral
			Gwent Levels drainage system (SSSI)	Very High	Negligible	Neutral

Construction Activity	Works Element	Potential Effects	Receptor	Receptor Sensitivity	Magnitude of Impact	Significance
	facilitate settlement of TFD on Gwent Levels	completed. Lateral or vertical flows to surface water receptors				
	Use of cement ground stabilisation and re-used materials as general embankment fill in embankments that utilise piled foundations without need for band drains to facilitate settlement of TFD on Gwent Levels	Generation of potentially contaminated leachate by infiltration through general embankment fill during surcharging period, before highway surface completed. Lateral or vertical flows to surface water receptors	Tidal Waterbodies - Designated (i.e. Usk / Severn)	Very High	Negligible	Neutral
			Tidal Waterbodies - Non-designated (Ebbw)	Medium	Negligible	Neutral
			Gwent Levels drainage system (SSSI)	Very High	Negligible	Neutral
	Surface runoff from embankments during construction and surcharging period	Generation of potentially contaminated, silt laden runoff during construction phase	Gwent Levels drainage system (SSSI)	Very High	Negligible	Neutral
			Inland watercourses (non-SSSI)	High	Negligible	Neutral
			Tidal waterbodies - Designated (Usk, Severn)	Very High	Negligible	Neutral
			Tidal waterbodies - Non-Designated (Ebbw)	Medium	Negligible	Neutral
Road Cuttings	Construction of road cuttings in the vicinity of the Castleton and Magor junctions.	Interception of contaminated waters emanating from known areas of contamination (CL Sites) or unknown sources	Gwent Levels drainage system (SSSI)	Very High	Negligible	Neutral
			Inland Watercourses (non-SSSI)	High	Negligible	Neutral

Construction Activity	Works Element	Potential Effects	Receptor	Receptor Sensitivity	Magnitude of Impact	Significance
	Generally extensions of exiting cut rather than new cuts	of groundwater contamination. Potential impact on receiving waters				
Construction of Mitigation Reens / Field Drain	-	Direct impact on reen system, principally by sediment generated during culverting	Gwent Levels drainage system (SSSI)	Very High	Negligible	Neutral
Bridge Tower and Viaduct Piers	Construction of bridge tower foundations that may involve construction of coffer dams and dewatering.	Generation, management and handling of contaminated sediments &/or groundwater during construction.	Gwent Levels Drainage System (SSSI)	Very High	N/A	N/A
			Inland watercourses (non-SSSI)	High	N/A	N/A
			Tidal waterbodies - Designated (Usk & Severn)	Very High	Minor Adverse	Moderate Adverse
			Tidal waterbodies - Non-Designated (Ebbw)	Medium	Minor Adverse	Slight Adverse
	Installation of piled foundations for viaduct piers	Creation of pathways that allow contaminated groundwater to enter bedrock / GFD beneath TDF.	Tidal Waterbodies - Designated (i.e. Usk / Severn)	Very High	Negligible	Neutral
			Tidal Waterbodies - Non-designated (i.e. Ebbw)	Medium	Negligible	Neutral
Construction and use of temporary access roads, compounds and laydown areas	Generation of potentially contaminated, silt laden runoff during excavation.		Gwent Levels drainage system (SSSI)	Very High	Negligible	Neutral

Construction Activity	Works Element	Potential Effects	Receptor	Receptor Sensitivity	Magnitude of Impact	Significance
Use and storage of Materials	Accidental spillage of hazardous substances to ground or direct to surface water		Gwent Levels drainage system (SSSI)	Very High	Negligible	Neutral
			Inland Watercourses (non-SSSI)	High	Negligible	Neutral
			Tidal Waterbodies - Designated (i.e. Usk / Severn)	Very High	Negligible	Neutral
			Tidal Waterbodies - Non-designated (Ebbw)	Medium	Negligible	Neutral

Groundwater

Groundwater Quality

16.11.9 Outside of areas of known contamination, groundwater quality may be affected by accidental emissions/releases of substances potentially hazardous to ground associated with construction activities, movements on temporary access roads, compounds and storage/laydown areas. These would be managed through the CEMP and the associated Pollution Control and Prevention Plan and Groundwater and Surface Water Management Plan.

16.11.10 The disturbance of areas affected by currently unknown contamination, particularly in areas where intrusive works are required (most notably pile foundations and/or bridge tower and viaduct piers and borrow pits) would be managed through the Discovery Strategy.

16.11.11 Potential leakage through piled foundations would be further mitigated by the piling risk assessments that would be undertaken to determine the preferred piling types and construction methodology.

Groundwater Resources and Resource Potential

16.11.12 Long term, extensive dewatering is not a feature of the Scheme. The greatest effects would occur in those areas of major cut principally at the Castleton end of the new section of motorway although short term effects may be associated with any dewatering of the borrow pits. Potential effects in these areas are set out in the assessment undertaken for private water users below.

Groundwater Dependent Receptors

16.11.13 No groundwater dependant receptors have been identified with the exception of private water users which are assessed separately.

Private Water Users

16.11.14 Potential effects on private groundwater abstractors considered to be at moderate or high risk as identified in Table 16.15 would be mitigated through measures outlined in the Groundwater and Surface Water Management Plan, most notably the following.

- Preconstruction baseline monitoring (quality and flow).
- Construction and post construction monitoring with agreed contingency measures.

16.11.15 Contingency measures would include the provision of an emergency source of water should the reliability of supply and/or water quality be affected during construction phase. For two highest risk sources identified in Table 16.15 and/or sources shown to be impacted during the construction and operation of the Scheme an alternative source of water supply shall be provided.

Table 16.23: Final Assessment of Mitigated Construction Effects on Groundwater

Construction Activity	Works Element	Potential Effects	Receptor	Receptor Sensitivity	Magnitude of Impact	Significance
Borrow Pits	Excavation or runoff	Disturbance of previously unknown contamination sources	Bedrock - Inland Bedrock (Castleton / Magor)	Medium	Negligible	Neutral
			Bedrock & GFD - Wentlooge Levels	Medium	N/A	N/A
			Bedrock & GFD - New bridged section of motorway	Low	N/A	N/A
			Bedrock & GFD - Caldicot Levels	Low	N/A	N/A
			Non-designated Groundwater Dependent Receptors (Castleton / Wentlooge Levels)	Medium	Negligible	Neutral
	Groundwater dewatering during excavation.	Localised reduction in groundwater levels and flows	Bedrock - Inland Bedrock (Castleton / Magor)	Medium	Minor Adverse	Slight Adverse
			Bedrock & GFD - Wentlooge Levels	Medium	N/A	N/A
			Bedrock & GFD - New bridged section of motorway	Low	N/A	N/A
			Bedrock & GFD - Caldicot Levels	Low	N/A	N/A
			Non-designated Groundwater Dependent Receptors (Castleton / Wentlooge Levels)	Medium	Negligible	Neutral
Highway Embankments including Haul Roads	Dewatering of TFD on Gwent Levels using band drains in embankments less than 5 m high	Impact on groundwater quality	Bedrock - Inland Bedrock (Castleton / Magor)	Medium	N/A	N/A
			Bedrock & GFD - New bridged section of motorway	Low	N/A	N/A
			Bedrock & GFD - Wentlooge Levels	Medium	Minor Adverse	Slight Adverse
			Bedrock & GFD - Caldicot Levels	Low	Minor Adverse	Neutral
			Non-designated Groundwater Dependent Receptors (Castleton / Wentlooge Levels	Medium	Negligible	Neutral
	Use of cement ground stabilisation and re-used	Generation of potentially contaminated leachate by infiltration through	Non-designated Groundwater Dependent Receptors (Castleton / Wentlooge Levels)	Medium	Negligible	Neutral
			Bedrock & GFD - New bridged section of motorway	Low	N/A	N/A

Construction Activity	Works Element	Potential Effects	Receptor	Receptor Sensitivity	Magnitude of Impact	Significance
	materials as general embankment fill in embankments the utilise band drains to facilitate settlement of TFD on Gwent Levels	general embankment fill during surcharging period, before highway surface completed. Vertical flows to groundwater in bedrock / GFD.	Bedrock & GFD - Wentlooge Levels	Medium	Negligible	Neutral
			Bedrock & GFD - Caldicot Levels	Low	Negligible	Neutral
	Use of cement ground stabilisation and re-used materials as general embankment fill in embankments that utilise piled foundations without need for band drains to facilitate settlement of TFD on Gwent Levels	Generation of potentially contaminated leachate by infiltration through general embankment fill during surcharging period, before highway surface completed. Lateral or vertical flows to surface water receptors	Bedrock & GFD - New bridged section of motorway	Low	N/A	N/A
			Bedrock - Inland Bedrock (Castleton / Magor)	Medium	Negligible	Neutral
			Bedrock & GFD - Wentlooge Levels	Medium	Negligible	Neutral
			Bedrock & GFD - Caldicot Levels	Low	Negligible	Neutral
Road Cuttings	Construction of road cuttings in the vicinity of the Castleton and	Disturbance of previously unknown contamination sources	Bedrock - Inland Bedrock (Castleton / Magor)	Medium	Negligible Adverse	Neutral

Construction Activity	Works Element	Potential Effects	Receptor	Receptor Sensitivity	Magnitude of Impact	Significance
	Magor junctions. Generally extensions of exiting cut rather than new cuts	Adverse impact on non-designated groundwater dependent features by localised lowering of groundwater levels and alterations to groundwater flow field. Potential loss of source, reduced reliability or changed quality.	Non-designated Groundwater Dependent Receptors (Castleton / Wentlooge Levels)	Medium	Negligible	Neutral
Bridge Viaduct Piers	Construction of bridge support structures than may involve construction of coffer dams and dewatering	Local reduction of groundwater level and/or groundwater flow	Bedrock & GFD - New bridged section of motorway	Low	Negligible	Neutral
			Non-designated Groundwater Dependent Receptors (Castleton / Wentlooge Levels)	Medium	N/A	N/A
	Installation of piled piers.	Creation of pathways and transport of contaminants to groundwater	Bedrock & GFD - New bridged section of motorway	Low	Minor Adverse	Neutral
Use & Storage Materials	Accidental spillage of hazardous substances to ground.		Bedrock - Inland Bedrock (Magor)	Medium	Minor Adverse	Slight Adverse
			Bedrock - Inland Bedrock (Castleton)	Medium	Negligible	Neutral
			Bedrock & GFD - Wentlooge Levels	Medium	N/A	N/A
			Bedrock & GFD - New bridged section of motorway	Low	N/A	N/A
			Bedrock & GFD - Caldicot Levels	Low	N/A	N/A

Construction Activity	Works Element	Potential Effects	Receptor	Receptor Sensitivity	Magnitude of Impact	Significance
			Non-designated Groundwater Dependent Receptors (Castleton / Wentlooge Levels)	Medium	Minor Adverse	Slight Adverse

Flood Risk and Drainage

16.11.16 Surface drainage would be managed during construction to control runoff, together with any groundwater from surcharging and the use of band drains to avoid uncontrolled discharges to the water environment and to avoid flooding. This design would comply with best practice as described in CIRIA C648 'Control of water pollution from linear construction projects' (CIRIA, 2006). Drainage control would be achieved by use of a site specific, hydraulically isolated construction drainage design comprising lateral bunds sized to allow capture and sufficient attenuation of rainfall for a 10 year return storm of two day duration. The scheme would also allow for the temporary storage of this water to achieve adequate settlement of 7 hours prior to controlled discharge to the water environment via reens under consent from NRW. Settlement would take place within the water treatment areas specifically designed for this purpose during the construction period.

16.11.17 Additional mitigation that may be required periodically to achieve acceptable discharge quality includes the use of pumps, flocculation devices, filtration media, other specialist treatment equipment or off-site disposal as a worst case contingency.

16.11.18 Prior to discharge, treated surface water would be tested to ensure compliance criteria are met for chemical and physical parameters including pH and total suspended solids, to be agreed with NRW.

16.11.19 The construction phase water management design proposed would be capable of the following.

- Retaining the volume of water from a 1 in 10 year intense (six hour) storm within the lateral lagoons without discharge to the existing reen network.
- Settlement of fine silt transported by runoff from a 1 in 10 year long duration (48 hour) storm using water treatment area footprints without the incoming flow rate exceeding the minimum settlement duration.

16.11.20 Achieving this standard would mitigate uncontrolled releases of potentially polluting drainage water and protect ambient high surface water quality within reens and ditches in close proximity to the construction corridor.

Complementary Measures

16.11.21 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 no significant predicted effects on hydrology or flood risk, over and above those assessed for the new section of motorway above.

16.12 Assessment of Operational Effects

16.12.1 During operation, the proposed mitigation provided would ensure that there would be no significant adverse effect on the water environment. Infrequent, local and temporary effects on ambient baseline surface water quality could occur but these would not be of sufficient magnitude to breach appropriate Environmental Quality Standards. There would also be a potential improvement

in water quality due to reduced use of the existing M4 and reduced spillage risk in this area.

Proposed New Section of Motorway

Surface Water Quality

16.12.2 The effects of routine highway runoff on surface water quality within the Gwent Levels SSSIs would be mitigated through the design elements incorporated into the new section of motorway and the proposed mitigation measures set out in Section 16.9.

16.12.3 Short term episodic breaches of ambient chloride concentrations may occur during severe winters where freeze-thaw periods release elevated loads of dissolved road salt to the water treatment areas. It is anticipated that under such conditions, dilution from the thawing of snow and ice within reen catchments would promote dilution of in channel concentrations to render such discharges negligible, taking into account their localised nature and short duration. Such infrequent, short term and highly localised elevated chloride concentrations close to water treatment area outfalls would not pose a risk to the wider biodiversity of the Gwent Levels.

16.12.4 The risk to surface water quality associated with the long term discharge of potentially contaminated waters to inland watercourses and the risk to the Gwent SSSIs would be mitigated by the measures implemented through the Groundwater and Surface Water Management Plan and Remediation Strategy. Outline documents are provided in Appendices 3.1 and 11.2 of this ES.

Groundwater

16.12.5 Potential effects on groundwater quality in bedrock or Glaciofluvial Deposits that underlie the Gwent Levels would be mitigated through the derivation of Reuse Target Concentrations for material reuse within embankments and the completion of a piling risk assessment in advance of construction.

16.12.6 Precautionary Reuse Target Concentrations would be derived for materials to be used as backfill for former borrow pits. This would ensure any effects of leaching from these deposits on groundwater quality and groundwater dependent receptors would be neutral.

Private Water Users

16.12.7 Only two sources (Source Ref. 1.1 and 16.2 in Table 16.15) are considered to have the potential to require an alternative source of supply to be provided as mitigation for potential effects associated with post construction areas at the Castleton and Magor Interchanges of the new section of motorway. Potentially measurable effects cannot be discounted at other sources.

Flood Risk

16.12.8 Further to the embedded mitigation for the Scheme describe in Section 16.5, it is professionally judged that any areas of increased flood depths above 10 mm could be effectively mitigated through adjustment of levels for new tilting weirs provided at each of the reens culverted through the alignment. No significant effects are likely with mitigation in place.

Table 16.24: Assessment of Operational Effects on Surface Water Quality

Aspect of Operational Design	Description	Potential Effects	Receptor	Receptor Sensitivity	Magnitude of Impact	Significance	Mitigation Measures & Monitoring
Highway Runoff	Routine runoff to new highway drainage system	Routine runoff directly to surface waterbodies receiving highway runoff from WTA	Gwent Levels drainage system (SSSI)	Very High	Negligible	Neutral	DMRB Assessment. Aftercare monitoring proposed
			Inland Watercourses (non-SSSI)	High	Negligible	Neutral	
		Serious pollution incidents arising as a result of a spillage resulting in direct impact on surface waterbodies receiving highway runoff from WTA	Gwent Levels drainage system (SSSI)	Very High	Negligible	Neutral	
			Inland Watercourses (non-SSSI)	High	Negligible	Neutral	
	Routine runoff from Bridged Section	Discharge to Tidal Waterbodies	Tidal Waterbodies - Designated (i.e. Usk / Severn)	Very High	Negligible	Neutral	DMRB Assessment. Aftercare monitoring proposed
			Tidal Waterbodies - Non-designated (Ebbw)	Medium	Minor Adverse	Slight adverse	
		Discharge to reen system within Gwent Levels	Surface Water - Gwent Levels Reen System	Very High	Negligible	Neutral	
		Serious pollution incidents arising as a result of a	Surface Water - Tidal Waterbodies (i.e. Usk / Severn)	Very High	Negligible	Neutral	DMRB Assessment.

Aspect of Operational Design	Description	Potential Effects	Receptor	Receptor Sensitivity	Magnitude of Impact	Significance	Mitigation Measures & Monitoring
		spillage resulting in discharge to Tidal Waterbodies	Tidal Waterbodies - Non-designated (Ebbw)	Medium	Minor Adverse	Slight adverse	
		Discharge to reen system within Gwent Levels	Surface Water - Gwent Levels Reen System	Very High	Negligible	Neutral	DMRB Assessment. Aftercare monitoring proposed
Embankments including Haul Roads	Completed embankments that use band drains (<5m). Completed highway that includes road surface and fin drains	Generation of potentially contaminated leachate by infiltration through embankment fill during operation of the highway.	Tidal Waterbodies - Designated (i.e. Usk / Severn)	Very High	Negligible	Neutral	Outline Remediation Strategy - RTCs for backfill materials Aftercare monitoring proposed
			Tidal Waterbodies - Non-designated (Ebbw)	Medium	Negligible	Neutral	
			Gwent Levels drainage system (SSSI)	Very High	Negligible	Neutral	
	Completed embankments that use piled foundations (>5m). Completed highway that includes road surface and fin drains	Generation of potentially contaminated leachate by infiltration through embankment fill during operation of the highway.	Tidal Waterbodies - Designated (i.e. Usk / Severn)	Very High	Negligible	Neutral	Outline Remediation Strategy - RTCs for backfill materials. Piling Risk Assessment. Aftercare monitoring proposed.
			Tidal Waterbodies - Non-designated (Ebbw)	Medium	Negligible	Neutral	
			Gwent Levels Drainage System (SSSI)	Very High	Negligible	Neutral	
Road Cuttings	Long term dewatering in area of new cutting	Long term discharge of potentially contaminated water to surface water receptors	Gwent Levels drainage system (SSSI)	Very High	Negligible	Neutral	Outline Groundwater and Surface Water Management Plan and Outline Remediation Strategy
			Inland Watercourses (non-SSSI)	High	Negligible	Neutral	

Aspect of Operational Design	Description	Potential Effects	Receptor	Receptor Sensitivity	Magnitude of Impact	Significance	Mitigation Measures & Monitoring
Culverts Beneath Embankments		Alteration to water quality of reens in culverted areas	Gwent Levels drainage system (SSSI)	Very High	Negligible	Neutral	Reen Mitigation Strategy. Aftercare monitoring proposed
Borrow Pits	Restoration with materials unsuitable for use	Generation of contaminated groundwater, that discharges to lateral surface water features	Inland Watercourses (non-SSSI)	High	Negligible	Neutral	Outline Remediation Strategy - RTCs for backfill materials
			Gwent Levels drainage system (SSSI)	Very High	Negligible	Neutral	

Table 16.25: Assessment of Operational Effects on Groundwater

Aspect of Operational Design	Description	Potential Effects	Receptor	Receptor Sensitivity	Magnitude of Impact	Significance	Mitigation Measures & Monitoring
Groundwater Quality							
Embankments including Haul Roads	Completed embankments that use band drains (<5m). Completed highway that includes road surface and fin drains (See Chapter 3)	Generation of potentially contaminated leachate by infiltration through embankment fill during operation of the highway.	Bedrock - Inland Bedrock (Castleton / Magor)	Medium	Negligible	Neutral	Outline Remediation Strategy - RTCs for backfill materials
			Bedrock & GFD - New bridged section of motorway	Low	Negligible	Neutral	
			Bedrock & GFD - Wentlooge Levels	Medium	Negligible	Neutral	
			Bedrock & GFD - Caldicot Levels	Low	Negligible	Neutral	
	Completed embankments that use piled foundations (>5m). Completed highway that includes road surface and fin drains (See Chapter 3)	Generation of potentially contaminated leachate by infiltration through embankment fill during operation of the highway.	Bedrock - Inland Bedrock (Castleton / Magor)	Medium	Negligible	Neutral	Piling Risk Assessment. Outline Remediation Strategy - RTCs for backfill materials
			Bedrock & GFD - Wentlooge Levels	Medium	Negligible	Neutral	
			Bedrock & GFD - Caldicot Levels	Low	Negligible	Neutral	
Borrow Pits	Restoration with materials unsuitable for use	Generation of contamination groundwater	Bedrock - Inland Bedrock (Castleton / Magor)	Medium	Negligible	Neutral	Outline Remediation Strategy - RTCs for backfill materials
			Bedrock & GFD - Wentlooge Levels	Medium	Negligible	Neutral	
			Bedrock & GFD - New bridged section of motorway	Low	Negligible	Neutral	
			Bedrock & GFD - Caldicot Levels	Low	Negligible	Neutral	

Aspect of Operational Design	Description	Potential Effects	Receptor	Receptor Sensitivity	Magnitude of Impact	Significance	Mitigation Measures & Monitoring
Groundwater Dependant Features (Non-designated)							
Road Cuttings	Long term dewatering in area of new cutting	Adverse impact on non-designated groundwater dependent features by localised lowering of groundwater levels and alterations to groundwater flow field. Potential loss of source, reduced reliability or changed quality.	Non-designated Groundwater Dependent Receptors Castleton / Wentlooge Levels	Medium	Minor	Slight Adverse	
Borrow Pits	Restoration with materials unsuitable for use	Generation of contamination groundwater	Non-designated Groundwater Dependent Receptors Castleton / Wentlooge Levels	Medium	Negligible	Neutral	Outline Remediation Strategy - RTCs for backfill materials

Table 16.26: Assessment of Operational Effects on Flood Risk and Drainage

Aspect of Operational Design	Works Element	Potential Effects	Receptor	Receptor Sensitivity	Magnitude of Impact	Significance
Highway structures	Completed embankments that use band drains (<5m). Completed highway that includes road surface and fin drains (See Chapter 3)	Changes to Flood Risk and conveyance of waters through reen system	Commercial and residential property	Very High	Negligible	Neutral
	Completed embankments that use piled foundations (>5m). Completed highway that includes road surface and fin drains (See Chapter 3)	Changes to Flood Risk and conveyance of waters through reen system	Commercial and residential property	Very High	Negligible	Neutral
	Reen / Field Ditch creation	Changes in changes in conveyance through reen system	Surface Water - Gwent Levels Reen System	Very High	Negligible	Neutral

Complementary Measures

16.12.9 For the operational phase, the potential effects on routine highway runoff and accidental emissions have been considered. The Complementary Measures would include the reclassification of the existing M4, which would significantly reduce the pollutant loading associated with the existing highway. AADT and HGV% figures for the existing M4 with and without the new section of motorway in place predict a minimum of 31% and 59% reduction in AADT and HGV% respectively (see DMRB Assessment at Appendix 16.3). No improvement to the existing standard of routine road runoff treatment is proposed as part of the Complementary Measures, however the stated predicted reductions in car, and in particular HGV, use would result in beneficial effects by locally improving water quality within the surface watercourses and groundwater currently receiving routine runoff discharges.

16.13 Assessment of Cumulative Effects

16.13.1 In terms of water quality, the principal premise of the Scheme's construction methodology and operational design is that surface water and groundwater pollution is managed to prevent deterioration. This is achieved through risk assessment, use of remediation criteria, supported by baseline and aftercare monitoring. The design of water treatment areas for operational highway runoff would mitigate any long term adverse effect on the water quality within the Gwent Levels, which would be identified prior to construction taking account of non-construction related variation in water quality measured at distant monitoring locations.

16.13.2 It is the responsibility of regulators to manage cumulative effects on the water environment through applications for planning, environmental permits, abstraction licensing or discharge consents. This regulatory process takes account of site specific ambient baseline conditions, together with the polluting potential of proposed development to mitigate unacceptable impacts, thus minimising the risk of cumulative impacts ion the water environment being realised.

16.13.3 Operationally, the principal direct risk to the water environment is from highway runoff polluted from traffic use. The assessment undertaken has used predicted AADT data from a traffic model, which includes key future development allocations. The impacts on the water environment are therefore reflective of cumulative effects with those developments that could generate increases in traffic flows on the new section of motorway/reclassified M4.

16.13.4 Due to the large linear size of the Scheme, flood risk has been modelled and assessed for this project at a regional scale and over 1 in 100 and 1 in 1,000 year plus climate change rainfall events. Flood risk assessment and management of all development is undertaken with the philosophy of not increasing flood risk of the land take and any third party land. Accordingly, cumulative risks from flooding are likely to be controlled through the planning and consent process insofar as development cannot be permitted to the detriment of other projects or existing receptors.

16.13.5 Further details of potential cumulative effects are provided in Chapter 17 of this ES.

16.14 Inter-relationships

16.14.1 Interrelationships have been identified with ecology and land use as biodiversity of the Gwent Levels SSSIs is dependent on unpolluted surface water quality. The SSSIs are specifically designated for aquatic macrophytes and invertebrates. Both these groups are expected to be sensitive to changes in water quality. Additionally, water quality within the reens can be adversely affected by agricultural and industrial pollution as well as changes in flows caused by penning in the short term or climate change in the longer term.

16.14.2 Given the complex inter-relationships between these factors, it is concluded that it would not be possible to determine a set of water quality objectives that would seek to lower water quality whilst maintaining the conservation status of the SSSIs. Therefore, a design approach has been adopted where water discharges from the new section of motorway would be via bespoke water treatment areas to maintain measured ambient background concentrations within the reens proposed to receive discharges of treated highway runoff.

16.14.3 Pollutants within highway drainage increase with increasing traffic density and vice versa. An inter-relationship therefore exists between the predicted traffic use of the new section of motorway and as well as reductions in traffic use of the existing M4. These have been accounted for by utilising traffic density predictions with and without the Scheme in place for the design year of the project.

16.14.4 Adverse effects on the water environment could be realised by dusts derived from construction materials entering watercourses. This could result in physical effects i.e. turbidity and silting, or chemical, i.e. pollution, occurring. A number of construction and materials management strategies would be employed to limit dust generation and prevent impacts of water courses beyond the construction corridor. These measures are considered in Chapter 7 of this ES.

16.14.5 Further details of inter-related effects are provided in Chapter 17 of this ES.

16.15 Summary of Effects

16.15.1 The assessment of likely effects on the water environment, including drainage, has identified potential impacts on surface water, groundwater and flood risk, both during the construction and operational phases of the proposed new section of motorway. Surface water comprising River Usk and the Gwent Levels and specifically the Special Area of Conservation and SSSIs therein, are recognised as highly sensitive owing to the important biodiversity supported, specifically in the case of the SSSIs, by the presence of high water quality and the general absence of pollutants.

16.15.2 By contrast, groundwater is not as sensitive owing to the general concealment of aquifers by low permeability, clay rich soils. Additionally, within the Caldicot Levels, elevated chloride concentrations reduce the value of groundwater as a drinking water resource. Some spring fed potable or agricultural water supplies are present near the Castleton Interchange, a small number of which are recognised as being at risk of interruption or denigration principally during the construction period. Mitigation would be provided in the form of monitoring and the temporary or long term replacement of affected supplies.

16.15.3 During construction the appropriate control, storage, treatment and discharge of runoff and dewatered groundwater has been recognised as the principal mitigation of both surface water and groundwater impacts. Such measures have been delineated following regulator guidance and best practices and key measures are contained within the Pre-CEMP (Appendix 3.2), supported by an Outline Pollution Control and Prevention Plan and an Outline Groundwater and Surface Water Management Plan. The construction period would also be subject to extensive performance and aftercare monitoring to demonstrate no detriment to existing long term water quality indicators.

16.15.4 The construction of the embankment through the Gwent Levels would require the redirection of reens and ditches severed and infilled by the route. This would be achieved by the construction of new reens, connecting the severed watercourses and passing through the embankment via large box culverts. A greater length of reens and ditches is proposed to be provided than would be lost to construction, as described in Chapter 2.

16.15.5 Site won soils as well as stabilised lagoon material from the Tata steelworks is proposed to be re-used within the Scheme, principally as a fill within embankments. The potential for lateral flow of contaminated leachate out of the embankments and into to the surrounding reen system has been considered. Re-use Target Concentrations have been developed that ensure no unacceptable impact to surface water quality would occur. The Re-use Target Concentrations for soils developed for the new section of motorway would be presented in the Remediation Strategy for the Scheme. This would ensure that infiltrating water through the permanent works would have a negligible impact on water quality of the surface water within the Gwent Levels.

16.15.6 During operation, the principal effects are from routine highways drainage and the effect of the permanent works on flood risk. Routine drainage has been assessed utilising an approved risk assessment tool for the evaluation of pollution of watercourses. Given the high sensitivity of the Gwent Levels, the Scheme design has incorporated the use of roadside grass lined channels capturing and transferring runoff to water treatment areas as described in Chapter 2 (Scheme Description). Both the grass lined channels and the water treatment areas are capable of removing the potential pollutants emanating from the carriageway to allow water to return to the reen network to both prevent flooding (to a 1 in 100 year plus climate change standard) and to preserve long term water quality conditions of the Gwent Levels.

16.15.7 A Flood Consequences Assessment has been produced based on a flood model for both the Wentlooge and Caldicot Levels to assess the effect on flood risk on the region with the Scheme in place. Both the 1 in 100 year and 1 in 1,000 year plus climate change scenarios have been assessed. The Flood Consequences Assessment has concluded that no property would experience an increased risk of fluvial or pluvial flooding and those areas of predicted detriment down stream of some of the main reen culverts through the embankment can be mitigated through control sluices present on the culverts.

16.15.8 With currently proposed improvements to the Gwent Levels sea defences, the proposed new section of motorway would not be at risk of tidal flooding up to the year 2030 notwithstanding sea level rises due to climate change. Continued improvements to sea defences beyond 2030, in line with Welsh Government policy to ‘Hold the Line’ would ensure that the proposed new section of motorway

would remain flood free into the future, notwithstanding sea level rises due to climate change.

16.15.9 Effects on private abstractions are not assessed for significance of impact as no criteria for sensitivity of receptor or magnitude of effect are prescribed by the DMRB methodology. The risk of private supply denigration has however been assessed on all identified private supplies on a relative risk basis as summarised in Table 16.15. Mitigation of possible short and long term effects on continuity or quality of supply is provided in the text and comprises the provision of either temporary or permanent alternative water supplies.

16.15.10 On the basis of the assessments presented a summary of effects is summarised in Table 16.27 below.

Table 16.27: Summary of Likely Environmental Effects on Water Environment and Drainage

Activity	Sensitivity of receptor	Works Element	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
Construction Phase: Surface Water Quality								
Borrow pits	Medium to Very High	Excavation and runoff – generation of runoff	Short and medium term	Minor to Moderate Adverse	Slight Adverse to Very Large Adverse	Negligible	Neutral	Not significant
		Groundwater dewatering during excavation		Moderate adverse	Large to Very Large Adverse	Negligible	Neutral	Not significant
Highway embankments	Medium to Very High	Dewatering of Tidal Flat Deposits using band drains	Short and medium term	Negligible to Minor Adverse	Neutral to Moderate Adverse	Negligible	Neutral	Not significant
		Use of cement ground stabilisation and reused materials as embankment fill		Negligible to Moderate Adverse	Neutral to Large Adverse	Negligible	Neutral	Not significant
		Surface runoff from embankments during construction and surcharging		Minor to Moderate Adverse	Slight adverse to Very Large Adverse	Negligible	Neutral	Not significant
Road cuttings	High to Very High	Construction of road cuttings – Magor and Castleton junctions – interception of contaminated waters	Short and medium term	Minor to Moderate Adverse	Moderate to Large Adverse	Negligible	Neutral	Not significant
Construction of mitigation reens / field drains	Very High	Sediment generation through culverting	Short and medium term	Moderate Adverse	Very Large Adverse	Negligible	Neutral	Not significant
Bridge towers and viaduct piers	Medium to Very High	Construction of bridge piers	Short and medium term	Moderate Adverse	Moderate to Very Large Adverse	Minor Adverse	Slight to Moderate adverse	Significant
		Installed piled foundations		Minor Adverse	Slight to Large Adverse	Negligible	Neutral	Not significant

Activity	Sensitivity of receptor	Works Element	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
Temporary access roads / compounds/ laydown areas	Very High	Generation of potentially contaminated runoff	Short and medium term	Moderate Adverse	Very Large Adverse	Negligible	Neutral	Not significant
Use and storage of materials	Medium to Very High	Accidental spillage of hazardous substances	Short and medium term	Moderate to Major Adverse	Moderate to Very Large Adverse	Negligible	Neutral	Not significant
Construction Phase: Groundwater Quality								
Borrow pits	Low to Medium	Groundwater dewatering during excavation	Short and medium term	Minor adverse	Slight Adverse	Negligible to Minor Adverse	Neutral to Slight Adverse	Not significant
		Excavation or runoff – disturbance of unknown contamination sources		Minor to Moderate Adverse	Slight to Moderate Adverse	Negligible	Neutral	Not significant
Highway embankments	Low to Medium	Dewatering of Tidal Flat Deposits using band drains	Short and medium term	Negligible to Minor Adverse	Neutral to Slight Adverse	Negligible to Minor Adverse	Neutral to Slight Adverse	Not significant
		Use of cement ground stabilisation and reused materials as embankment fill – band drains		Negligible to Minor Adverse	Neutral to Slight Adverse	Negligible	Neutral	Not significant
		Use of cement ground stabilisation and reused materials as embankment fill – piled foundations		Minor Adverse	Slight Adverse	Negligible	Neutral	Not significant
Road cuttings	Medium	Construction of road cuttings – Magor and Castleton junctions	Short and medium term	Minor Adverse	Slight Adverse	Negligible	Neutral	Not significant
Bridge towers and viaduct piers	Low to Medium	Construction of bridge support structures	Short and medium term	Minor Adverse	Neutral	Negligible	Neutral	Not significant
	Low	Installation of piled piers	Short and medium term	Moderate Adverse	Slight Adverse	Minor Adverse	Neutral	Not significant

Activity	Sensitivity of receptor	Works Element	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
Use and storage of materials	Low to Medium	Accidental spillage of hazardous substances	Short and medium term	Minor to Moderate Adverse	Slight to Moderate Adverse	Negligible to Minor Adverse	Neutral to Slight Adverse	Not significant
Construction Phase: Flood Risk and Drainage								
Highway structures	Very High	Impacts on property from changes in conveyance through reen system	Short and medium term	Negligible	Neutral	Negligible	Neutral	Not significant
	Very High	Impacts on property from changes to flood risk	Short and medium term	Negligible	Neutral	Negligible	Neutral	Not significant
Operational Phase: Surface Water Quality								
Borrow Pits	High to Very High	Restoration with materials suitable for use	Long term	Moderate Adverse	Moderate to Large Adverse	Negligible	Neutral	Not significant
Routine highway runoff	High to Very High	Runoff to new drainage system	Long term	Negligible	Neutral	Negligible	Neutral	Not significant
	Medium to Very High	Runoff from new bridged section of motorway		Negligible to Minor Adverse	Neutral to Slight Adverse	Negligible to Minor Adverse	Neutral to Slight Adverse	Not significant
Highway embankment	Medium to Very High	Generation of potentially contaminated leachate from embankment fill by infiltration	Long term	Negligible	Neutral	Negligible	Neutral	Not significant
Road cuttings	High to Very High	Long term dewatering in area of new cutting	Long term	Minor Adverse	Slight to Moderate Adverse	Negligible	Neutral	Not significant
Culverts beneath embankments	Very High	Alteration to water quality of reens	Long term	Minor Adverse	Moderate Adverse	Negligible	Neutral	Not significant
Operational Phase: Groundwater Quality								
Borrow Pits	Low to Medium	Restoration backfill with potentially contaminated soils	Long term	Moderate Adverse	Slight to Moderate Adverse	Negligible	Neutral	Not significant

Activity	Sensitivity of receptor	Works Element	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
Highway embankments	Low to Medium	Completed embankments	Long term	Negligible	Neutral	Negligible	Neutral	Not significant
Road Cuttings	Medium	Long term dewatering in area of new cutting – alternations to groundwater levels and flow	Long term	Minor Adverse	Slight Adverse	Negligible	Neutral	Not significant
Operational Phase: Flood Risk and Drainage								
Embankments, culverts, reens and ditches	Very High	Changes conveyance through reen system	Long term	Negligible	Neutral	Negligible	Neutral	Not significant
Highway structures	Very High	Impacts on property from changes in conveyance through reen system	Long term	Negligible	Neutral	Negligible	Neutral	Not significant
	Very High	Impacts on property from changes to flood risk	Long term	Negligible	Neutral	Negligible	Neutral	Not significant