M5 Junction 10 Improvements Scheme

Preliminary Environmental Information Report (PEIR) Road Drainage and the Water Environment chapter

Date: 10/11/21

Status: A1 APPROVED - PUBLISHED

Gloucestershire COUNTY COUNCIL

Notice

This document and its contents have been prepared and are intended solely for the Client's information and use in relation to M5 Junction 10 Improvements Scheme.

SNC Lavalin assumes no responsibility to any other party in respect of or arising out of or in connection with this document and/or its contents.

This document has 189 pages including the cover

Document history

Revision	Status	Purpose description	Originated	Checked	Reviewed	Authorised	Date
C04	A1	For issue	CDC	SL	VA	TT	10/11/21
C03	A1	For Client Review	MT	LB	CDC	TT	01/11/21
C02	A1	For Client Review	MT	LB	CDC	HC	08/10/21
C01	A1	Draft for Client Review	MT	SM	MB	TT	17/09/21

Client signoff

Client	**Gloucestershire County Council**
Project	**M5 Junction 10 Improvements Scheme**
Job number	**5206696**
Client signature / date	

Contents

Chapter

Tables

Figures

Document accessibility

If you need to access this report in a different format like accessible PDF, large print, easy read, audio recording or braille, please get in touch with our team who will do their best to assist.

You can contact us by email on M5Junction10@atkinsglobal.com, leave us a voicemail on 01454 667900 or write to us at M5 Junction 10 Team, Atkins, 500 Park Avenue, Bristol, BS32 4RZ. You can also view Gloucestershire County Council's Accessibility Statement on our website at https://www.gloucestershire.gov.uk/accessibility/

Glossary

Term	Description
AADT	Annual Average Daily Traffic
AAWT	Annual Average Weekday Traffic
AEP	Annual Exceedance Probability
ALC	Agricultural Land Classification
AMP	Archaeological Management Plan
AONB	Area of Outstanding Natural Building
ARN	Affected Road Network
ASPT	Average Score Per Taxon
AQAL	Air Quality Assessment Level
AQMA	Air Quality Management Area
AQS	Air Quality Strategy
BAP	Biodiversity Action Plan
BCT	Bat Conservation Trust
BEIS	Department of Business, Energy, and Industrial Strategy
BGS	British Geological Survey
BMV	Best and Most Versatile
BoQ	Bill of Quantities
BS	British Standards
BTO	British Trust for Ornithology
CAMS	Catchment Abstraction Management Strategy
CBC	Cheltenham Borough Council
CBC	Common Birds Census
CCC	Committee on Climate Change
CD&E	construction, Demolition and Excavation
CEMP	Construction Environmental Management Plan
CEA	Cumulative Effects Assessment
CIEEM	Chartered Institute of Ecology and Environmental Management
CIRIA	Construction Industry Research and Information Association
CL:AIRE	Contaminated Land: Applications in Real Environments
CLP	Classification, Labelling and Packaging
CMS	Continuous Monitoring Station
CO_2	Carbon Dioxide
CO_2e	Carbon Dioxide Equivalent
COP	Conference of the Parties
COSHH	Control of Substances Hazardous to Health
CPS	Connecting Places Strategies
CRoW	Countryside and Rights of Way
CRTN	Calculation of Road Traffic Noise
CSZs	Core Sustenance Zones
DCO	Development Consent Order
DfT	Department for Transport
DM	Do Minimum
DMOY	Do Minimum Scenario in the Opening Year
DMFY	Do Minimum Scenario in the Future Assessment Year
DMRB	Design Manual for Roads and Bridges
DoE	Department of the Environment
DoWCoP	Definition of Waste: Development Industry Code of Practice
DS	Do Something
DSFY	Do Something in the Future Assessment Year
DSOY	Do Something Scenario in the Opening Year
EC	European Commission
ECoW	Ecological Clerk of Works
eDNA	environmental DNA

Term	Description
EEA	European Economic Area
EFT	Emissions Factors Toolkit
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
END	Environmental Noise Directive
EPA	Environmental Protection Act
EPS	European Protected Species
EPUK	Environmental Protection UK
EQS	Environmental Quality Standards
EU	European Union
ES	Environmental Statement
FRA	Flood Risk Assessment
ES	Environmental Statement
GCC	Gloucester City Council
GCER	Gloucestershire Centre for Environmental Records
GCN	Great Crested Newt
GFirst LEP	Gloucestershire Local Enterprise Partnership
GHER	Gloucestershire Historic Environment Record
GHGs	Greenhouse Gases
GLNP	Gloucestershire Local Nature Partnership
GLVIA3	Guidelines for Landscape and Visual Impact Assessment
GLTA	Ground Level Tree Assessment
GPLC	Guiding Principles for Land Contamination
GWDTE	Groundwater Dependant Terrestrial Ecosystems
GWT	Gloucestershire Wildlife Trust
HDV	Heavy Duty Vehicles
HER	Historic Environment Record
HEWRAT	Highways England Water Risk Assessment Tool
HGVs	High Good Vehicles
HIF	Housing Infrastructure Fund
HLC	Historic Landscape Characterisation
HMC	Habitat Modification Class
HMS	Habitat Modification Score
HRA	Habitat Regulations Assessments
HSI	Habitat Suitability Index
IAQM	Institute of Air Quality Management
IDB	International Drainage Board
IPCC	International Panel on Climate Change
JCS	Joint Core Strategy
JNCC	Joint Nature Conservation Committee
LAQM	Local Air Quality Management
LCAs	Landscape Character Assessments
LCRM	Land Contamination: Risk Management
LCT	Landscape Character Type
LDV	Light Duty Vehicles
LLFA	Lead Local Flood Authority
LNR	Local Nature Reserves
LOAEL	Lowest observed adverse effect level
LTP	Local Transport Plans
LVIA	Landscape and Visual Impact Assessment
MAFF	Ministry of Agriculture, Fisheries and Food
MCHW	Manual of Contract Documents for Highway Works
MHCLG	Ministry of Housing, Communities and Local Government
MMP	Materials Management Plan
MSA	Mineral Safeguarding Areas
MW	Minor Watercourse

Term	Description
NCA	National Character Area
NERC	Natural Environment and Rural Communities
NHLE	National Heritage List for England
NIAs	Noise Important Areas
NMP	National Mapping Programme
NMU	Non- Motorised User
NNR	National Nature Reserves
NPS NN	National Policy Statement for National Networks
NOEL	No Observed Effect Level
NPPF	National Planning Policy Framework
NPPG	National Planning Practice Guidance
NPSE	Noise Policy Statement for England
NRFA	National River Flow Archive
NSIP	Nationally Significant Infrastructure Projects
NSR	Noise Sensitive Receptors
NVC	National Vegetation Classification
OS	Ordnance Survey
PAH	Polyaromatic Hydrocarbons
PAS	Portable Antiquities Scheme
PCBs	Polychlorinated Biphenyls
PCF	Project Control Framework
PCL	Potential Contaminant Linkage
PCM	Pollution Climate Mapping
PCSM	Preliminary Conceptual Site Model
PEAOR	Preliminary Environmental Assessment of Options Report
PEIR	Preliminary Environmental Information Report
PINS	Planning Inspectorate
PPE	Personal Protective Equipment
PPGs	Pollution Prevention Guidelines
PPG	Planning Practice Guidance
PPS10	Planning Policy Statement 10
PPGN	Planning Practice Guidance: Noise
PRA	Preliminary Roost Assessment
PRoW	Public Right of Way
Q_{95}	The 5 percentile flow
RAMS	Risk Assessments, Method Statements
RBD	River Basin Districts
RBMP	River Basin Management Plans
RCP	Relative Concentration Pathway
RCS	River Corridor Survey
RFFPs	Reasonably Foreseeable Future Projects
RHS	River Habitat Survey
RNAG	Reason for not Achieving Good
RoWIP	Rights of Way Improvement Plan
SAC	Special Area of Conservation
SHMP	Soil Handling Management Plan
SM	Scheduled Monument
SOAEL	Significant Observed Adverse Effect Level
SoCC	Statement of Community Consultation
SPD	Supplementary Planning Document
SPA	Special Protection Area
SPZ	Source Protection Zones
SSSI	Site of Special Scientific Interest
SuDS	Sustainable Drainage Systems
SWMP	Site Waste Management Plan
TAMP	Transport Asset Management Plan

Term	Description
TBC	Tewkesbury Borough Council
TAR	Technical Appraisal Report
TSCS	Thin Surface Course System
UKCP18	United Kingdom Climate Projections 2018
UNFCCC	United Nations Framework Convention on Climate Change
UXO	Unexploded Ordnance
VfM	Value for Money
WCH	Walkers, Cyclists and Horse Riders
WEEE	Waste Electrical and Electronic Equipment
WER	Water Environment Regulations
WFD	Water Framework Directive
WHTP	Whalley, Hawkes, Paisley & Trigg
WSI	Written Scheme of Investigation
ZTV	Zone of Theoretical Visibility

Chapters 1-4 of this PEIR have been produced as a separate document.

1. Introduction

2. The Scheme

3. Assessment of Alternatives

4. Environmental Assessment Methodology

Table 4-1 - Significance Matrix

Sensitivity of receptor	Magnitude of impact				
	Major	Moderate	Minor	Negligible	No change
Very high	Very large	Large or very large	Moderate or large	Slight	Neutral
High	Large or very large	Moderate or large	Slight or moderate	Slight	Neutral
Medium	Moderate or large	Moderate	Slight	Neutral or slight	Neutral
Low	Slight or moderate	Slight	Neutral or slight	Neutral or slight	Neutral
Negligible	Slight	Neutral or slight	Neutral or slight	Neutral	Neutral

Table Source: DMRB LA 104 Environmental assessment and monitoring Table 3.8.1

Table 4-2 - Significance categories and typical descriptions

Value	Typical descriptors
Very Large	Effects at this level are material in the decision-making process.
Large	Effects at this level are likely to be material in the decision-making process.
Moderate	Effects at this level can be considered to be material decision-making factors.
Slight	Effects at this level are not material in the decision-making process.
Negligible	No effects or those that are beneath levels of perception, within normal bounds of variation or within the margin of forecasting error.

Table Source: DMRB LA 104 Environmental assessment and monitoring Table 3.7

The discipline specific chapters of this PEIR have been produced as separate documents.

5. Air Quality

6. Noise and Vibration

7. Biodiversity

8. Road Drainage and the Water Environment

8.1. Introduction

8.1.1. This chapter PEIR presents the preliminary environmental information of the M5 Junction 10 Improvements Scheme (the Scheme) for Road Drainage and the Water Environment based on the Scheme as it is described in Chapter 2 (and detailed in the Design Fix 2 drawings in Appendix 2.1). It identifies the regulatory/policy framework that applies to water, defines the study area, outlines the methodology used and describes baseline conditions, identifying receptors that are potentially affected (and their importance). It goes on to suggest potential mitigation and enhancement measures (where relevant), the monitoring requirements and the magnitude of impacts and significance of effects of the Scheme.

8.1.2. The assessment covers:

- Surface water quality;
- Surface water hydromorphology;
- Groundwater resources (including Groundwater Dependent Terrestrial Ecosystems (GWDTE) and groundwater water quality);
- Flood risk; including a flood risk assessment (Appendix 8.1 – Flood Risk Assessment); and,
- A Water Framework Directive Assessment (Appendix 8.2 – WFD Compliance Assessment).

8.1.3. The assessment builds upon that presented in the Environmental Scoping Report with the addition of baseline information obtained from the Environment Agency and Lead Local Flood Authority (LLFA).

8.1.4. The assessment has been prepared in accordance with guidance within the DMRB LA 113 and LA 104.

8.2. Planning policy and topic legislative context

8.2.1. The relevant National policy, legislation and guidance used as the basis for preparation of the PEIR chapter and EIA supporting technical assessments (FRA and WFD compliance assessment) are provided in Table 8-1.

Table 8-1 - Relevant planning policy and guidance

Legislation/ regulation	Summary of requirements
National	
Water Environment (Water Framework Directive) (England and Wales) Regulations 2017	The WFD legislation requires that all inland waters within defined river basin districts must reach at least Good status and defines how this should be achieved through the establishment of environmental objectives and ecological targets for surface waters. Any new project must not cause deterioration of the water environment or prevent the future attainment of Good status. The WFD requires that surface water discharges are managed so that their impact on the receiving environment is mitigated. The objective is to protect the aquatic environment and control pollution from diffuse sources such as urban drainage – a key aspect that effectively precludes use of the traditional approach to drainage.

Legislation/ regulation	Summary of requirements
Environmental Quality Standards Directive (2008/105/EC), amended by Directive 2013/39/EU	Lists Environmental Quality Standards (EQS) for priority substances and certain other pollutants as provided for in Article 16 of the WFD, with the aim of achieving good surface water chemical status. It includes certain substances that may be associated with runoff from highways.
Groundwater Directive (2006/118/EC)	Complements the WFD. It requires measures to prevent or limit inputs of pollutants into groundwater to be operational so that WFD environmental objectives can be achieved.
Antipollution Works Regulations 1999	Where pollution occurs or is likely to occur the Environment Agency can serve a works notice under Section 161A of the Water Resources Act on any person who has caused or knowingly permitted the pollution (or risk of pollution) to a watercourse, requiring them to carry out anti-pollution/preventative works and operations. The Environment Agency can also recover the costs of any investigation and anti-pollution works carried out. The Anti-Pollution Works Regulations prescribe the content of anti-pollution works notices and the particulars that need to be placed on the pollution control registers maintained by the Environment Agency.
Environment Act 1995	The Act provides for the establishment of the Environment Agency, the Scottish Environmental Protection Agency (SEPA) and the National Parks Authority.
Environmental Damage (Prevention and Remediation) Regulations 2015	The emphasis of these Regulations is proactively putting in place appropriate pollution prevention measures to reduce risks to the environment.
Environmental Protection Act 1990	This Act brings in a system of integrated pollution control for the disposal of wastes to land, water, and air.
Flood Risk Regulations 2009 Amended 2009/3042	These Regulations transpose the Floods Directive (2007/60/EC). They aim to provide a consistent approach to managing flood risk. The Environment Agency are responsible for managing flood risk from main rivers, the sea, and reservoirs. LLFAs are responsible for local sources of flood risk, in particular surface water, groundwater, and ordinary watercourses.
Flood and Water Management Act 2010 and Commencement Orders	The key areas covered by this Act are: • Roles and responsibilities for flood and coastal erosion risk management; • Improving reservoir safety.
Highways Act 1980 (HA 1980)	The Act deals with the management and operation of the road network in England and Wales including the drainage of highways into environmental waters and sewers.
National Planning Policy Framework (NPPF) (Department for Communities and Local Government (DCLG), 2019)	The NPPF sets strict tests to protect people and property from flooding which all local planning authorities are expected to follow. It forms the basis of assessment of flood risk for Schemes.

Legislation/ regulation	Summary of requirements
National Planning Practice Guidance (NPPG) 2018	Accompanying the NPPF, the NPPG (DCLG, 2018) was published in 2014 and updated in 2018. This advises on how Local Planning Authorities can ensure the protection of water quality, the delivery of adequate water infrastructure and take account of the risks associated with flooding in the planning application process.
The Environmental Permitting (England and Wales) Regulations 2016	These Regulations provide a consolidated system of environmental permitting in England and Wales and transpose provisions of fifteen EU Directives which impose obligations requiring delivery through permits or which are capable of being delivered through permits. Covers Environment Agency permits for flood risk (on Main River) and certain discharges to watercourses.
The Water Resources (Environmental Impact Assessment) (England and Wales) Regulations 2006	These Regulations impose procedural requirements in relation to the consideration of applications or proposals for an abstraction or impounding licence under Chapter II of Part II of the Water Resources Act 1991 and require consent in other cases.
Water Act 2003 and Water Act 2014	These Acts aim to improve water conservation, protect public health and the environment, and improve the service offered to consumers. The basis of the Act is three parts relating to water resources, regulation of the water industry and other provisions.
WFD (Standards and Classification) Directions (England and Wales) 2015	These Directions set out the environmental standards to be used for the second cycle of river basin plans. They transpose Directive 2013/39/EU on environmental quality standards for priority substances. They also cover Specific Pollutants which include certain metals that are associated with road are associated with road drainage.
Water Industry Act 1991 (Amendment) (England and Wales) Regulations 2009	This Act sets out the responsibilities of the Environment Agency of England and Wales in relation to water pollution, resource management, flood defence, fisheries, and in some areas, navigation. The Act regulates discharges to controlled waters, namely rivers, estuaries, coastal waters, lakes and groundwaters.
Water Resources Act 1991	This Act sets out to regulate water resources, water quality and pollution, and flood defence. It sets out standards for Controlled Waters.
The Land Drainage Act 1991 and 1994	This Act requires that a watercourse be maintained by its owner in such a condition that the free flow of water is not impeded. The 1994 Act amends it in relation to the functions of internal drainage boards and local authorities.
The Control of Pollution (Oil Storage) (England) Regulations 2001	Applicable for storage of more than 200 litres of oil above ground at industrial, commercial, or institutional sites. The sites they cover include; factories, shops, offices, hotels, schools, churches, public sector buildings and hospitals. The Regulations apply only in England.
The Environmental Bill (final stages)	The Bill makes provisions about targets, plans and policies for improving the natural environment. It outlines how the government will reduce waste, make better use of resources, and improve management of water resources in a changing climate.
Regional	
Severn River Basin Management Plan (RBMP)	This RBMP is designed to protect and improve the quality of the water environment. It includes consideration of the following topics:

Legislation/ regulation	Summary of requirements
	• Plans for the protection and improvement of the water environment • Future plans that may affect the infrastructure sector and its obligations • Development proposal considerations regarding the requirements of the plan • Environmental permit applications.
Local	
The adopted Joint Core Strategy (JCS) (Gloucester City Council, Cheltenham Borough Council, and Tewkesbury Borough Council., 2017)	The JCS provides a co-ordinated strategic plan for this joint administrative area during the period up to 2031. The JCS sets out strategic objectives one of which focuses on conservation and enhancement of the natural environment, including biodiversity, waterways and geological assets. It also has an extensive and up-to-date evidence base, including Strategic FRA which provide a detailed assessment of multiple flood sources for specific broad locations within the JCS area. Whilst the JCS provides the strategic level policies for development in the area, this will be supplemented at individual district level by locally specific plans. In Tewkesbury Borough, the council has begun preparation of the Tewkesbury Borough Plan, which is at a relatively early stage of preparation.
The Flood and Water Management Supplementary Planning Document (SPD) (Tewkesbury Borough Council, 2018)	Guidance on the approach that should be taken to manage flood risk and the water environment as part of new development proposals. The SPD highlights the documents which will be required to accompany planning applications including site specific FRAs and drainage strategies (incorporating an appropriate approach to surface water drainage including suitability evidence).

8.3. Methodology

8.3.1. The methodology presented in DMRB LA 113 has been applied to assign the importance of the water environment receptors. An assessment of potential impacts and their significance has been undertaken following this methodology with the assumption that all generic impacts will be mitigated against as part of the design (embedded mitigation).

8.3.2. At the next stage, in the Environmental Statement, the DMRB LA 113 methodology will be followed to re-assess the Scheme and include any further embedded mitigation. The significance of the potential impact is determined in accordance with DMRB LA 104.

8.3.3. The assessment has used a range of open source data and information provided by the Environment Agency and LLFA (Gloucestershire County Council and Tewkesbury Borough Council). This data includes:

- The Environment Agency Catchment Data Explorer (Environment Agency - Catchment Data Explorer);
- Environment Agency Flood Maps for Planning (Flood map for planning - GOV.UK (flood-map-for-planning.service.gov.uk));
- The Environment Agency Main Rivers Maps (ArcGIS Web Application);
- British Geological Survey 1:50k bedrock and superficial geology mapping (Geology of Britain viewer | British Geological Survey (BGS));
- Aquifer Vulnerability (Magic Map Application (defra.gov.uk));
- Q95 flows (http://nrfa.ceh.ac.uk/data/search);

- Traffic modelling data (Atkins 2021)
- Drainage Plans (Appendix 2.1)
- Environmental Plans (Appendix 2.2)
- WFD Extended Water Body Summary Reports;
- Abstraction and discharge locations; and,
- Mitigation strategies in place.

Study area

8.3.4. The scope of the assessment includes as a minimum, features of the water environment within 1 km of the proposed development Red Line Boundary (RLB). In accordance with DMRB LA 113, a 1 km buffer zone is considered an appropriate study area for the assessment of surface water quality soluble pollutants. This study area has been adopted as a minimum for the groundwater assessments as, in line with DMRB LA113, the conceptual understanding indicates any impacts to groundwater flow will also be dissipated within 1 km. For hydromorphology, the study area consists of any watercourse within the RLB and the associated WFD water body catchments.

8.3.5. The study area for flood risk is defined by the hydraulic zone of influence created by the Scheme and as a minimum considers the 1 km buffer zone. This is influenced by encroachments into the watercourse and floodplain.

Surface water

8.3.6. The methodology for the assessments undertaken as part of this PEIR includes the following:

- An assessment of the impact of the Scheme on water quality in line with the DMRB LA 113. However, at this stage of the assessment only the routine runoff assessment within the Highways England Risk Assessment Tool (HEWRAT) has been completed due to programme constraints.
- An assessment of the hydromorphological impact of the Scheme on surface water features was undertaken in line with the LA 113. Analysis of freely available maps, arial photographs and walkover surveys has been undertaken to determine the importance of receptors and impact from the Scheme.

8.3.7. A WFD compliance assessment is a requirement for new developments and schemes to demonstrate that they will not result in a deterioration in status (or potential) of any water body or prevent the water body from meeting good status (or potential) in the future (2021 or 2027). A WFD preliminary assessment was undertaken in December 2019. The assessment has been updated (September 2021) based on the most recent design (Appendix 8.2 – WFD Compliance Assessment).

8.3.8. The WFD legislation applies to all surface watercourses (Main River and ordinary watercourse). The Environment Agency are the overall competent authority, however, the LLFA (Gloucestershire County Council and Tewkesbury Borough Council) should ensure the Scheme complies with WFD legislation regarding ordinary watercourses.

8.3.9. The approach to the WFD compliance assessment will follow the PINS guidance (The Planning Inspectorate, 2017) on preparation of WFD assessments for a NSIP. The assessment can be readily updated, creating a clear audit trail of WFD compliance as the Scheme progresses through its lifecycle from options assessment to design and environmental permitting.

8.3.10. Risks of pollution to the water environment associated with the release of pollutants (e.g. hydrocarbons, cement, fine sediment, mobilised contaminants) due to existing ground contamination are considered within the PEIR Chapter 10 Geology and Soils and will not be considered here.

Groundwater

8.3.11. At the time of writing this report, there is not sufficient information on either the proposed structures or the site-specific groundwater conditions to make an informed assessment of impacts to groundwater levels and flows. Therefore, the assessment is limited to identifying risk rather than completing an impact assessment at this stage, with only potential impacts to groundwater highlighted.

8.3.12. At the next stage of the assessment, in the Environmental Statement and for the final delivery of the Environmental Statement, a more detailed impact assessment will be undertaken incorporating design data (e.g. piling depth and installation method) and site-specific ground investigation data, where available. This assessment will be in accordance with DMRB LA 113.

8.3.13. At the time of reporting, discharge to ground is not part of the drainage strategy. If this changes at later stages of the design, the assessment of the potential pollution impacts from runoff to groundwater may be required. This will be in accordance with the simple assessment for determining the risk of impact on groundwater from routine runoff as outlined in DMRB LA 113.

8.3.14. Groundwater will also be included as part of the WFD compliance assessment as outlined for surface water above (section 8.3.7).

8.3.15. Risks of pollution to the water environment associated with the release of pollutants (e.g. hydrocarbons, cement, fine sediment, mobilised contaminants) due to existing ground contamination are considered within Chapter 10 Geology and Soils and will not be considered here.

Flood Risk

8.3.16. Detailed hydraulic modelling has been undertaken to understand the baseline flood risk conditions and evaluate the flood risk both to and from the Scheme. This work remains ongoing as the Scheme develops.

8.3.17. In line with the NPPF (Environment Agency, 2020a), the design flood for the Scheme is the 1% annual exceedance probability event (1 in 100-year return period) with an allowance for future climate change. The Environment Agency updated its climate change guidance during the preparation of this PEIR (July 2021), in line with the UKCP18 data. This has resulted in a downgrade of the climate risk profile for the Scheme and a decrease in the required peak river flow allowances: the guidance no longer requires applying an upper end climate change allowance (+70% increase in flow) but now recommends using a higher central climate change allowance (+53% increase in flow). However, the modelling results at the time of writing applied +70% increase in peak flows: this former (now precautionary) allowance has been used in this PEIR, ensuring consistency and true comparison to the baseline assessment. As a result, this PEIR assessment uses higher flood flows than will be described in the subsequent Environmental Statement.

8.3.18. At the next stage of the assessment, following public consultation and in the Environmental Statement, the flood modelling and FRA (Appendix 8.1 – Flood Risk Assessment) will be updated to include the application of the Environment Agency's updated climate change allowances (Environment Agency, 2021).

8.4. Consultation

8.4.1. To date, consultation has been undertaken with the Environment Agency and LLFA with the main points highlighted below. Consultation with regulators (principally the Environment Agency and LLFA) will continue throughout the design process to ensure that the Scheme is designed to be compliant with the objectives of the WFD and flood risk guidance and that opportunities for improvements to the water environment are integrated into the Scheme.

Non-statutory consultation

8.4.2. In November 2020, the Environment Agency commented on the Scheme as part of the non-statutory consultation. The main issues identified were:

- Climate change;
- Fluvial flood risk;
- Ecological protection and enhancement;
- Ground conditions; and
- Water quality and pollution prevention.

8.4.3. The Environment Agency has emphasised the importance for early consideration of climate change adaptation and mitigation specifically highlighting drainage, hydrology and flood risk and ecology as key aspects likely to be impacted.

8.4.4. The River Chelt floodplain and M5 crossing were highlighted as key points to be considered as part of the detailed flood modelling. However, the Environment Agency concluded that there were no significant concerns with the Scheme should flood risk be appropriately investigated. Further consultation with the Environment Agency has been undertaken to ensure a suitable baseline flood model, and seek advice on compensatory floodplain and the design of river crossings.

8.4.5. The Environment Agency noted that additional consideration should be made to the impact on the Severn Estuary SSSI/SPA/Ramsar/SAC to ensure the Scheme does not negatively impact protected species within that ecosystem due to hydrologically connected environments. This will be considered as part of the Biodiversity Chapter. Additionally, further consideration should be given to the impact on the River Chelt due to its significant hydromorphological activity. Further details on compensatory mitigation should be included to ensure biodiversity net gain across the Scheme including consideration of wetlands, ponds, scrapes, reedbeds, floodplain grazing marsh, semi-improved or unimproved grassland (lowland meadows and pastures) and traditional orchard.

8.4.6. It was highlighted that the assessment should consider the impact of foundation/piling works which have the potential to increase contamination and migration pathways of pollutants. Surface water drainage should also be considered as part of the detailed impact assessment.

8.4.7. The Environment Agency has advised that road drainage design should include consideration of swales, balancing ponds/wetlands and other Sustainable Drainage Systems (SuDS) to improve water quality.

8.4.8. As part of the non-statutory consultation, the LLFA highlighted that the design of drainage systems should be in accordance with the CIRIA SuDS Manual C753. It is confirmed that this will be adopted throughout the Scheme.

8.5. Baseline conditions

8.5.1. This section sets out the baseline conditions of the water environment. At this stage, a desk-based assessment has been undertaken using publicly available spatial data under the Open Government Licence and from open sources including the Environment Agency and, where appropriate, information from 2019 site visits. The assessment for flood risk is based on a detailed baseline flood model which included gauged flow and rainfall from the Environment Agency, and topographic survey of the watercourses.

Surface water

8.5.2. Surface watercourses within the study area generally flow from east to west and are located within the Severn River Basin District (RBD), as set out in the Severn River Basin Management Plan (RBMP). Figure 8-1 shows the location of the Scheme in relation to the surface water bodies.

8.5.3. Table 8-2 provides the current WFD status for the six surface water body catchments within the study area (within 1 km of the RLB).

8.5.4. The Environment Agency have suggested that further consideration should be given to the potential impacts on the River Severn. Therefore, although the River Severn WFD water body lies more than 1 km away from the RLB, it has also been included in the baseline assessment for further scoping.

Table 8-2 - Summary of status, Reasons for Not Achieving Good (RNAG), and objectives for WFD surface water bodies within the study area.

Water Body Name (Water Body ID)	Water-course Name	2019 (Cycle 2) Overall Status	HMWB* or Artificial	RNAG	Objective**
Chelt - source to M5 (GB109054032820)	River Chelt	Moderate	HMWB	Mitigation Measures Assessment	Good by 2027 (Disproportionate Burdens)
Chelt - M5 to conf. R. Severn (GB109054032810)	River Chelt	Poor	Not assigned heavily modified or artificial	Phosphate Macrophytes and Phytobenthos	Good by 2027 (Disproportionate Burdens)
Leigh Bk - source to conf. R. Chelt (GB109054039770)	Leigh Brook	Moderate	Not assigned heavily modified or artificial	Phosphate Macrophytes and Phytobenthos	Moderate by 2015 (Unfavourable balance of costs and benefits)
Swilgate - source to conf. R. Avon (GB109054039780)	River Swilgate	Moderate	n/a	Phosphate Invertebrates Macrophytes and Phytobenthos Dissolved Oxygen	Good by 2027 (Ecological Recovery Time)
Hatherley Bk - source to conf R Severn (GB109054032801)	Hatherley Brook	Moderate	HMWB	Phosphate	Good by 2027 (Disproportionate Burdens)
Severn – conf R Avon to conf Upper Parting (GB10905404440)	River Severn	Moderate	HMWB	Local and Central Government and Urban transport, Urban and transport Navigation Water Industry	Moderate by 2015 (Unfavourable balance of costs and benefits)

* Heavily Modified Water Body
** Objectives as published on Catchment Data Explorer (Environment Agency 2020b) https://environment.data.gov.uk/catchment-planning/

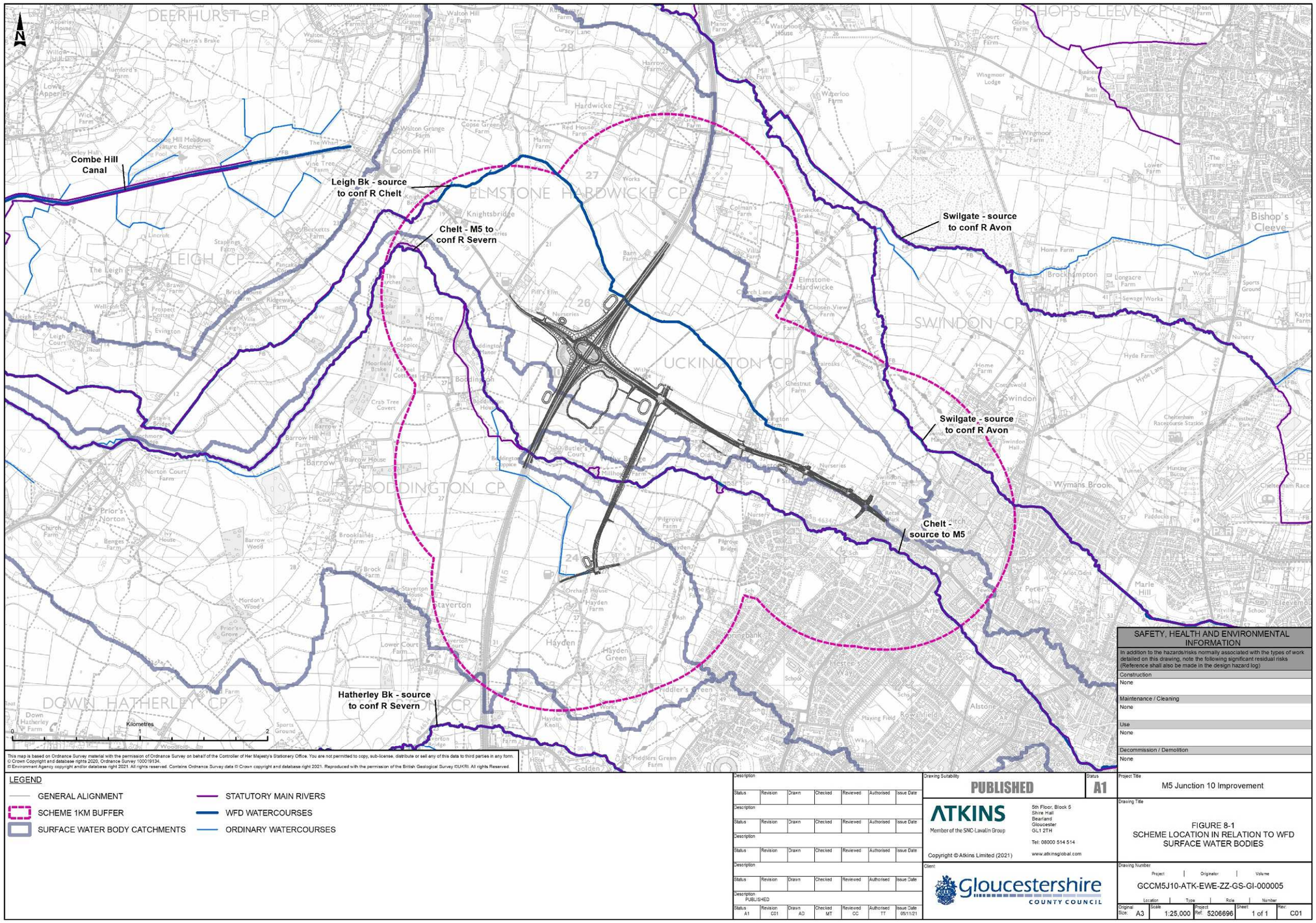


Figure 8-1 - Scheme location in relation to WFD surface water bodies

8.5.5. The River Chelt is a Main River within the study area and is accounted for under two WFD catchments: Chelt - source to M5 (GB109054032820) and Chelt - M5 to conf. R. Severn (GB109054032810) (Table 8-2)). It is currently crossed by the M5 approximately 0.9 km south of Junction 10 (SO 90019 24822).

8.5.6. The Leigh Brook is crossed by the M5 0.4 km north of Junction 10 (SO 89278 26792). At the point of intersection with the Scheme, the watercourse is an ordinary watercourse, defined as: every river, stream, ditch, drain, cut, dyke, sluice, sewer (other than a public sewer) and passage through which water flows and which does not form part of a Main River. Approximately 2.3 km downstream of the M5 crossing, the watercourse is designated as Main River. The Leigh Brook is designated under the WFD from its source to its confluence with the River Chelt (Leigh Bk - source to conf. R. Chelt, GB109054039770).

8.5.7. The River Swilgate and Hatherly Brook are Main Rivers and are designated under the WFD (Swilgate - source to conf. R. Avon, GB109054039780 and Hatherley Bk - source to conf R Severn, GB109054032801). Although they lie within the 1 km study are, they are not directly crossed by the Scheme. Although the River Severn (Severn – conf R Avon to conf Upper Parting, GB10905404440) lies outside the study area, it has been included as part of the scoping process following consultation with the regulators. Detailed descriptions of the WFD water bodies, including site photos, and survey information, have been outlined as part of the WFD assessment (Appendix 8.2 – WFD Compliance Assessment). These two water bodies fall within the area of the RLB where works will only be carried out on signage. As this is expected to have no impact on the water environment, the water bodies have been scoped out of further assessments.

8.5.8. The watercourses which are classified reaches under the WFD are listed in Table 8-3 along with a number of additional ordinary watercourses within the study area. These watercourses are also shown in Figure 8-2. The ordinary watercourses have been given a unique ID where they do not have a known name which aligns with those presented in Chapter 7: Biodiversity and have been identified as drains and minor watercourses. None of these watercourses are classified reaches under the WFD, however they do fall within a WFD water body. These have been listed for context. Where a watercourse does not have hydrological connectivity to the Scheme footprint, they have been scoped out of the assessment with the assumption that there will be no hydromorphological or water quality impacts.

Table 8-3 - Watercourses within the study area

Watercourse ID	Main River	Scoped in/out	Reason for scoping out where appropriate
		Chelt - source to M5 (GB109054032820)	
River Chelt	Yes	In	
MW5	No	Out	No hydrological connectivity to the Scheme footprint
Drain 21	No	In	N/A
Uckington Moat	No	Out	No hydrological connectivity to the Scheme footprint
		Chelt - M5 to conf. R. Severn (GB109054032810)	
River Chelt	Yes	In	
MW3	No	In	
MW4	No	Out	No hydrological connectivity to the Scheme footprint
Drain 12	No	In	N/A

Watercourse ID	Main River	Scoped in/out	Reason for scoping out where appropriate
Drain 13a	No	Out	No hydrological connectivity to the Scheme footprint
Drain 14	No	Out	No hydrological connectivity to the Scheme footprint
Drain 15	No	In	
Drain 16	No	In	
Drain 17	No	Out	No hydrological connectivity to the Scheme footprint
Drain 19	No	Out	No hydrological connectivity to the Scheme footprint
Drain 20	No	In	
		Leigh Bk - source to conf. R. Chelt (GB109054039770)	
Leigh Brook	No*	In	
Drain 3	No	Out	No hydrological connectivity to the Scheme footprint
Drain 4	No	Out	No hydrological connectivity to the Scheme footprint
Drain 5	No	Out	No hydrological connectivity to the Scheme footprint
Drain 6	No	In	
Drain 7	No	Out	No hydrological connectivity to the Scheme footprint
Drain 8	No	In	
Drain 9	No	In	
Drain 10	No	In	
Drain 11	No	In	
Drain 13	No	Out	No hydrological connectivity to the Scheme footprint
Drain 22	No	In	
		Swilgate - source to conf. R. Avon (GB109054039780)	
River Swilgate	Yes	Out	No hydrological connectivity to the Scheme footprint
		Hatherley Bk - source to conf R Severn (GB109054032801)	
Hatherley Brook	Yes	Out	No hydrological connectivity to the Scheme footprint
		Severn – conf R Avon to conf Upper Parting (GB10905404440)	
River Severn	Yes	Out	No hydrological connectivity to the Scheme footprint

* The Leigh Brook is an ordinary watercourse where it is crossed by the Scheme. Approximately 2.3 km downstream of its M5 crossing, it is designated Main River.

8.5.9. Guidance presented in the DMRB LA 113 uses WFD designation and Q_{95} flow to determine the importance of a watercourse. At this stage of assessment, WFD designated watercourses with a Q_{95} flow greater than 1.0 m^3/s will be assigned **Very High** importance. WFD designated watercourses with Q_{95} flow less than 1.0 m^3/s will be assigned **High** importance.

8.5.10. Ordinary watercourses with a Q_{95} flow greater than 0.001 m^3/s will be assigned **Medium** importance. Ordinary watercourses with a Q_{95} flow less than 0.001 m^3/s will be assigned **Low** importance. Where the Q^{95} flow is unknown, a conservative approach using professional judgement has been adopted.

8.5.11. The importance of each surface water receptor for water quality and hydromorphology are listed in Table 8-6.

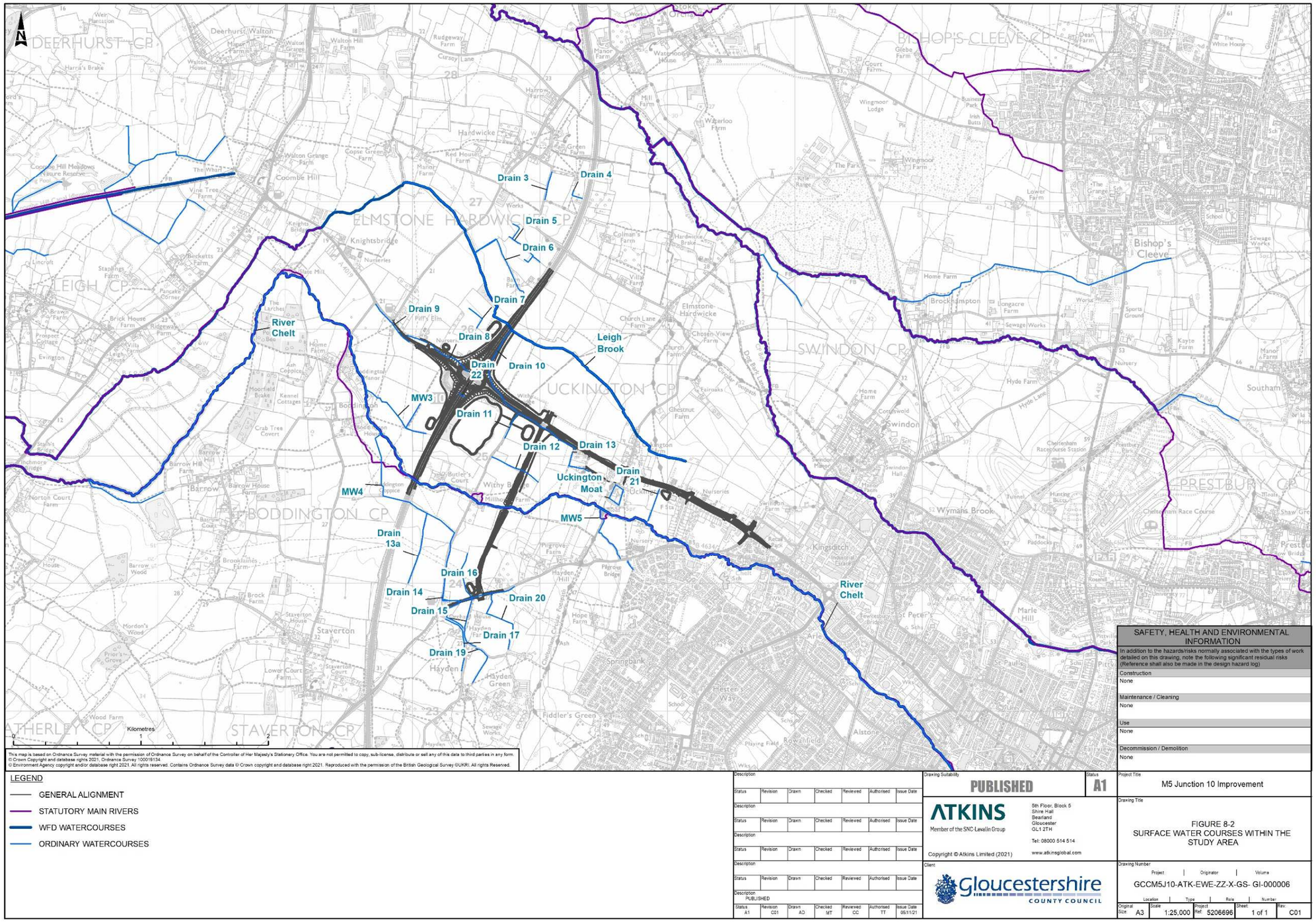


Figure 8-2 - Surface water courses within the study area

Surface water abstractions and discharges

8.5.12. Based on Envirocheck ® data (Landmark, 2019), there are two public surface water abstraction licences within the study area operated by Corilla. There are 12 surface water discharge locations within the study area. This does not include duplicates and revoked licences on the assumption these are no longer relevant/active.

8.5.13. A review of private abstractions has been supplied by Tewkesbury Borough Council, suggesting there are no private abstractions within 1 km of the Scheme.

Lakes and other surface water features

8.5.14. There are no WFD designated lakes within the study area, however there are several ponds which will be assessed as part of chapter 7: Biodiversity and where relevant, cross-references will be made.

Designated sites

8.5.15. There are no designated sites, including Sites of Special Scientific Interest (SSSI), RAMSARs, Special Protection Areas (SPA), Special Areas of Conservation (SAC), Local Nature Reserves or National Nature Reserves within the study area.

8.5.16. The Coombe Hill Canal is an SSSI which lies approximately 1.7 km to the west of the Scheme. The Site is down slope of the Scheme but is not within a downstream catchment as the A38 lies on an elevated ridge which forms a barrier to surface water flow pathways which are crossed by the Scheme.

Groundwater

8.5.17. Site specific ground investigations are ongoing. Therefore, the baseline geological conditions have been identified using online, publicly available data. Where possible, data have been verified using site specific information from the ongoing ground investigations. It is expected that a full suite of ground investigation data will be available at the next stage of assessment.

8.5.18. According to the 1:50,000 mapped geology (BGS, 2021), there is moderate superficial deposit coverage, consisting of isolated areas of Alluvium, Wasperton Sand and Gravel (river terrace deposits), Cheltenham Sand and Gravel (river terrace deposits) and Head. The eastern portion of the study area is largely underlain by the Charmouth Mudstone Formation bedrock with the western portion underlain by the Rugby Limestone Member. Where site specific ground investigation data is available, this is consistent with the 1:50,000 mapped geology. The geology at the 1:625km scale is shown in Figure 8-3.

8.5.19. Lithological descriptions of both superficial and bedrock geology and a generalised geological sequence are provided in Table 8-4. Further detail particularly regarding made ground, soils and local geology can be found in Chapter 10: Geology and Soils.

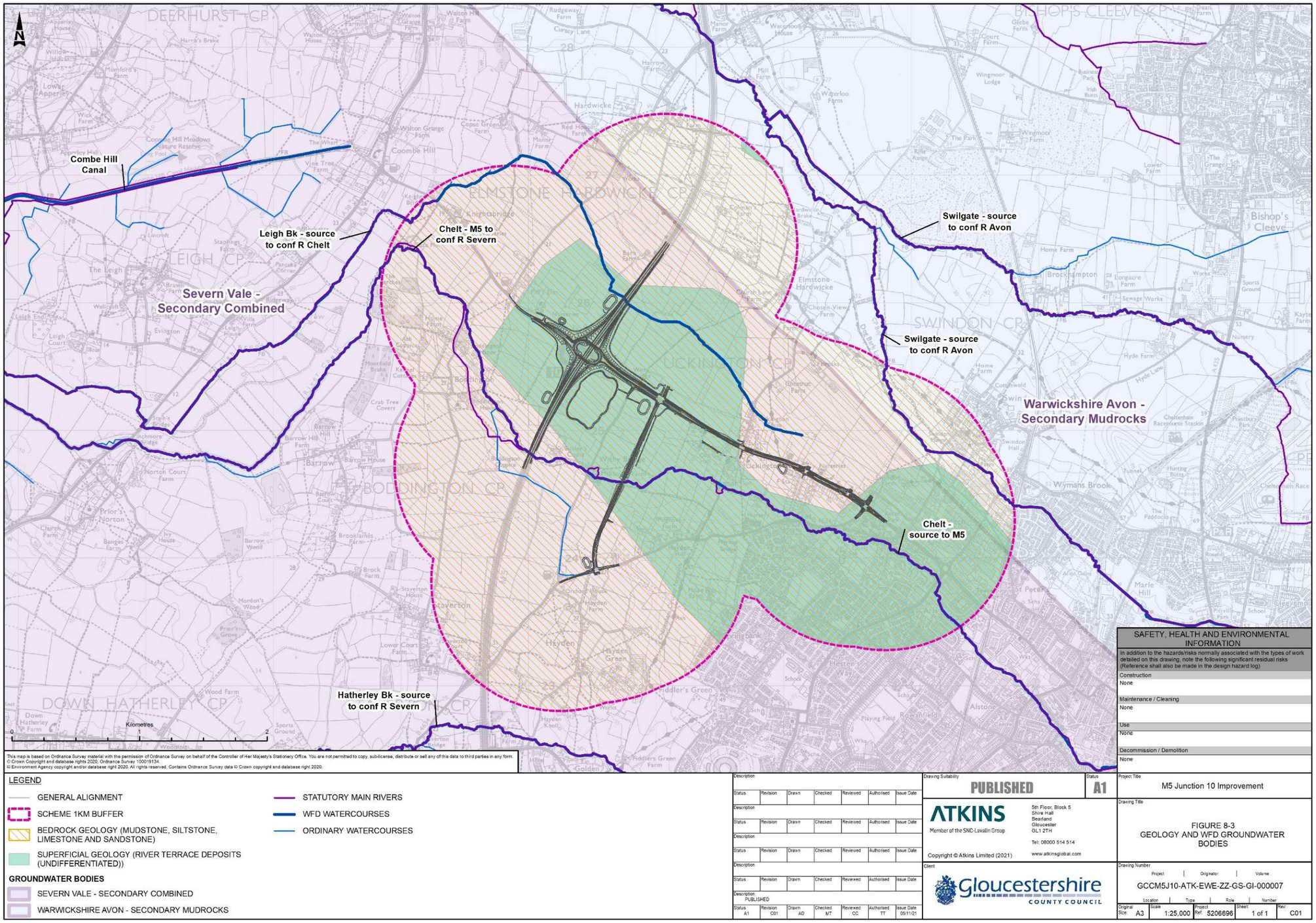


Figure 8-3 - Geology and WFD groundwater bodies

Table 8-4 - Generalised geological sequence for the Scheme

Type	Period	Formation/ Sub-unit	Lithological Description (BGS, 2020)	Environment Agency Aquifer Designation (EA, 2020)
Superficial Geology	Quaternary	Cheltenham Sand and Gravel	Fine-medium grained of quartroze sand with seams of poorly sorted limestone gravel.	Secondary A
		Alluvium	Unconsolidated clay, sand, and silt.	
Bedrock Geology	Triassic	Charmouth Mudstone Formation	Dark grey laminated shales, blue/grey mudstones with local concretions and argillaceous limestone beds with some sandy layers at the base of the stratigraphy.	Secondary Undifferentiated
		Rugby Limestone Member	Grey argillaceous mudstones and limestones.	Secondary A

8.5.20. The study area is underlain by Secondary A and Secondary (undifferentiated) bedrock aquifers (Environment Agency, 2020c). These bedrock aquifer designations are associated with the Charmouth Mudstone Formation (Secondary Undifferentiated) and the Rugby Limestone Member (Secondary A). The Scheme is also underlain by discreet areas of Secondary A superficial aquifer associated with Alluvium and Cheltenham Sand and Gravel (Environment Agency 2017). Secondary A aquifers are defined as “Principal and secondary aquifers provide significant quantities of drinking water, and water for business needs. They may also support rivers, lakes and wetlands” (Environment Agency 2020c). Secondary B aquifers are defined as “predominantly lower permeability layers which may store and yield limited amounts of groundwater due to localised features such as fissures, thin permeable horizons and weathering”. Secondary (undifferentiated) aquifers are assigned by the Environment Agency where it has not been possible to attribute either category A or B to a rock type.

8.5.21. There is currently limited information available to characterise groundwater levels and flow directions in the study area for the Scheme. It is anticipated that subsequent monitoring of the groundwater in the ongoing ground investigation boreholes should give a more robust representation of the groundwater conditions. The study area is underlain by two WFD groundwater bodies: (Environment Agency, 2020b) Figure 8-3.

- Severn Vale - Secondary Combined (GB40902G204900); and
- Warwickshire Avon - Secondary Mudrocks (GB40902G990900).

8.5.22. The status of these groundwater bodies is set out in Table 8-5. For both water bodies, the overall status is good.

Designated sites

8.5.23. A search for Groundwater Dependent Terrestrial Ecosystems (GWDTEs) was performed within the 1 km study area. The results concluded that there are no designated sites and no GWDTEs. The Coombe Hill Canal SSSI is a GWDTE located just to the west of the 1 km study area. However, as it overlies the Triassic Branscombe Mudstone Formation, a different aquifer to that underlying the study area, it has not been assessed further in relation to groundwater effects.

Table 8-5 - Summary of status, RNAG, and objectives for WFD groundwater bodies within the study area.

Water Body Name (Water Body ID)	2016 (Cycle 2) Overall Status	RNAG	Objective*
Severn Vale - Secondary Combined (GB40902G204900)	Good	N/A – already at Good status	Achieved at Good
Warwickshire Avon - Secondary Mudrocks (GB40902G990900)	Good	N/A – already at Good status	Achieved at Good

Groundwater abstractions and discharges

8.5.24. There are no Source Protection Zones (SPZ) within the study area.

8.5.25. Based on Envirocheck ® data (Landmark, 2019), there are no licensed groundwater abstractions within the study area. However, there is a single groundwater discharge located approximately 250 m from the Scheme. A review of private abstractions has been supplied by Tewkesbury Borough Council, suggesting there are no private abstractions within the study area.

8.5.26. One spring was identified within the study area using OS mapping (NGR SO 91661 24606). The spring is located on the superficial alluvium deposits, proximal to the Cheltenham sands and gravels. From background mapping, the spring looks to feed Uckington Moat.

8.5.27. The baseline information shows the two bedrock, and two superficial aquifers are the only groundwater receptors. As these aquifers are not principal, based on DMRB LA 113, they will be classified with **Medium** importance. Although the aforementioned spring seems to provide water to Uckington Moat, the moat is not classified as a GWDTE, therefore the importance of the associated aquifers is not increased to High.

Flood risk

Flood risk from watercourses

8.5.28. The study area is drained by the River Chelt (a designated Main River) and the Leigh Brook (an ordinary watercourse) which combine downstream of the M5 motorway. The flood risk to the study area arising from these watercourses has been assessed. Additional watercourses are present outside of the watershed, and have been identified for water quality and WFD assessment. They do not warrant detailed assessment for flood risk where there is no direct (hydraulic) interaction with the Scheme.

8.5.29. The Environment Agency's Flood Map for Planning (Environment Agency, 2020d) identifies areas potentially at risk of flooding from fluvial or tidal sources (Figure 8-4). The areas not within Zone 2 or 3 are by default Flood Zone 1 (although this may include areas not assessed by the Environment Agency such as Ordinary Watercourses). The zones are defined in the NPPF as follows:

- Flood Zone 1 (Low Probability) comprises land assessed as having a less than 1 in 1,000 annual probability of river or sea flooding (<0.1% annual exceedance probability).
- Flood Zone 2 (Medium Probability) comprises land assessed as having between a 1 in 100 and 1 in 1,000 annual probability of river flooding (1% – 0.1% annual exceedance probability), or between a 1 in 200 and 1 in 1,000 annual probability of sea flooding (0.5% – 0.1% annual exceedance probability) in any year.
- Flood Zone 3 (High Probability) comprises land assessed as having a 1 in 100 or greater annual probability of river flooding (>1% annual exceedance probability), or a 1 in 200 or greater annual probability of flooding from the sea (>0.5%) annual exceedance probability in any year.

8.5.30. The land to the north of the A4019, alongside the Leigh Brook, is identified in the Flood Map for Planning as being within Flood Zone 1. However, this land relates to the ordinary watercourse and it is likely that no flood mapping has been undertaken for that area. Significant areas of land just south of the A4019 and east of the M5 motorway are classified as Flood Zone 2 and 3. These floodplain areas are associated with the River Chelt. Part of the residential area at Withybridge Gardens, is located in Flood Zone 3, although some is shown to be in Flood Zone 1. To the south of the River Chelt, the floodplain is less extensive and most of the land is identified within Flood Zone 1.

8.5.31. Large areas of land to the west of the M5 motorway, including the hamlets of Knightsbridge, Coombe Hill and Boddington, are located within Flood Zone 2 with narrower areas following the river corridors under Flood Zone 3.

8.5.32. A new 1D-2D linked hydraulic model of the River Chelt and Leigh Brook has been developed for this Scheme, using the Environment Agency's Middle Chelt model (The Middle Chelt Hydraulic Model, August 2012); supplemented with a model (the Boddington Model) prepared for Robert Hitchens Ltd in August 2019 which covers an area downstream of the M5 motorway (Figure 8-4). The new model also includes the updated (2019) LiDAR, topographic survey of the Leigh Brook (2019), and was enhanced throughout, with new survey data at the M5 motorway and other critical structures. New hydrology has been applied to the model based on the Environment Agency's flood estimation guidelines (July 2020). This model and the hydrology have been by reviewed by external consultants on behalf of the Environment Agency (March 2021).

8.5.33. The predictions from the new baseline flood model for the 1% annual exceedance probability event (1 in 100-year return period), and other events, are described in the FRA and can be summarised as:

- There is flooding upstream of the M5 motorway embankment, north of the A4019 on the Leigh Brook floodplain, located upstream of Barn Farm culvert and also west of the upstream point of the Leigh Brook watercourse, that would result in flooding to the properties near Uckington Farm; and,
- The flooding upstream of the M5 motorway embankment, south of the A4019, reaches just under 1 km east, but not as far as Uckington. The flooded depth by the M5 motorway is approximately 1 m at Withybridge Gardens (from the River Chelt).

8.5.34. The 0.1% annual exceedance probability event (1 in 1,000-year return period) is predicted to cause additional flooding, specifically:

- Significant overtopping of the A4019 from the River Chelt, resulting in widespread flooding in the Leigh Brook floodplain east of the motorway;
- Widespread out of bank flooding along the Leigh Brook, west of the motorway;
- Significant flooding east of the motorway upstream of the Piffs Elm (Drain 22), River Chelt and Staverton culverts; and,
- Widespread out of bank flooding along the Chelt, west of the motorway, in the fields east of Boddington House and Boddington Manor.

8.5.35. The 1% annual exceedance probability event (1 in 100-year return period) with allowance for climate change is shown in Figure 8-4. This is marginally bigger than the present day 0.1% annual exceedance probability event (1 in 1,000-year return period), and can be summarised as:

- Significant overtopping of the A4019 from the River Chelt, resulting in widespread flooding in the Leigh Brook floodplain upstream of the M5 motorway embankment;
- Widespread out of bank flooding in the Leigh Brook floodplain west of the motorway;
- More significant flooding upstream of the M5 motorway embankment than previously described events, particularly at the eastern end of the River Chelt floodplain. This is, evidenced by higher peak flows passing through the River

Chelt culvert compared to those in the 0.1% and 1% annual exceedance probability events;

- Widespread out of bank flooding along the Chelt, west of the motorway, just upstream of Boddington House and Boddington Manor; and,
- North of the A4019, this flood extent is almost undistinguishable from the present day 0.1% annual exceedance probability event (1 in 1000-year return period).

8.5.36. The modelling confirms the EA's advice that that flood risk from the River Chelt and Leigh Brook is a major consideration in this area.

Flood risk from surface water

8.5.37. The Environment Agency's Risk of Flooding from Surface Water map (Figure 8-5) indicates that the risk of surface water flooding is generally low across the area. Medium and high flood risk (i.e. 1% to 3.33% Annual Exceedance Probability (AEP) events respectively) are identified in areas immediately north-east and south-east of the M5 Junction 10, with the highest risk located against the motorway embankment. In particular, surface water appears to pond along the north-east border of the M5 Junction 10 southbound off slip road and extend approximately 750 m north from the junction. This ponding is shown to affect properties on the north bank of the Leigh Brook.

8.5.38. An area of low to high surface water flood risk (0.1% to 3.33% AEP) is located at the M5 motorway crossing of the River Chelt, approximately 800 m south from the M5 Junction 10. Surface water is shown to pond within this area, sitting beside the motorway off either bank and extending south to the unnamed watercourse that passes through the Staverton culvert. This flooding affects residential properties at Butlers Court.

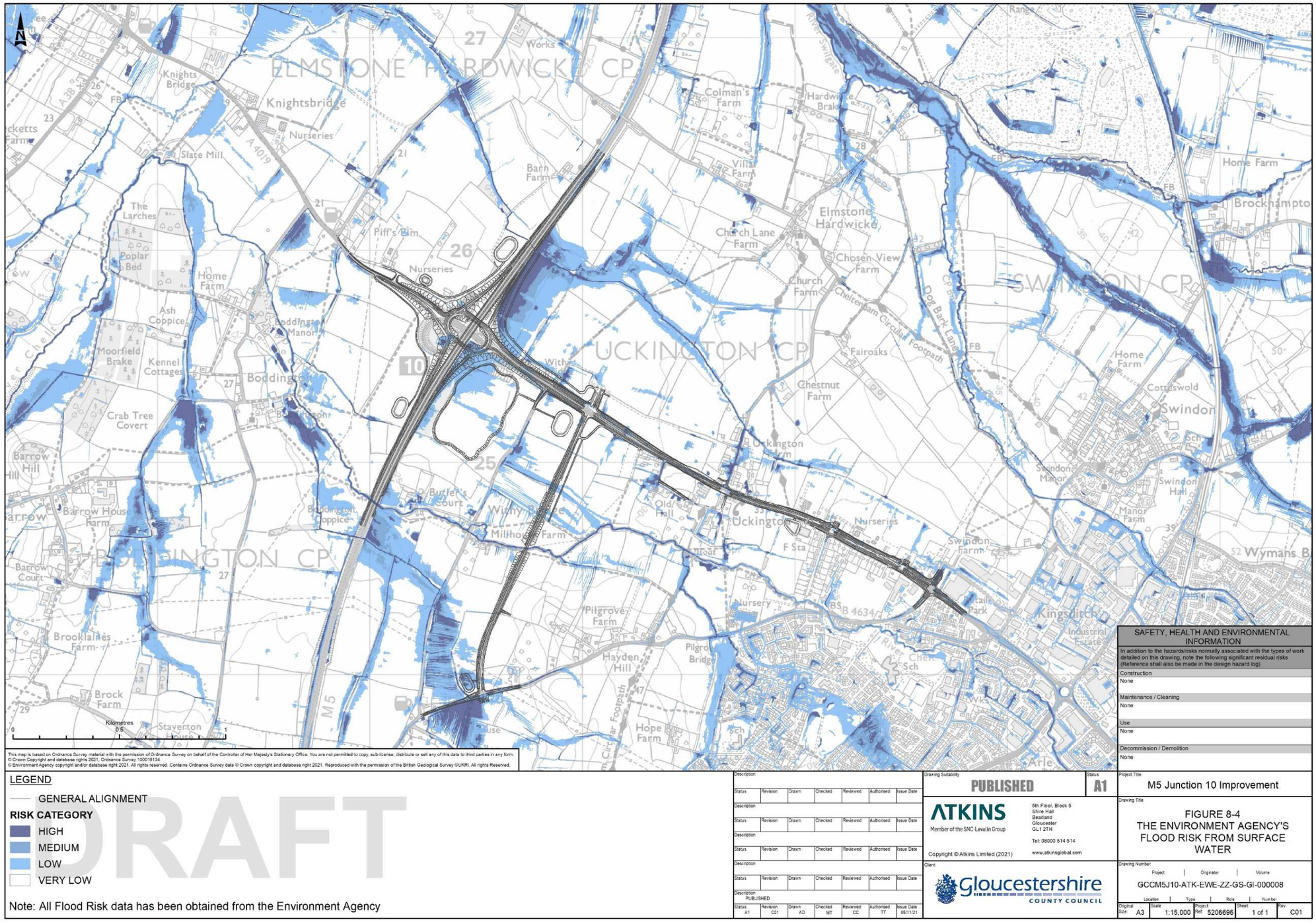


Figure 8-4 - Environment Agency Risk of Flooding from Surface Water

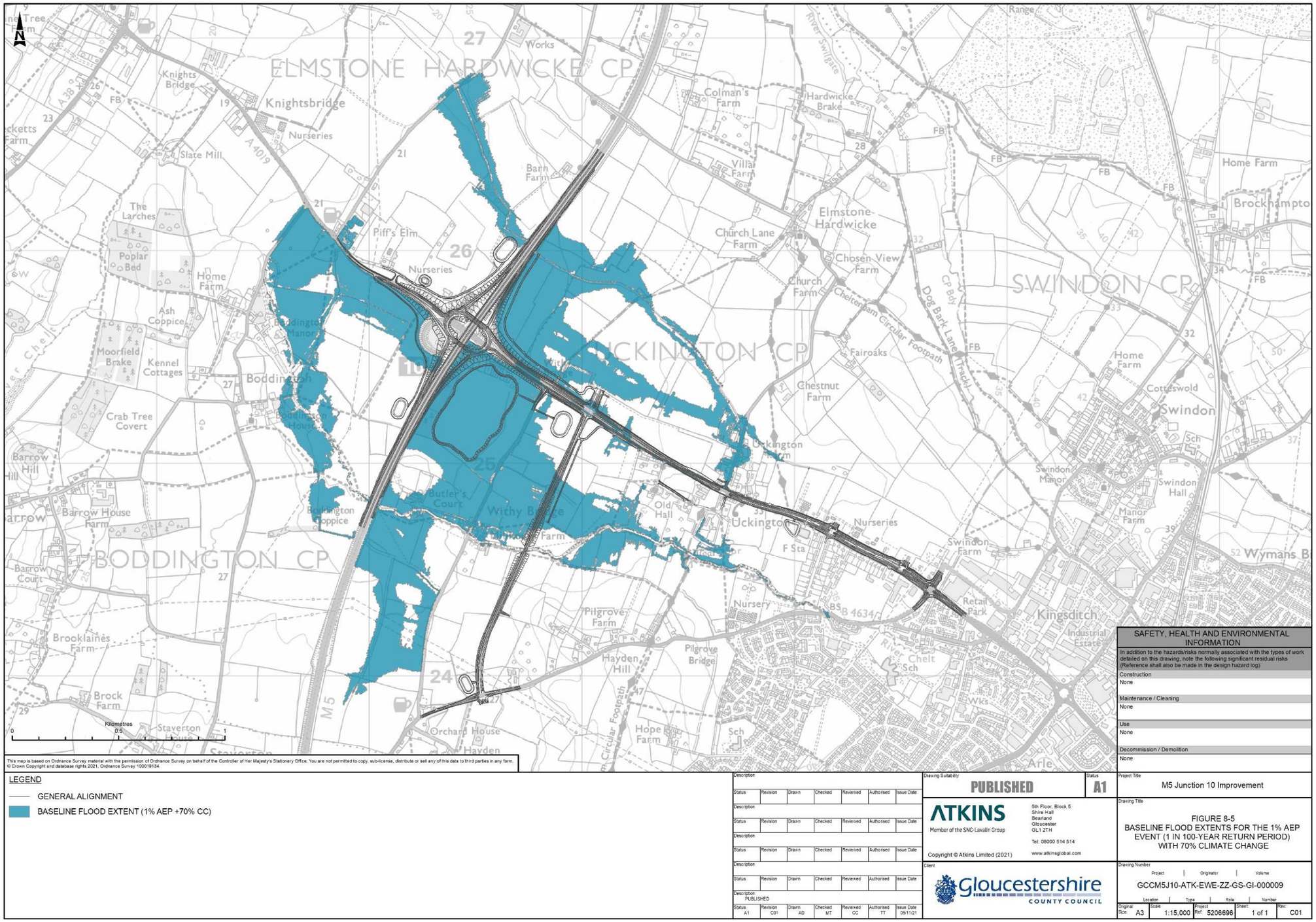


Figure 8-5 - Baseline flood map showing modelled 1 in 100yr with CC extents

Flood risk from groundwater

8.5.39. Groundwater flooding of land can occur when groundwater levels rise close to or above ground surface. Groundwater flooding is most likely to occur in low-lying areas underlain by permeable rocks (aquifers).

8.5.40. The BGS susceptibility to groundwater flooding maps show that the Scheme is at high to medium-high risk of groundwater flooding.

Vulnerability to flood risk

8.5.41. Receptors in the areas identified as being at flood risk include residential properties, farmland and highway. Under the NPPF these are classified as a mix of essential infrastructure, more, highly and less vulnerable development. Where there are different vulnerabilities in a group of receptors, the highest vulnerability is assigned to give a precautionary representation, rather than identify each individual receptor. In accordance with DMRB LA 113, the flood risk receptors were classified as having **Medium**, **High** or **Very High** importance.

8.5.42. The importance of each flood risk receptor is listed in Table 8-6.

Summary of baseline conditions

8.5.43. The water receptors scoped into this PEIR have been assigned an importance in the sections above which is summarised in Table 8-6. Where the indicators of importance identified in the DMRB LA 113 are unknown, a conservative approach has been applied using professional judgement.

Table 8-6 - Summary of water environment receptors and their importance

Type of water receptor	Receptor	Indicator of Importance based on LA 113	Importance
Surface water	River Chelt	WFD designated, Q_{95} approx. 0.298	High
	Leigh Brook	WFD designated, Q_{95} unknown	High
	MW3	ordinary watercourse, Q_{95} unknown	Medium
	Drain 6	ordinary watercourse, Q_{95} unknown	Medium
	Drain 8	ordinary watercourse, Q_{95} unknown	Medium
	Drain 9	ordinary watercourse, Q_{95} unknown	Medium
	Drain 10	ordinary watercourse, Q_{95} unknown	Medium
	Drain 11	ordinary watercourse, Q_{95} unknown	Medium
	Drain 12	ordinary watercourse, Q_{95} unknown	Medium
	Drain 15	ordinary watercourse, Q_{95} unknown	Medium
	Drain 16	ordinary watercourse, Q_{95} unknown	Medium
	Drain 20	ordinary watercourse, Q_{95} unknown	Medium
	Drain 21	ordinary watercourse, Q_{95} unknown	Medium
	Drain 22	ordinary watercourse, Q_{95} unknown	Medium
	Uckington North	More vulnerable developments - dwelling houses	High
	Uckington South	Highly vulnerable infrastructure – fire station	Very High

Type of water receptor	Receptor	Indicator of Importance based on LA 113	Importance
Flood Risk	Barn Farm East	Highly vulnerable developments – caravans and mobile homes intended for permanent residential use	Very High
	Butlers Court	More vulnerable developments - dwelling houses	High
	Millhouse Farm	More vulnerable developments - dwelling houses	High
	Elmstone Business Park	More vulnerable developments - dwelling houses	High
	Leigh Brook Floodplain - upstream of M5	Less vulnerable – land and building used for agriculture	Medium
	River Chelt Floodplain - upstream of M5	Less vulnerable – land and building used for agriculture	Medium
	A4019	Essential transport infrastructure	Very High
	M5 Motorway	Essential transport infrastructure	Very High
Groundwater	Cheltenham Sand and Gravel superficial aquifer	Secondary A Aquifer	Medium
	Alluvium superficial aquifer	Secondary A Aquifer	Medium
	Charmouth Mudstone Formation bedrock aquifer	Secondary Undifferentiated aquifer	Medium
	Rugby Limestone Member bedrock aquifer	Secondary A Aquifer	Medium

8.6. Potential impacts

8.6.1. Impacts from the Scheme to surface water quality, hydromorphology, flood risk and groundwater have been outlined below. This assessment has been completed for the Scheme with the embedded mitigation in place. The guidance is clear that embedded mitigation is included in the best practice design approach. Embedded mitigation covers the project design principles adopted to avoid or prevent adverse environmental effects, whereas Essential/Additional mitigation (section 8.7) are those measures subsequently required to reduce and if possible offset likely significant adverse environmental effects, in support of the reported significance of effects in the environmental assessment.

8.6.2. The assessment includes a routine runoff assessment with the Scheme in place to determine the potential for impacts from the Scheme to surface water quality. At the next stage, in the Environmental Statement, the HEWRAT assessment will be run in full, to include the baseline scenario and spillage assessments.

8.6.3. The WFD assessment and FRA have also been completed and support the assessment of impacts. These will also be updated in the Environmental Statement.

Construction

8.6.4. Impacts during construction have the potential to affect the water environment and have been highlighted in the section below.

8.6.5. Examples of where and how the impacts might occur have been provided. It should be noted that generally only one example has been provided but other examples of the impact are likely to be present.

Surface water quality

- The excavation of materials, and the subsequent deposition of soils, sediment, or other construction materials, for example through the creation of SuDS ponds which are proposed at various locations;
- The spillage of fuels or other contaminating liquids from plant used in the construction process;
- The mobilisation of contamination following the disturbance of contaminated ground or groundwater, for example through earth movement during the construction of the West Cheltenham Link Road;
- Runoff from construction sites to surface water bodies, for example where construction works are immediately adjacent to a watercourse such as the West Cheltenham Link Road construction immediately adjacent to the River Chelt; and
- Disturbance of non-native invasive species - construction activities can result in the spread along surface water bodies and their riparian zone, for example through the construction of bridges and construction/modification of culverts.

8.6.6. These impacts could result in sediment and/or other contaminants entering watercourses or lakes and affecting the quality of the water which could have implications for the designated sites, abstractions and WFD compliance.

Hydromorphology

8.6.7. Construction of West Cheltenham Link Road River Chelt Bridge may cause temporary damage to riparian and channel features.

8.6.8. Construction associated with culvert replacements and extensions (for example the lengthening of the Barn Farm Culvert) may result in a) localised damage to channel and riparian features and b) disruption of the natural hydraulic and sediment transport processes.

8.6.9. Realignment of minor watercourses to connect to new culverts or extended old culverts presents a risk of damage to channel features, substrate and riparian zones.

8.6.10. Loss of ephemeral ditches due to construction of Scheme components may result in habitat loss. For example the construction of the southern junction on the Link Road may cause a temporary loss of open ditch along a number of ordinary watercourses.

Groundwater

8.6.11. Risks to the groundwater environment are associated with dewatering activities from cuttings potentially impacting local groundwater flow and levels and water quality, the spillage of fuels or other contaminating liquids, introduction of rapid vertical flow paths from surface to groundwater and local changes to groundwater flow associated with piling activities.

Flood Risk

8.6.12. There is an increase in flood risk arising from the storage of plant and materials on the floodplain of the River Chelt or Leigh Brook. This may impact on the health and safety of the workforce, or the quality and viability of any materials. An increase in flood risk would impact on some or all of the flood risk receptors, depending on its magnitude. No specific hydraulic modelling of temporary construction conditions has been undertaken: it is assumed that a construction environmental management plan would set out measures and procedures for dealing with construction stage flood risk.

Operation

Surface water quality

8.6.13. The Drainage Plans (Appendix 2.1) have identified six catchments as part of the Scheme. Table 8-7 provides a summary of the proposed drainage catchments. All of the

catchments discharge to surface water features. In terms of embedded mitigation, the Drainage strategy consists of:

- M5 J10 and A4019: Collection systems are to be a kerb and gully arrangement or combined drainage and kerbs as per the existing arrangement. Grassed channels will be introduced where space allows. Flows will be conveyed via pipes to new ponds prior to discharge to watercourses via new ditches for at least 8m upstream of the outfalls. Due to several private land parcels along the A4019 being retained, there is limited space to add additional open ditch features or swales. Flows are to be restricted to existing rates. Ponds will include forebay areas to manage contaminants and contain spillages.
- Link Road: The link road includes road-side swales to collect runoff and convey it to new ponds. Outgoing pipes from ponds will discharge to new ditches at least 8m upstream of the outfalls. Flows are to be restricted to greenfield runoff rates. Ponds will include forebay areas to manage contaminants and contain spillages.

8.6.14. The magnitude of impact of the Scheme on water quality is determined by using the HEWRAT, taking into consideration the influence of mitigation measures.

8.6.15. At this stage, the HEWRAT has been used to assess the impact of routine runoff on surface water quality. This includes the assessment of the acute impacts from soluble pollutants, chronic impacts from sediment related pollutants and compliance with Environmental Quality Standards (EQSs) using annual average concentrations of soluble pollutants. Results of any cumulative assessment are presented in section 8.9.

8.6.16. The HEWRAT can also be used to provide an indication of the risk of a spillage causing a pollution impact/incident on a receiving watercourse. The risk is defined as the probability that there will be a spillage of pollutant and that the pollutant will reach and impact the watercourse to such an extent that it causes a serious pollution incident. The risk is expressed as the probability of an incident in any one year. The spillage risk assessment has not been completed at this stage and will be undertaken for the Environmental Statement.

8.6.17. Table 8-8 shows the findings of the routine runoff HEWRAT assessment with the Scheme in place. An assessment of the baseline conditions has not yet been completed but will be undertaken following for the Environmental Statement to understand the differences between existing and potential impacts.

8.6.18. As the combined pond catchment passes the EQS for zinc, the magnitude of impact has been classified as Large rather than Very Large. However, as catchment S2 fails on all tests, the magnitude of impact has been assigned as Very Large. Similarly, for catchments J1 and Link Road, Slight has been assigned as there is a failure of acute impact from soluble copper therefore the impact is greater than Neutral.

Table 8-7 - Surface water quality drainage catchments

Outfall reference	Drainage Catchment	Receptor	Area (ha)	Impermeable area (ha)	Permeable area (ha)	Embedded mitigation
1	J1	Drain 8	1.371	0.937	0.434	SuDS attenuation pond
2	Link Road	Drain 15	1.957	1.649	0.308	SuDS attenuation pond and Swales
3	A4019 main line at Elms park	River Chelt	2.629	2.294	0.335	SuDS attenuation pond
4	Combined pond	Leigh Brook	8.472	7.198	1.274	Drainage ditch leading to SuDS attenuation pond with swales included adjacent to the Link Road section
5	S1	River Chelt	4.174	3.775	0.399	SuDS attenuation pond
6	S2	Leigh Brook	11.159	7.494	3.665	SuDS attenuation pond

Table 8-8 - Routine runoff assessment results prior to mitigation

Drainage Catchment	Acute impacts from soluble copper – pass or fail	Acute impacts from soluble zinc – pass or fail	Compliance with Environmental Quality Standard (EQS) for copper (compliant or non-compliant)	Compliance with EQS for zinc (compliant or non-compliant)	Chronic impacts from sediment related pollutants – pass or fail	Magnitude of impact	Significance
J1	Pass	Pass	Pass	Pass	Pass	Negligible	Neutral
Link Road	Pass	Pass	Pass	Pass	Pass	Negligible	Neutral
A4019 main line at Elms park	Pass	Pass	Pass	Pass	Pass	Negligible	Slight
Combined pond	Fail	Pass	Fail	Pass	Fail	Major adverse	Large
S1	Pass	Pass	Pass	Pass	Pass	Negligible	Slight
S2	Fail	Fail	Fail	Fail	Fail	Major Adverse	Very Large

Hydromorphology

8.6.19. Culvert extensions, bridge crossings and bank protection can lead to a reduction in hydromorphological complexity. This loss of channel complexity, together with the shading effect of structures and possible loss of riparian zone/floodplain can lead to a simplification/loss of in-channel, riparian and floodplain habitat. Bridge and culvert structures can also reduce biological or sediment continuity (e.g. reduce the ease with which fish or gravels can move along a channel).

8.6.20. Realignment of river channels to make space for highway infrastructure has the potential to reduce hydromorphological complexity (e.g. reduced channel length, loss of channel bends and in-channel features such as bars, berms and backwaters). Loss of hydromorphological complexity can lead to a simplification of in-channel, riparian, and floodplain habitat, and potentially lead to an adverse effect on WFD ecological quality elements.

8.6.21. The details of Scheme activities which have the potential to impact hydromorphology are outlined in the WFD assessment (Appendix 8.2). Some details, such as lengths of culvert extensions on small watercourses, are unknown at this time. Therefore, conservative assessments have been made to outline the potential impacts within this chapter.

8.6.22. Table 8-9 identifies the surface water receptors which may be impacted by the Scheme in terms of hydromorphology.

Table 8-9 - Surface water receptors and mechanisms of impact

Scheme Activity	Receptor	Mechanism of impact	Embedded mitigation	Magnitude of impact	Significance
West Cheltenham Link Road River Chelt Bridge	River Chelt	Riparian vegetation loss	The Link Road River Chelt Bridge has been designed as a clear span structure with no in channel features or alterations to the bed and banks	Negligible	Slight
River Chelt Culvert	River Chelt	At this stage there are expected to be no impacts. However, this may change as the design evolves.	The design has been adjusted to ensure no changes to the River Chelt Culvert are required	Negligible	Slight
Barn Farm Culvert extension	Leigh Brook	Vegetation loss Reduced hydromorphological complexity Potential loss of sediment continuity	Where culverts are required, continuity of natural bed substrate and gradient through the structures will be retained. Culverts will be embedded 0.3m below the surface. The culvert lengths will be kept to a minimum and sized to facilitate any environmental needs (e.g., fish passage). Environment plans have been produced to ensure implementation of appropriate riparian vegetation upstream and downstream of any new crossing, crossing extensions or channel realignments.	Minor Adverse	Slight
Piffs Elm Culvert	Drain 22	Vegetation loss Reduced hydromorphological complexity Potential loss of sediment continuity		Minor Adverse	Slight
Existing culvert extensions (details unknown)	Drain 8 Drain 10 Drain 12 Drain 15 Drain 18 Drain 20	Vegetation loss Reduced hydromorphological complexity Potential loss of sediment continuity		Negligible Negligible Negligible Negligible Negligible Negligible	Neutral Neutral Neutral Neutral Neutral Neutral
Encroachment of drainage channels	Drain 8	Vegetation loss	Where watercourse or ditches are realigned or encroached, designs will replicate the	Negligible	Neutral

Scheme Activity	Receptor	Mechanism of impact	Embedded mitigation	Magnitude of impact	Significance
	Drain 9 Drain 10 Drain 11 Drain 16 Drain 21	Reduced hydromorphological complexity Potential loss of sediment continuity	natural character of the watercourse and be considered appropriate improvements to the hydromorphological and biological quality of the watercourse. Environment plans have been produced to highlight where ditches will be replaced across the Scheme.	Negligible Negligible Negligible Negligible Minor Adverse	Neutral Neutral Neutral Neutral Slight
Flood Compensation	Leigh Brook Drain 22	Increased flow volumes in Drain 22 with decreased flood flows in the Leigh Brook between the M5 and Coombe Hill	No embedded mitigation to manage alterations in flows.	Minor Adverse Minor Adverse	Slight Slight

Groundwater

8.6.23. During operation deep foundations and piling may create rapid vertical flow pathways and introduce contamination into the aquifer. They may form a barrier to groundwater flow, potentially reducing groundwater contributions to adjacent water courses and any groundwater abstractions in the water body.

8.6.24. At the time of reporting (September 2021) limited information is known regarding earthworks (cuttings, embankments and jet grouting) and deep foundations (sheet piling) which will be carried out as part of this Scheme. The current design shows large sections of the M5 Junction 10 and West Cheltenham Link Road which are strongly elevated/embanked and will require earthworks. Drawings also show shallow sections of cutting in the north eastern link road.

8.6.25. It is expected that due to the large sections of the Scheme which are elevated/embanked throughout the Junction and West Cheltenham Link Road, deep foundations (sheet piling) may be included at the next stage of design.

8.6.26. As the absolute extent and dimensions of the embankments, cuttings and foundations are unknown, there is potential for them to impact all groundwater receptors. A preliminary estimate has been undertaken to determine the potential significance of impact (Table 8-10). This has considered embedded mitigation which includes best practice guidance for example, the completion of a piling risk assessment and implementation of best practice guidance regarding pollution prevention.

8.6.27. When more detailed design is available, the receptors will be identified and potential impacts updated.

Table 8-10 - Preliminary significance of impact to groundwater receptors

Scheme Activities	Potential receptors	Potential magnitude of impact	Potential significance
Foundations	All Superficial and bedrock aquifers	Negligible	Slight
Earthworks	All Superficial and bedrock aquifers	Negligible	Slight
Cuttings	All Superficial and bedrock aquifers	Negligible	Slight

Flood risk

8.6.28. In accordance with the guidance DMRB LA 113 all projects on motorways and all-purpose trunk roads shall be designed to:

- remain operational and safe for users in times of flood;
- result in no net loss of floodplain storage;
- not impede water flows; and
- not increase flood risk elsewhere.

8.6.29. These requirements limit the potential impacts and ensure embedded mitigation. However, where these guidelines are not followed significant impacts to flood risk receptors could arise during operation of the Scheme from:

- earthworks generating a loss of floodplain
- encroachment into the watercourses and/or the floodplains,
- blockage and severance of overland flow paths leading to ponding of surface water; and
- increases in the paved (impervious) area for new carriageways generating more runoff.

8.6.30. However, the embedded mitigation measures included in this Scheme control the flood risk. The flood modelling has shown that the Scheme will displace floodwater and impact

on the flood risk of its neighbours if the embedded mitigation is not implemented. The embedded mitigation included in the design is described in detail in the FRA (see Appendix 8.1 – Flood Risk Assessment). Hydraulic modelling has advised the design of the embedded mitigation and is ongoing.

8.6.31. For M5J10 in terms of flooding, the embedded mitigation includes:

- A drainage strategy to limit the peak rate and overall volume of discharge;
- Compensatory floodplain to offset the volume of water displaced by the Scheme during the design flood, prior to the removal of any existing floodplain. This includes a large (200,000 m^3) flood storage basin between the M5 motorway and Withybridge Lane, and 14,363 m^2 of compensatory floodplain immediately east of the West Cheltenham Link Road;
- a permanent watercourse crossing of the River Chelt designed to convey the design flood with a minimum of 600mm freeboard to soffit;
- floodplain conveyance structures through the West Cheltenham Link Road. At this stage, the Scheme includes 37 box culvert openings, each 3m wide and 1m tall; and
- extension of the Piffs Elm and Barn Farm watercourse culverts underneath the M5 motorway, and the local drainage culverts under the A4019, to suit the new roads at the same size and slope as the existing culverts. The existing River Chelt and Staverton culverts do not require extending as part of this Scheme. The opportunity to realign (straighten) the existing twin 750 mm diameter culverts under the A4019 is being taken, reducing its length from 88m to 78m.

8.6.32. Hydraulic modelling is being used to predict the with-Scheme flood risk in the study area (and hence change from the baseline). The current results indicate that the Scheme can sufficiently maintain the hydraulic connectivity, floodplain conveyance and volumetric storage without significant adverse effects on flood risk.

8.6.33. The impact of the Scheme flood model for the present day 1% annual exceedance probability event (1 in 100-year return period) is described in detail in the FRA. The effect of the Scheme on the baseline conditions for this event are shown in Figure 8-6 and can be summarised as:

- A reduction in baseline flood levels upstream of the M5 motorway embankment, south of the A4019;
- A reduction in baseline flood levels downstream of the Piffs Elm and Staverton culverts, extending west to Boddington Road;
- A modification in flood extents immediately upstream and downstream of the proposed West Cheltenham link road: a mix of increases and decreases in flooding associated with the proposed link road culverts;
- New flooding in the compensatory floodplain, immediately upstream of the link road (the land was previously flood free);
- Deeper flooding in the flood storage area by the M5 motorway as a result of excavated (reduced) ground levels;
- A reduction in baseline flood levels near The Green road in Uckington, west of the upstream point of the Leigh Brook watercourse, resulting in less flooding to the properties near Uckington Farm; and,
- No other significant changes to flood levels in Leigh Brook floodplain, upstream and downstream of motorway.

8.6.34. The 1% annual exceedance probability event (1 in 100-year return period) with allowance for climate change (the design flood) is described in detail in the FRA. The effect of the Scheme on the baseline conditions for this event are shown in Figure 8-7 and can be summarised as:

- An increase in baseline flood levels upstream of the M5 motorway embankment, south of the A4019;
- An increase in baseline flood levels west of the property at Piffs Elm (Elmstone Business Park), downstream of the M5 motorway embankment, where flows overtop the A4019 and raise flood levels in the pond;
- An increase in baseline flood levels in the field ditches upstream and downstream of the realigned A4019 culvert;
- New flooding filling the compensatory floodplain, upstream of the proposed West Cheltenham link road. Increases and decreases in baseline flood levels both upstream and downstream of the proposed link road culverts;
- Deeper flooding in the flood storage area by the M5 motorway as a result of excavated (reduced) ground levels; and,
- A significant reduction in baseline flood levels in the Leigh Brook floodplain, upstream and downstream of the motorway, due to the Scheme raising the A4019 and preventing extreme floods from overtopping this road and entering the Leigh Brook catchment.

8.6.35. Table 8-11 details the magnitude and significance of impacts from flood risk based on the information below:

- Receptors are grouped by area.
- The magnitude and impact for each receptor group was assessed using the typical impact on peak flood levels for the whole group.
- The magnitude and impact for each receptor group was based on the modelled 1% AEP event (1 in 100-year return period) with climate change (pre-July 2021 guidance applied: +70% increase in flow applied).
- As the receptor group at Barn Farm East has a Very High importance (DMRB LA 113) and benefits from a reduction in peak flood level significantly greater than the 100 mm required for a major beneficial impact (DMRB LA 113) (the reduction being 1,100 mm), the significance of effect for this group has been classified as Very Large rather than Large.
- As the receptor groups at the Leigh Brook floodplain and River Chelt floodplain have a Medium importance (DMRB LA 113), containing less vulnerable developments (being farmland), the significance of effect for both of these groups has been classified as Moderate (beneficial and adverse respectively) rather than Large.
- The receptor group at Elmstone Business Park has a High importance (DMRB LA 113), containing more vulnerable developments. However, since only one receptor in the group with High importance (a public house) is affected by an increase in flood levels only just greater than the 50mm required for a moderate impact (the increase being 60mm), the significance of effect for this group has been classified as Moderate (adverse) rather than Large. Furthermore, it is intended that this detriment will be designed out in the coming months.

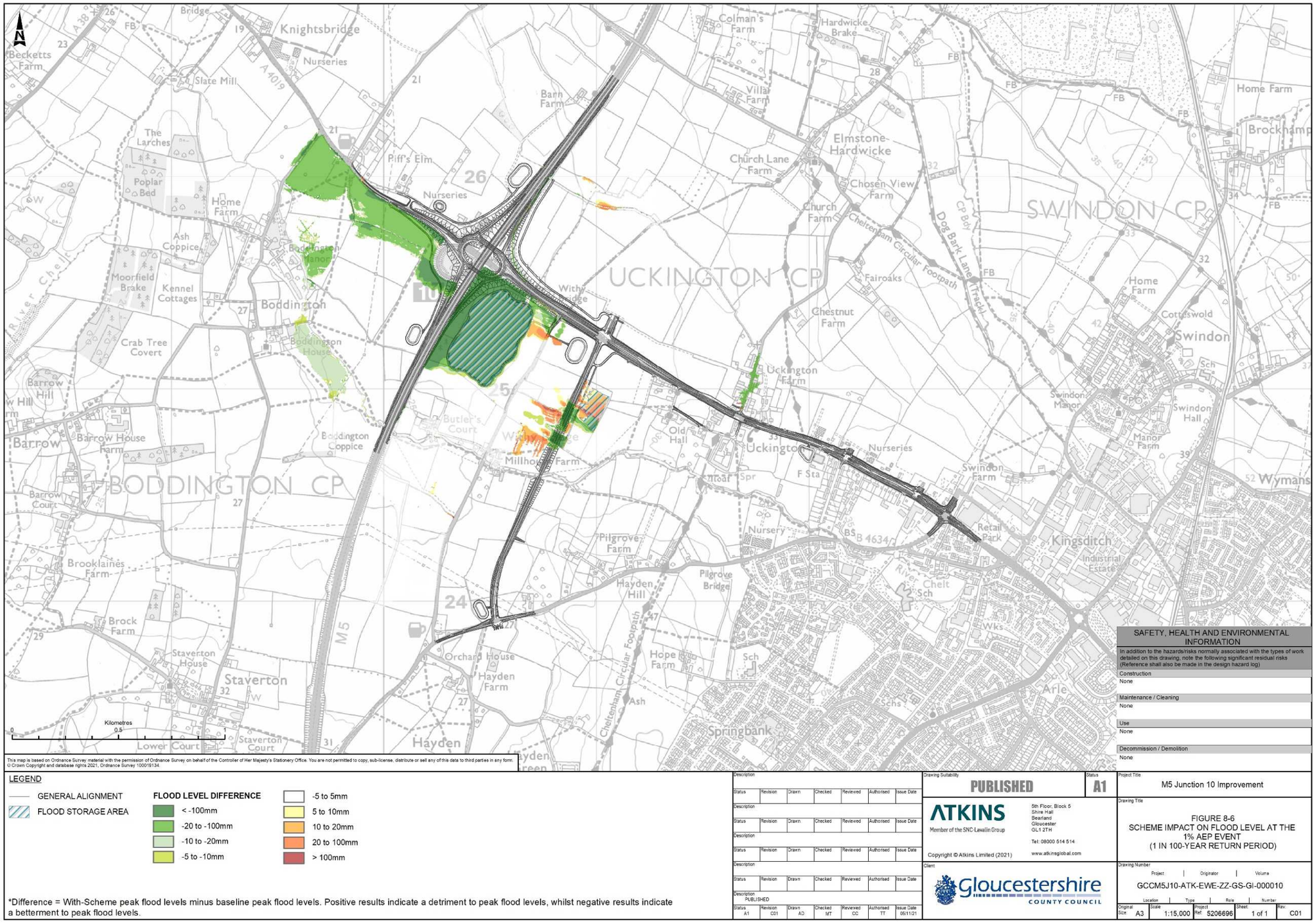


Figure 8-6 - Scheme impact on flood level at the 1% AEP event (1 in 100-year return period)

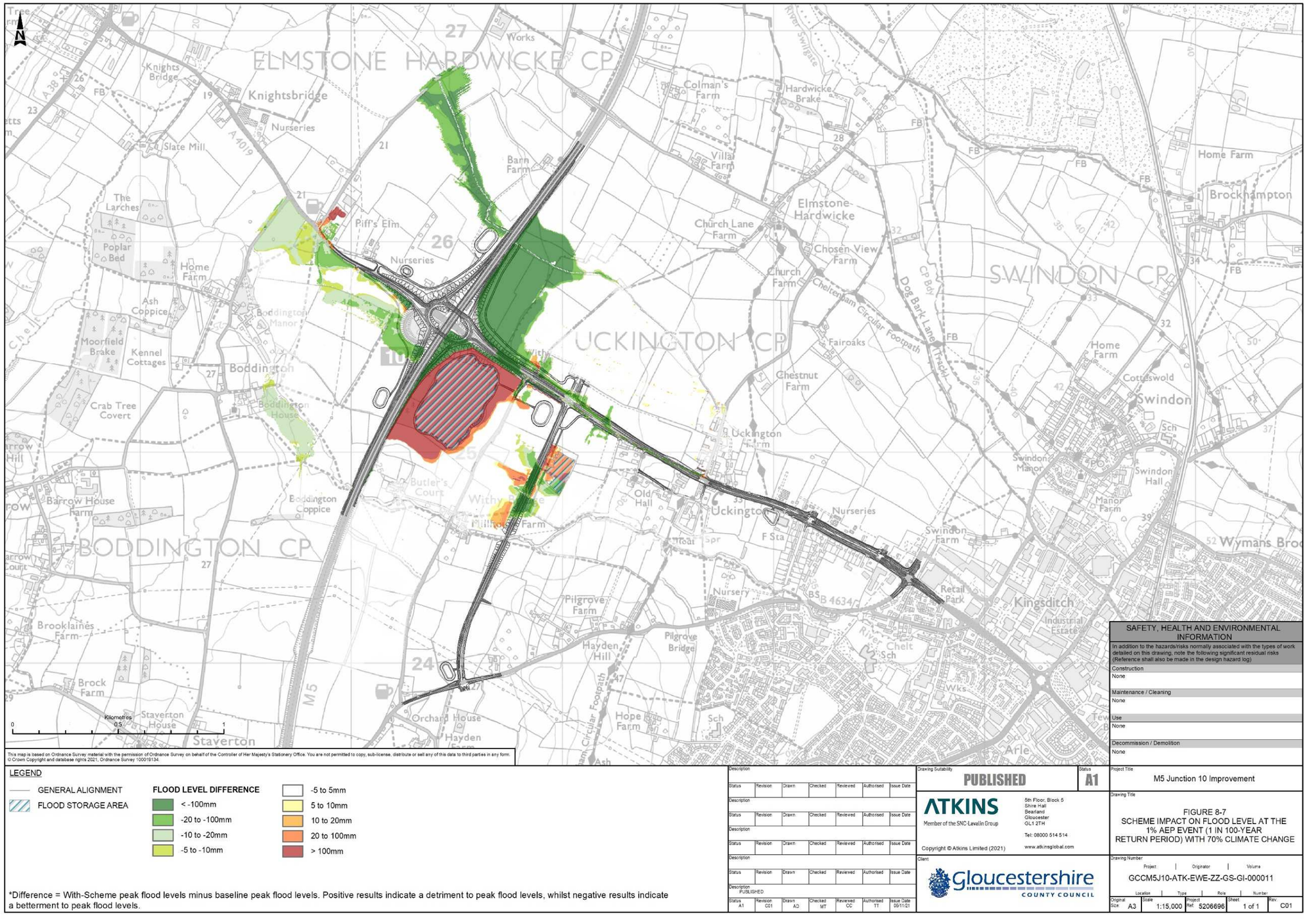


Figure 8-7 - Scheme impact on flood level at the 1% AEP event (1 in 100-year return period) with climate change

Table 8-11 - Magnitude and significance of impact from flood risk

Receptor	Impact (1% AEP with CC)	Magnitude of Impact (based on 1% AEP with CC)	Significance (based on 1% AEP with CC)
Uckington North (high importance)	The highest magnitude of impact in the receptor group was predicted as an increase of 10mm to peak flood levels, affecting two properties in the north of the group. For the remainder of the group, there is no change to peak flood levels.	Negligible	Slight (adverse)
Uckington South (very high importance)	No change to peak flood levels for all receptors.	No Change	Neutral
Barn Farm East (very high importance)	All receptors impacted by typically a 1,110 mm reduction to peak flood levels.	Major Beneficial	Very large (benefit)
Butlers Court (high importance)	No change to peak flood levels for all receptors.	No Change	Neutral
Millhouse Farm (high importance)	No change to peak flood levels for all receptors.	No Change	Neutral
Elmstone Business Park (high importance)	The highest magnitude of impact in the receptor group was predicted as an increase of 60mm to peak flood levels, affecting a public house in the west of the group. The remainder of the group is affected by typically a 10mm reduction to peak flood levels.	Moderate adverse	Moderate (adverse), that is intended to be designed out in the coming months
Leigh Brook Floodplain - upstream of M5 (medium importance)	Small area immediately north of A4019 culvert predicting increases to peak flood levels ranging from 10 to 240mm. However, typical reduction of 1,000 mm to peak flood levels across most of Leigh Brook floodplain (upstream of M5).	Areas of major beneficial and others of major adverse	Large area of moderate beneficial and a small area of moderate adverse, that will be reduced through design iterations.

Receptor	Impact (1% AEP with CC)	Magnitude of Impact (based on 1% AEP with CC)	Significance (based on 1% AEP with CC)
River Chelt Floodplain - upstream of M5 (medium importance)	Areas predicting reduction to peak flood levels ranging from 10 to 1,900 mm, mainly within footprint of the Scheme as well as upstream and downstream of the proposed link road. However, typical increase of 1000mm to peak flood levels across majority of Chelt floodplain (upstream of M5) due to reduction in ground levels for the flood storage area.	Areas of major beneficial and others of major adverse[1]	Balance of moderate beneficial and moderate adverse
A4019 – east of M5 (very high importance)	No change from peak flood levels, but Scheme raises A4019. Therefore existing baseline overtopping and flooding (with average depth of 500mm) is prevented.	Major Beneficial	Very Large
M5 Motorway (very high importance)	No change from peak flood levels.	No Change	Neutral

[1] Negotiations to be held with the affected landowners with the aim of gaining 'Right to Flood' agreement on additional flooding; no further mitigation required if agreed.

8.7. Potential mitigation measures

8.7.1. Where the assessment of current design, using the above methodology, identifies any significant adverse effects, essential mitigation measures would need to be implemented. The proposed mitigation measures would be in addition to the embedded mitigation within the project's design, such as SuDS pollution control measures on outfalls (if appropriate) and measures within the Construction Environmental Management Plan (CEMP) to control and prevent polluted run-off. Mitigation measures have been highlighted below which will be updated following in the Environmental Statement.

Construction

Surface water quality

8.7.2. During construction, mitigation measures will be captured within a CEMP. Many of these measures are likely to be associated with good site practice and the preparation of robust method statements (e.g. Pollution Prevention and Incident Control Plan Pollution Prevention Guidelines (PPGs)) (Environment Agency, 2013). Although PPGs have been archived, they are still relevant and considered good practice.

8.7.3. An assessment of impacts from pollution during construction should align with CIRIA C648 which outlines potential impacts and mitigation measures.

8.7.4. Temporary works sites, haul roads and other associated works should be designed and maintained to minimise impact.

8.7.5. Where temporary watercourse diversions are required or in–channel working, specific mitigation may be needed to ensure the temporary design is in line with the WFD and that temporary impacts are minimised.

8.7.6. Areas which may generate contaminated water, such as oil storage areas, would need to be bunded and have water discharged to self–contained units with treatment facilities. There would be no discharge to groundwater.

8.7.7. Tests would be undertaken to ensure contaminated material is identified, isolated and reworked or removed to special landfill to avoid any leachate problems.

8.7.8. Temporary land–take required for construction will include adequate areas of land set aside for robust control measures, for example sustainable drainage control.

Hydromorphology

8.7.9. To minimise the impact of the Scheme components on hydromorphological elements, the following guidance has also been adopted:

- Single span structures are the preferred type of crossing because they minimise impact on the water environment if designed appropriately. The West Cheltenham Link Road River Chelt Bridge has been designed as a clear span structure with no mid channel features;
- Where widening, deepening, straightening, or realigning of naturally functioning channels cannot be avoided, modification will be carried out in an environmentally sensitive manner to reduce temporary impacts; and
- Where construction works are taking place, care will be taken to minimise impact on riparian vegetation to reduce the impacts from surface runoff and sediment entrainment.

8.7.10. Application document TR010030/APP/5.4 contains further details on the mitigation associated with hydromorphological elements and the WFD.

Groundwater

8.7.11. Where deep foundations extending below the groundwater table are intended to be installed as part of the Scheme, these should be designed in accordance with industry

standards - taking into account the site-specific water level and flow monitoring data obtained from intrusive ground investigation for the Scheme.

8.7.12. Where dewatering activities are required, these shall be compliant with industry standards. The disposal of water would also be in accordance of these standards.

8.7.13. A piling risk assessment would be carried out to ensure the selected piling method would not introduce contamination pathways into the aquifer. Piling design should include mitigation in the form of substantial clear spacing between piles and appropriate piling installation methods.

8.7.14. Areas which may generate contaminated water, such as oil storage areas, would need to be bunded and have water discharged to self–contained units with treatment facilities.

Flood risk

8.7.15. The construction activities within the functional floodplain will be minimised as far as possible. To mitigate the impact of earthworks within the wider floodplain, construction work will be phased so that floodplain compensation areas are constructed prior to loss of floodplain volume to ensure no overall adverse impact.

8.7.16. The Environment Agency flood warning system will be adopted during construction. A suitable flood management plan should be put in place to ensure effective and safe evacuation of personnel (plant and materials if safe to do so) from the areas at risk on receipt of a flood warning.

8.7.17. Where subsurface works are required, for structural foundations, buried services etc., localised dewatering may be required.

Operation

8.7.18. Where there are significant impacts outlined as part of the impact assessment, additional mitigation will be required to reduce the impact on receptors. These mitigation measures will be implemented as part of the next phase of design and are outlined below.

Surface water quality

8.7.19. The drainage strategy has been put into place to allow for management of volumes and quality of any surface runoff. The routine runoff test which has been conducted to date suggests the drainage strategy may not be providing enough mitigation to compensate for the impacts to the Leigh Brook. Further testing is required to get a better understanding of these impacts. This will include a full sweep of the HEWRAT tool to include the baseline scenario, spillage assessments and metal bioavailability modelling to determine an appropriate EQS for the watercourse based on toxicity. Following this, if the tests still fail, additional mitigation is likely to be required.

8.7.20. The preferred approach is to provide mitigation in the form of SuDS. The DMRB considers how SuDS may be used to treat run-off and provide mitigation for both the quality and attenuation of water. The choice of the system is dependent on the physical environment of the Scheme and needs to consider the availability of land, climate and rainfall characteristics, soil permeability, topography and spillage risk.

8.7.21. Further mitigation measures will be embedded into the Scheme as part of the next stage of design based on best practice guidance as well as the outcome of the HEWRAT assessment, WFD compliance assessment, consultation with the Environment Agency and through discussions with the specialists carrying out the drainage strategy and biodiversity assessment.

Hydromorphology

8.7.22. To minimise the impact of the Scheme components on hydromorphological elements, the mitigation outlined in Table 8-9 have been adopted. Where any significant impacts are highlighted as part of the next design stage, additional mitigation may include:

- Where culverts are required, continuity of natural bed substrate and gradient through the structures should be retained. Sediment retention mechanisms may

be required in the form of baffles to ensure sediment is maintained within steep culverts. Energy dissipation measures may be required depending on the culvert gradients; these may include stilling basins. The culvert lengths should be kept to a minimum and sized to facilitate any environmental needs (e.g., fish passage);

- Where bed or bank protection are proposed, 'softer' bioengineered solutions should be prioritised to provide a cheaper, more sustainable design where possible;
- The role of vegetation and riparian planting should also be considered to provide long-term bank stability and additional habitat; and
- Where river realignments are proposed, the designs should replicate the natural character of the watercourse and be considered appropriate improvements to the hydromorphological and biological quality of the watercourse.

8.7.23. Mitigation measures will be proposed based on best practice guidance as well as the outcome of the WFD assessment, consultation with the Environment Agency and through discussions with the specialists carrying out the biodiversity assessment.

Groundwater

8.7.24. Mitigation measures for operational impacts to groundwater receptors are similar to those for surface water, and include, but are not necessarily limited to:

- Groundwater site specific intrusive ground investigation must be undertaken to obtain appropriate groundwater level and quality monitoring in the vicinity of the works to feed into the design of any deep foundations extending beneath the groundwater table;
- A piling risk assessment would be carried out to ensure the selected piling method would not introduce contamination pathways into the aquifer. Piling design should include mitigation in the form of substantial clear spacing between piles and appropriate piling installation methods; and
- Implementation of SuDS to mitigate the pollution risk associated with road runoff.

Flood risk

8.7.25. The assessment to date has demonstrated some increases in flood levels affecting farmland (classified in the NPPF as less vulnerable and hence of medium importance). As the predicted changes in flood depth are, in some places, more than 100 mm, the guidance in LA113 describes this as a major impact and hence of moderate or large significance. These effects would require additional mitigation.

8.7.26. The hydraulic modelling is now being used to develop the essential mitigation to those significant adverse effects as described above (Table 8-11). Essential mitigation measures for the significant adverse effects could include, but are not limited to:

- Use of larger conveyance structures for new and replacement crossings of the watercourses and floodplains; and
- Inclusion of additional compensatory floodplain or storage.

8.7.27. In order to limit the extent of and additional flood storage or compensatory floodplain, and the sustainability impact of providing that, it is intended that negotiations will be held with the affected landowners with the aim of gaining an agreement on the additional flooding (extent, depth and duration). Such an agreement would materialise as a Right to Flood. Where such a Right is agreed, no further mitigation is required, and the impact becomes an acceptable effect. At the time of this PEIR, it is likely that a Right to Flood agreement will be sought for:

- 5 fields of existing farmland either side of the West Cheltenham Link Road (increases in flood level of up to 100 mm and reductions of more than 100 mm)
- The compensatory floodplain on the east of the West Cheltenham Link Road (new flooding of up to 100 mm depth)

- 1 field of existing farmland north of Butlers Court, south of the flood storage area (increase in flood level of up to 250 mm)

8.8. Residual impacts

8.8.1. At this stage of assessment, an assessment of residual impacts has been undertaken and summarised in the below sections. This has assumed that best practice mitigation will be incorporated during construction.

Construction

Surface water quality

8.8.2. Likely impacts from road construction activities are typically temporary and can be mitigated through good engineering practices.

8.8.3. For surface water receptors, subject to the implementation of all mitigation measures, the overall effect on surface water during construction has been assessed as **Neutral** which is not considered significant.

8.8.4. As no significant effects on surface water features have been identified, no significant effects on licensed abstractions or consented discharges are predicted.

8.8.5. The WFD assessment has been completed and has concluded that that temporary impacts are not likely to cause a deterioration to the water quality elements of the WFD at a water body scale (Appendix 8.2 – WFD Compliance Assessment).

Hydromorphology

8.8.6. Likely impacts on hydromorphology from construction activities are the same as those stated for surface water quality.

8.8.7. Similarly, the WFD assessment has been completed and has concluded that that temporary impacts are not likely to cause a deterioration to the biological elements of the WFD at a water body scale (Appendix 8.2 – WFD Compliance Assessment).

Groundwater

8.8.8. As for surface water, likely impacts from road construction activities are typically temporary and can be mitigated through good engineering practices.

8.8.9. For groundwater receptors, subject to the implementation of all mitigation measures the overall effect from construction on groundwater has been assessed as **Neutral** which is not considered significant. The design and implementation of Scheme components to which groundwater is particularly sensitive are further protected by requirements of the Development Control Order (DCO) for the Scheme.

Flood Risk

8.8.10. For flood receptors, subject to the implementation of the essential mitigation measures, the overall effect on flood risk during construction has been assessed as **Neutral** which is not considered significant.

Operation

Surface water quality

8.8.11. An assessment of the baseline water quality conditions has not yet been completed but will be undertaken for the Environmental Statement to understand the differences between existing and potential impacts.

8.8.12. As stated in section 8.6.18, the combined pond catchment (out falling to the Leigh Brook) only fails the copper tests, therefore only has a significance of **Large** rather than very large. Whereas the S2 catchment (also out falling to the Leigh Brook) fails all tests resulting in a significance of **Very Large**.

8.8.13. Further testing with the HEWRAT tool needs to be undertaken to include the baseline scenario, spillage assessments and metal bioavailability modelling to determine an appropriate EQS for the watercourse based on toxicity. This will allow for a more representative assessment of impacts from the Scheme. Once these tests have been completed, any appropriate mitigation will be implemented as part of the next stage of design.

8.8.14. A cumulative assessment of the routine runoff has been completed following implementation of embedded mitigation and has been presented in section 8.9.

Hydromorphology

8.8.15. Residual impacts to hydromorphology are outlined in Table 8-12 below. This has assumed that all embedded mitigation is implemented and any additional mitigation is implemented as part of the next stage of design.

8.8.16. This assessment will be updated following for the Environmental Statement.

Groundwater

8.8.17. At the time of writing this report there is not sufficient information on the proposed structures or the groundwater conditions to make an informed assessment of impacts to the groundwater receptors.

8.8.18. A preliminary assessment has determined that, subject to the implementation of all mitigation measures, as set out in the principles and purpose of environmental assessment DMRB LA 113, and with the assumptions set out in section 8.11, the overall residual magnitude of impact on groundwater receptors during operation is predicted to be **Negligible** resulting in **Neutral** significance of effects (Table 8-12).

Flood Risk

8.8.19. Subject to the implementation of the essential mitigation, various Right to Flood agreements, and with the assumptions set out in section 8.11, the worst-case adverse residual magnitude of impact on all flood receptors during operation is **Negligible** resulting in a **Slight** or **Neutral** significance of effect.

8.8.20. Future updates to this assessment will apply the new Environment Agency climate change guidance with a reduction in peak flow allowance (arising from a +53% allowance for future climate change as opposed to the +70% allowance included in the current assessment).

Summary

8.8.21. The residual significance of effect on the water environment during operation are outlined in Table 8-12.

Table 8-12 - Residual impacts on the surface water environment during operation.

Receptor	Importance as outlined in Table 8-6	Magnitude of impact	Significance of effect
	Surface water quality		
River Chelt	High	Negligible	Slight
Leigh Brook	High	Major Adverse	Very Large
Drain 8	Medium	Negligible	Neutral
Drain 15	Medium	Negligible	Neutral
	Hydromorphology		
River Chelt	High	Negligible	Slight
Leigh Brook	High	Minor Adverse	Slight

Receptor	Importance as outlined in Table 8-6	Magnitude of impact	Significance of effect
Drain 8	Medium	Minor Adverse	Slight
Drain 9	Medium	Negligible	Neutral
Drain 10	Medium	Minor Adverse	Slight
Drain 11	Medium	Negligible	Neutral
Drain 12	Medium	Minor Adverse	Slight
Drain 15	Medium	Minor Adverse	Slight
Drain 16	Medium	Negligible	Neutral
Drain 20	Medium	Minor Adverse	Slight
Drain 21	Medium	Minor Adverse	Slight
	Groundwater		
Cheltenham Sand and Gravel superficial aquifer	Medium	Assumed negligible	Neutral
Alluvium superficial aquifer	Medium	Assumed negligible	Neutral
Charmouth Mudstone Formation bedrock aquifer	Medium	Assumed negligible	Neutral
Rugby Limestone Member bedrock aquifer	Medium	Assumed negligible	Neutral
	Flood Risk		
Uckington North	High	Negligible	Slight Adverse
Uckington South	Very high	No change	Neutral
Barn Farm East	Very high	Major Beneficial	Very Large Benefit
Butlers Court	High	No Change	Neutral
Millhouse Farm	High	No Change	Neutral
Elmstone Business Park	High	Moderate Adverse	Moderate Adverse
Leigh Brook Floodplain - upstream of M5	Medium	Areas of major beneficial and others of major adverse	Large area of moderate beneficial and a small area of moderate adverse
River Chelt Floodplain - upstream of M5	Medium	Areas of major beneficial and others of major adverse[2]	Balance of moderate beneficial and moderate adverse
A4019 – east of M5	Very high	Major Beneficial	Very Large Benefit
M5 motorway	Very high	No Change	Neutral

8.9. Cumulative effects

8.9.1. Cumulative effects can arise from within one Scheme, and where more than one Scheme is under construction at the same time that has the potential to impact on the same receptor. The latter assessment will be assessed at the next stage of the assessment.

[2] Negotiations to be held with the affected landowners with the aim of gaining 'Right to Flood' agreement on additional flooding; no further mitigation required if agreed.

The former assessment has been completed for the routine runoff assessment for water quality. The results are below. All other cumulative impact assessments will be completed for the Environmental Statement.

Water quality

8.9.2. Following the guidance, for assessment of impacts associated with soluble pollutants, outfalls within 1 km of each other on the same watercourse have been aggregated for the cumulative assessment. This cumulative impact assessment has been completed for the Combined Pond and S2 catchments as they both outfall to the Leigh Brook within 1 km of each other. The assessment was completed prior to any mitigation and following the embedded mitigation outlined in Table 8-7.

8.9.3. As all tests fail with the embedded mitigation, the significance of impact has been assigned as Very Large rather than Large. Further tests will be completed following for the Environmental Statement to understand the baseline and with Scheme impacts. The spillage test will also be completed.

Table 8-13 - Cumulative impact from S2 and Combined Pond

Drainage Catchment	Acute impacts from soluble copper – pass or fail	Acute impacts from soluble zinc – pass or fail	Compliance with Environmental Quality Standard (EQS) for copper (compliant or non-compliant)	Compliance with EQS for zinc (compliant or non-compliant)	Chronic impacts from sediment related pollutants – pass or fail	Magnitude of impact	Significance
Cumulative results from Combined Pond and S2 drainage catchments on the Leigh Brook	Fail	Fail	Fail	Fail	Fail	Major Adverse	Very Large

8.10. NPS compliance

8.10.1. Paragraph 5.221 of the NPS NN sets out that where a development is likely to have significant adverse effects on the water environment, assessment of the impacts is required. In line with the NPS NN requirements this chapter of the PEIR ascertains the existing status of and undertakes an assessment of the impacts of the Scheme on, the water environment.

8.10.2. The NPS NN also states that development proposals should have regard to the relevant RBMP and the requirements of the WFD (including Regulation 19) and its daughter directives, including those on priority substances and groundwater, as transposed by the WFD regulations in England and Wales. The PCF Stage 2 WFD Compliance Assessment has been updated and includes an assessment of appropriate design and mitigation measures to facilitate WFD compliance. The WFD assessment will be updated following for the Environmental Statement.

8.10.3. The principles of how developments are to be assessed by the Examining Authority and the Secretary of State with respect to pollution control and other environmental protection regimes are detailed in paragraphs 4.48 to 4.56 of the NPS NN. The key requirements are that any discharges or emissions from a Scheme may be subject to separate regulation under the pollution control framework or other consenting and licensing regimes and relevant permissions will need to be obtained for such activities with permit applications submitted at least six months prior to submission of a DCO.

8.10.4. With regard to flood risk and surface water drainage, the NPS NN supports the NPPF (Department for Communities and Local Government, 2018). In line with the Flood Risk section (paragraphs 5.90 to 5.115) of the NPS NN, the Scheme would require a FRA that considers all sources of flood risk. The ongoing FRA is informed by consultation with the Environment Agency and Gloucestershire County Council as LLFA. The FRA will be informed by the results of the hydrological and hydraulic modelling already undertaken to define baseline flood risk, and underway for the Scheme design. This will quantify any Scheme impacts on the baseline, and inform the design of any necessary flood risk management measures. An FRA has been completed for the Scheme appropriate to stage of design development for this PEIR (Appendix 8.1 – Flood Risk Assessment). The Scheme design has incorporated a drainage strategy that centers on the application of SuDS, appropriate to local conditions, to manage surface water runoff.

8.10.5. The NPS NN encourages pre-application discussions with all relevant regulators to begin as early as possible. Discussions with stakeholders, including the Environment Agency, has already taken place regarding the WFD Compliance Assessment and FRA. These are documented in the consultation section (8.4).

8.11. Assumptions and limitations

Surface water quality

8.11.1. Watercourses within the study area are have been identified through assessment of Ordinance Survey data and background mapping. However, this data may not highlight all of the small agricultural ditches in the area.

8.11.2. The HEWRAT has not been used to complete an assessment for the baseline drainage system. Although the initial results of the routine runoff assessment for surface water quality with the Scheme drainage strategy in place shows failures, this is likely to be a betterment to the existing conditions due to mitigation applied.

8.11.3. Flow data for the receiving watercourse are required to assess the effects of routine runoff on surface water quality. If available, flow data were obtained from The National River Flow Archive (NRFA). The flow gauge on the River Chelt is located approximately 2 km downstream of the existing M5 crossing. The flow information on the NRFA website will be an overestimate of the flows at the sites of interest. Where flow data were not available the assumed flow was taken as 0.001m^3/s or less, which is the lowest flow accepted by the HEWRAT.

8.11.4. The routine runoff assessment for surface water uses two-way Annual Average Daily Traffic (AADT) volumes in the estimation of pollution build-up on the road, where AADT is entered in road bands of 10,000 to 50,000, 50,000 to 100,000 and >100,000 vehicles. If a number of road areas with different band two-way AADT volumes drain to the same outfall the highest band has been used, as a conservative assumption.

Hydromorphology

8.11.5. The limitations noted for surface water quality are also relevant for hydromorphology.

8.11.6. The watercourse features and processes (outlined in detail within the WFD assessment) may vary with time, seasonality, and high flow events. Site surveys were undertaken under relatively dry conditions, and the overall watercourse function and stability were inferred through professional judgement and the interpretation of features on site.

8.11.7. Several sites were not accessible during site visits at PCF Stage 2 site visits due to land access not being granted or health and safety concerns. Where a site visit was not possible, these watercourses have been characterised through desk study using openly available data and professional judgement. The locations which were not seen included:

- Directly downstream of the River Chelt Culvert
- Directly downstream of the Barn Farm Culvert
- Drains 21 and 22
- Drains 20 and 16 around Old Gloucester Road

8.11.8. The detailed design for all structures has not yet been confirmed. Therefore, the potential impacts and mitigation measures for surface water features have been based on some high-level assumptions in places; for example the length of culvert extensions on smaller drainage ditches.

Groundwater

8.11.9. Site specific ground investigation is ongoing. Any assessment of impacts to groundwater have been based on online publicly available data. Assessments of impacts to groundwater will be updated when robust site-specific data are available.

8.11.10. At this stage, no details are known of the below ground structures, therefore, a precautionary approach has been taken to identify all potential impacts and mitigation measures assuming there will be interaction between the structures and groundwater.

Flood risk

8.11.11. This assessment has relied upon the accuracy and level of detail of the new baseline hydraulic model which been reviewed by the Environment Agency. The accuracy of hydraulic modelling is primarily dependent on the quality of hydrological and topographical data, such as LiDAR data. Whilst the baseline model has been calibrated, key factors include the availability observed flow and flood level data.

8.11.12. At this stage, testing of the with-Scheme conditions is ongoing. The Scheme modelling described is based on current design as of July 2021. This is under development and the model will be updated in line with forth coming design development which may change the definitive numbers reported in this assessment, but unlikely to affect the conclusions.

8.11.13. The flood modelling undertaken to date applies a +70% increase in peak flow for 100-years in the future. Future work will take account of the Environment Agency's updated climate change guidance (July 2021) which is in line with UKCP18: a +53% increase in peak flow for the year 2121 will be applied.

8.12. Chapter summary

8.12.1. The spatial scope of the assessment has included features of the water environment within 1 km of the Scheme as a minimum.

8.12.2. The assessment has considered the impacts (both construction and operation) on surface water (quality and hydromorphology), groundwater (quality, levels and flows), and flood risk from rivers, surface water and groundwater.

8.12.3. Key water environment receptors within the study area include:

- The River Chelt: a WFD water body and Main River;
- 13 ordinary watercourses including the Leigh Brook;
- Infrastructure and development in Flood Zones 2 and 3 associated with the River Chelt and the Leigh Brook;
- Cheltenham Sand and Gravel Secondary A aquifer;
- Alluvium Secondary A aquifer;
- Rugby Limestone Member Secondary A aquifer;
- Severn Vale - Secondary Combined WFD groundwater body; and
- Warwickshire Avon - Secondary Mudrocks WFD groundwater body.

8.12.4. At this stage, there is potential significant impact to the water quality of the Leigh Brook and to the River Chelt floodplain. There are additional tests which will be required to understand the actual impact from the Scheme on the Leigh Brook. These include the baseline HEWRAT scenario, spillage assessments and metal bioavailability modelling to determine an appropriate EQS for the watercourse based on toxicity.

8.12.5. The significant adverse effects to the River Chelt floodplain will be mitigated through a series of Right to Flood agreements. These will still result in large impacts, although the intention is that the land owners will have accepted them.

8.12.6. The FRA (Appendix 8.1 – Flood Risk Assessment) and WFD compliance assessment (Appendix 8.2 – WFD Compliance Assessment) have been completed and will be updated following for the Environmental Statement.

8.13. References

BGS, 2020. Geology of Britain Viewer. [Online] Available at: Geology of Britain viewer | British Geological Survey (BGS) [Accessed on 23 March 2121]

CIRIA, 2015. SuDS Manual.: CIRIA.

Department for Communities and Local Government, 2014. National Planning Policy Framework Technical Guidance.

Department for Communities and Local Government, 2018. National Planning Policy Framework.

Department for Transport, 2014. National Policy Statement for National Networks.

DMRB LA 113, 2020. Design Manual for Roads and Bridges - LA 113 Road drainage and the water environment. Vol 1. s.l.: s.n.

DMRB LA 104, 2019. Design Manual for Roads and Bridges – LA 104 [Online] Available at: https://standardsforhighways.co.uk/dmrb/ [Accessed 01 March 2021].

Environment Agency, 2013. Pollution Prevention Guidelines. [Online] Available at: https://webarchive.nationalarchives.gov.uk/20140328090931/http://www.environment-agency.gov.uk/business/topics/pollution/39083.aspx [Accessed 01 March 2021].

Environment Agency, 2017. Groundwater Vulnerability Maps on MAGIC [Online] Available at: Groundwater Vulnerability Maps (2017) on MAGIC - data.gov.uk [Accessed 24 March 2021]

Environment Agency, 2020a. Flood risk assessments: climate change allowances. [Online] Available at: https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances [Accessed 01 March 2021].

Environment Agency, 2020b. Catchment Data Explorer. [Online] Available at: Environment Agency - Catchment Data Explorer [Accessed 24 March 2021].

Environment Agency, 2020c. Protect groundwater and prevent groundwater pollution. [Online] Available at: Protect groundwater and prevent groundwater pollution - GOV.UK (www.gov.uk) [Accessed 03 September 2021].

Environment Agency, 2020d. Flood Map for Planning. [Online] Available at: https://flood-map-for-planning.service.gov.uk/ [Accessed 01 March 2021].

Gloucester City Council, Cheltenham Borough Council, and Tewkesbury Borough Council., 2017. Joint Core Strategy. [Online] Available at: https://www.jointcorestrategy.org/ [Accessed 01 March 2021].

Highways Agency. November 2009. Design Manual for Roads and Bridges. Volume 11. Section 3. Part 10. HD45/09. Road Drainage and the Water Environment

Landmark (2019) Envirocheck Reports.

Tewkesbury Borough Council, 2018. Flood and Water Management Supplementary Planning Document.

The Planning Inspectorate, 2017. The Water Framework Directive. Advice Note Eighteen: The Water Framework Directive,

Williams et al, 1999. The Pond Book: A Guide to Management and Creation of Ponds. 2nd Addition: Freshwater Habitats Trust.

The discipline specific chapters of this PEIR have been produced as separate documents.

9. Landscape and Visual

10. Geology and Soils

11. Cultural Heritage

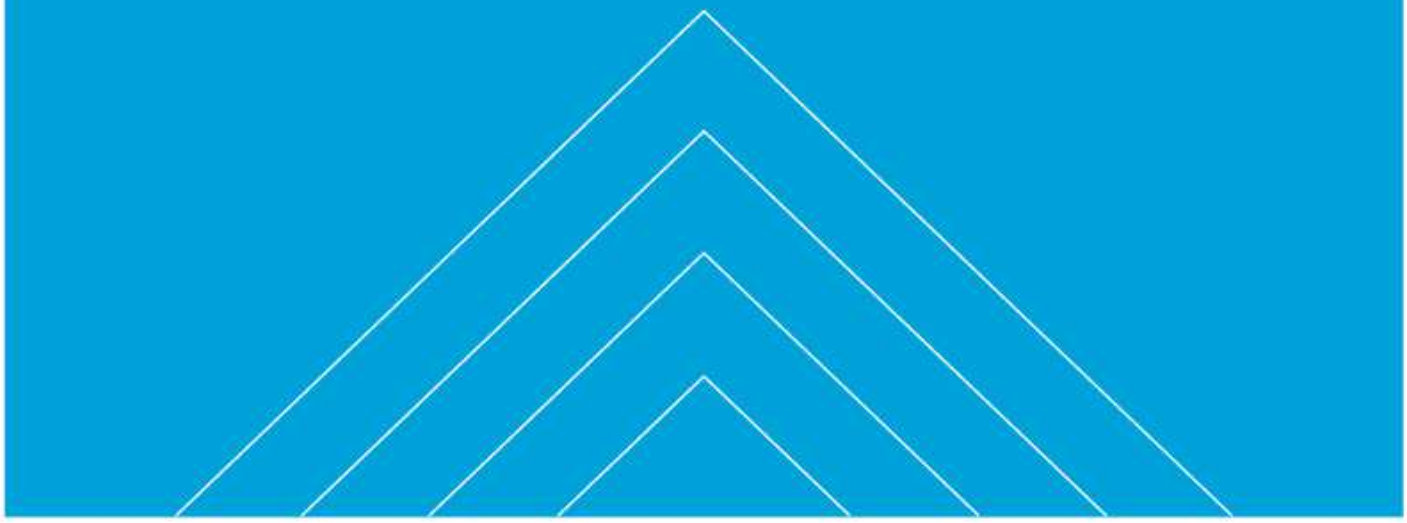
12. Materials and Waste

13. Population and Human Health

14. Climate

15. Cumulative Effects Assessment

Appendices



Appendix 8.1 – Flood Risk Assessment

Executive Summary

Site Name and Address	M5 Junction 10 Improvements Scheme		
Grid Ref	Site centred on SO 904 256	Size of study area	162 ha
Current Use	Mixture of current M5 motorway and farmland	Proposed use	Transport infrastructure, new A4019 highway widening with improved motorway junction and link road

Flood Zone	The proposed road crosses regions of Flood Zone 2 and 3
Vulnerability class	Essential Infrastructure (Motorway and new link roads)
Is it compatible?	Yes, Exception Test required

Application of the Sequential test.	The risk-based Sequential Test is aimed at steering new development to areas at the lowest probability of flooding. The purpose of this Flood Risk Assessment (FRA) is to appraise the proposed Scheme based on the level of flood risk to and from the Scheme. The Scheme interacts with active floodplain of the River Chelt and Leigh Brook and their tributaries. The proposed Scheme is justified by Gloucestershire County Council (GCC) to be located in the locality of the existing M5 Junction 10 area to improve local and national transport links. Although the proposed options cross areas at risk of flooding, the Environment Agency guidance on flood risk and coastal change[1] accepts that Essential Infrastructure may be permitted in Flood Zone 3 where the development passes the Exception Test.

Exception test (Part B)?	Pass	Detailed hydraulic modelling has been undertaken to assess the risk of flooding to the road scheme and nearby receptors. This has ensured that suitable embedded mitigation measures are incorporated by virtue of the flood storage area, compensatory floodplain and culverts through the new Link Road. These measures will safeguard the Scheme with it being designed and constructed to remain operational and safe in times of flood. At this time, without that design and mitigation, the Scheme passes the exception test: *that the development will be safe for its lifetime taking account of the vulnerability of its users, without increasing flood risk elsewhere, and, where possible, will reduce flood risk overall.*

Overview Statement
The Scheme proposes a new motorway junction improvement for the M5 Junction 10, new link road, and road widening for the A4019. The Scheme is classified as Essential Infrastructure and is located within existing Flood Zones 2 and 3 and interacts with the River Chelt and Leigh Brook. As the Scheme is Essential Infrastructure, it is still permittable to be developed in Flood Zones 2 and 3, so long as the Scheme is designed and constructed to remain operational and safe in times of flood. Detailed hydraulic modelling of the Scheme, with calibrated hydrology and a baseline model, indicates that the Scheme will remain safe for use during the design flood, and not cause detriment to 3rd party receptors, except where, by agreement, minor impacts are predicted on surrounding farmland.

[1] https://www.gov.uk/guidance/flood-risk-and-coastal-change

Contents

Tables

Figures

List of abbreviations

Term	Description
ABD	Areas Benefitting from Defences
AEP	Annual Exceedance Probability
BGS	British Geological Survey
CDA	Critical Drainage Area
Flood Zone 1	Area with a low probability of flooding from either rivers or the sea (< 1 in 1,000 annual chance of flooding).
Flood Zone 2	Area with a medium probability of flooding from either rivers (1 in 100 – 1 in 1,000 annual chance of flooding) or the sea (1 in 200 – 1 in 1000 annual chance of flooding).
Flood Zone 3	Area with a high probability of flooding from either rivers (> 1 in 100 annual chance of flooding) or the sea (> 1 in 200 annual chance of flooding).
FRA	Flood Risk Assessment
ha	Hectare
LiDAR	Light Detection and Ranging
m AOD	metres Above Ordnance Datum
NGR	National Grid Reference
NPPF	National Planning Policy Framework
SFRA	Strategic Flood Risk Assessment
SWMP	Surface Water Management Plan
SoP	Standard of Protection
RoFSW	Risk of Flooding from Surface Water

1. Introduction

1.1.1. This flood risk assessment (FRA) identifies if there are any flooding issues related to the M5 Junction 10 Improvements Scheme (hereafter referred to as 'the Scheme' or 'M5J10') which warrant further consideration through the design process.

1.1.2. As an FRA, it provides a site-specific flood risk assessment with an indication of whether the proposed development is located in an area appropriate for the type of development.

1.1.3. This document, as a PEIR FRA is preliminary, and presents the information available at the time of writing. Flood risk assessment work is continuing both in terms of defining impacts to and from the Scheme, and in informing the design development.

1.2. Scheme background

1.2.1. Gloucestershire faces significant challenges to achieve its vision for economic growth. A Joint Core Strategy (JCS) – a partnership between Gloucester City Council, Cheltenham Borough Council (CBC) and Tewkesbury Borough Council (TBC) has been formed to produce a co-ordinated strategic development plan to show how the region will develop during the period 2011 - 2031. This includes a shared spatial vision targeting 35,175 new homes and 39,500 new jobs by 2041. Major development of new housing (c.9,000 homes) and employment land (c.100ha) is proposed in strategic and safeguarded allocations in the west and north-west of Cheltenham, much of which lies within TBC's boundary as the Local Planning Authority. This development, in turn, is linked to wider economic investment, including a government supported and nationally significant 45 ha Cyber Central UK adjacent to GCHQ in West Cheltenham, as part of the Golden Valley Development, which also comprises the Garden Community Development. The Cyber Central UK hub is predicted to support c.7,500 jobs.

1.2.2. Cheltenham currently experiences significant congestion at peak times, which has led to air quality issues at various locations across the town and led to the creation of an Air Quality Management Area (AQMA) within Cheltenham. The existing M5 Junction 10 only provides access and egress to and from the north, with no connectivity to M5 south. This drives existing traffic across Cheltenham through various routes to access and leave the M5 from the south which contributes significantly to existing traffic flows in the town. To unlock the housing and job opportunities, a highways network is needed that has the capacity to accommodate the increased traffic it will generate, within a sustainable transport context.

1.2.3. An all movements junction has been identified as a key infrastructure requirement to enable the housing and economic development proposed by the Gloucestershire Local Enterprise Partnership's (GFirst LEP) Strategic Economic Plan and is central to the transport network sought by the council in the adopted Gloucestershire Local Transport Plan. The planned housing and economic growth have been included in the adopted JCS. National Highways (formerly Highways England (changed August 2021)) also identified that improvements to M5 Junction 10 are a critical requirement to maintain the safe and efficient operation of the M5 corridor in their Birmingham to Exeter Route Strategy, whilst enabling the planned development and economic growth around Cheltenham, Gloucester and Tewkesbury. A Business Case was submitted in March 2019 to Homes England to the Housing Infrastructure Fund (HIF), wherein an investment case was made for the following infrastructure improvements. Funding was successfully awarded by Homes England in March 2020:

- Element 1: Improvements to Junction 10 on the M5 and a new road linking Junction 10 to west Cheltenham from the A4019 to Old Gloucester Road;
- Element 2: A38/A4019 Junction Improvements at Coombe Hill;
- Element 3: A4019 widening, east of Junction 10; and
- Element 4: An upgrade to Arle Court Park and Ride.

1.2.4. Elements 1 and 3 comprise the M5 Junction 10 Improvements Scheme (the Scheme). The upgrade to Arle Court Park and Ride (now known as the Arle Court Transport Hub) and the junction improvements at Coombe Hill were included as part of the package of improvements funded by Homes England. Because they are located some distance from M5 Junction 10 and do not form part of the proposed improvement of the junction, Gloucestershire County Council (GCC) has decided to take these two elements forward as separate packages of work in order to accelerate the programme for these elements, and will deliver them through separate planning strategies.

1.3. Site location

1.3.1. M5 Junction 10 is located 48 miles to the south of Birmingham, 40 miles to the north of Bristol, 5 miles to the south of Tewkesbury, 4 miles to the north-west of Cheltenham, and 8 miles to the north-east of Gloucester.

1.3.2. The junction is in a strategically important location for the region, particularly as northern and western Cheltenham are the sites of a number of large retail parks and employment areas, and the location of planned future housing and nationally significant business development.

1.3.3. The location of M5 Junction 10 is shown in Figure 1-1. The locations of the proposed infrastructure improvements that make up the M5 Junction 10 Improvements Scheme are illustrated in Figure 1-2 below.

1.3.4. A geographical summary of the study area is given in Table 1-1.

Table 1-1 - Site location details

Site centroid grid reference	393494, 232220 for the 1 km study area
Maximum / minimum elevation	155.24 m AOD / 9.92 m AOD
Study area	1.62 km^2
Lead local flood authority	Gloucestershire County
Borough council	Tewksbury County Council
River Basin District	Severn
Management catchment	Severn Vale

1.4. Project Scope

1.4.1. Atkins was appointed by Gloucestershire County Council (GCC) as the designer for the Scheme. The scope was to develop scheme proposals for the following elements of the Scheme which are related to the changes to the strategic road network (and indicated on Figure 1-2).

- An all-movements junction at M5 Junction 10 and a new West Cheltenham Link Road from J10 (element 1);
- Dualling of the A4019 to the East of the Link Road (element 3)

1.4.2. The overall purpose of the Scheme is to improve the highway network around the existing M5 Junction 10 with an overarching aim to ease traffic congestion and to facilitate development in the area.

1.4.3. The A38/A4019 junction improvements at Coombe Hill; and extension to Arle Court Park and Interchange are geographically located away from the M5 Junction 10 improvements and are within Gloucestershire County Council's (GCC) road network. These elements of the Scheme will not be appraised as part of this flood risk work.

Figure 1-1 - Location of the Scheme

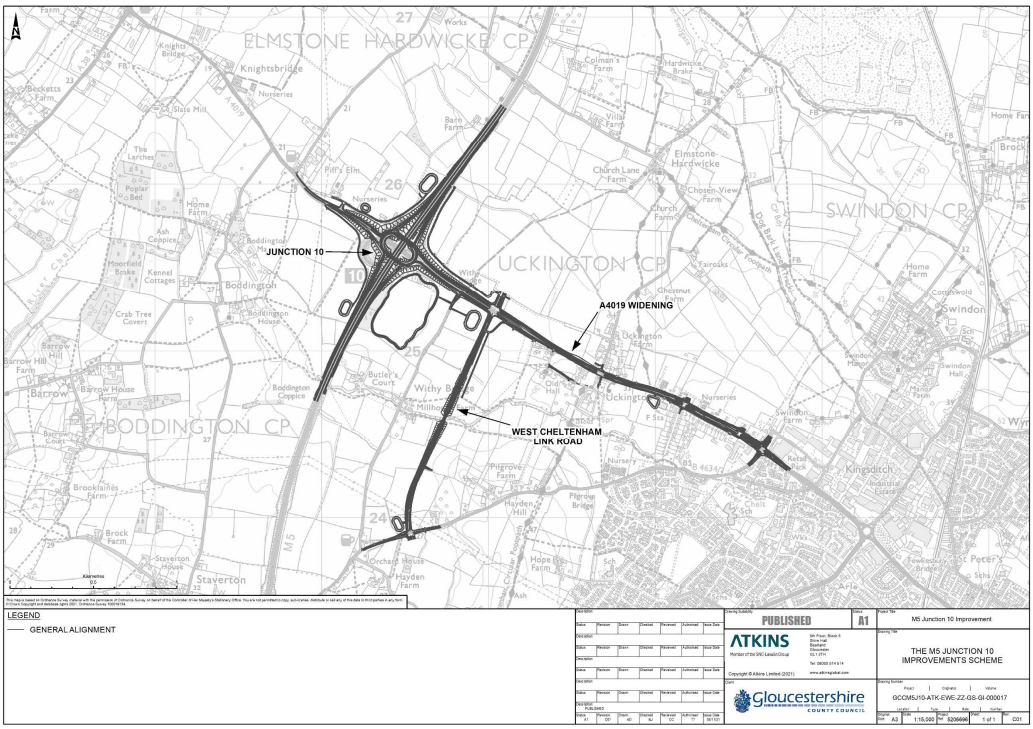


Figure 1-2 - The M5 Junction 10 Improvements Scheme

The proposed development

1.4.4. The Scheme upgrades the M5 Junction 10 and provides a new link road running south from the A4019 to the B4634 Old Gloucester Road (element 1) and widens the A4019 through Uckington (element 3). Element 2 (A38/A4019 Junction Improvements at Coombe Hill) and Element 4 (Upgrade to Arle Court Park and Ride) are not part of this particular project and are the subject of separate planning applications. The following sections describe the different elements of the Scheme.

M5 Junction 10

1.4.5. The improvements to M5 Junction 10 are to increase the capacity of the junction, and to upgrade the currently northbound only junction to an all-movements junction. To enable travel both south and north on the M5, the two existing Junction 10 exit sliproads will be removed, and four new slip roads will be constructed to provide access and egress to the M5 in all directions.

1.4.6. Two new overbridges will be constructed over the M5, centered either side of the existing overbridge (carrying the A4019 over the M5), which will then be demolished. The new overbridges will create a new elongated shaped roundabout junction over the M5. The A4019 will be realigned to provide an appropriate entry angle to the new roundabout. A dedicated route for cyclists and pedestrians will be provided at grade through the junction (see the section below on the A4019 Widening). Extensions will be required for the Piffs Elm and Leigh Brook culverts, that pass under the M5, as a result of the new slip roads. The planned alignment of the new slip roads means that an extension of the River Chelt culvert under the M5 will not be required.

West Cheltenham Link Road

1.4.7. The West Cheltenham Link Road (the 'Link Road') is a proposed new two lane road, with a segregated cycleway and footway, from the B4634 to the A4019. The Link Road is intended to provide greater connectivity between the reconfigured M5 Junction 10 and both the West Cheltenham Strategic Allocation, Safeguarded Land and the Proposed Cyber Park.

1.4.8. The Link Road crosses predominantly agricultural land. The design of the Link Road includes flood relief structures across the floodplain to the north of the River Chelt, and a single span bridge over the River Chelt. The current design of this bridge is a structure that will be set back from the riverbanks (by 4m on each side of the river), and will have a clearance of 2.8m between the underside of the bridge and the top of the river banks.

1.4.9. To connect the Link Road with the existing A4019 (to the north) and the B4634 (to the south), two new junctions will be constructed:

- A4019 - a four-arm signalised junction with the northern arm providing access to the new developments to the north of the A4019, as safeguarded in the JCS. Pedestrian and cycle access over this junction will be incorporated into the signal phasing for this junction. The DF3 design will identify the requirements for pedestrian and cycle crossings at this location.
- B4634 - a new four arm signalised junction is proposed on the B4634 to connect both the Cyber Park and the West Cheltenham Strategic Allocation and Safeguarded Land to the M5 Junction 10 via the Link Road and the A4019. The location of this proposed junction is close to Hayden Hill Farm on the B4634, approximately 300m east of the junction for Withybridge Lane.

A4019 Widening

1.4.10. The A4019 links the M5 Junction 10 to north-west Cheltenham. Currently, the A4019 is a dual carriageway over the M5 Junction, returning to single carriageway east of the junction to serve the turning into Withybridge Lane. The A4019 continues eastwards to Cheltenham as a single carriageway, where it ties into an existing dual carriageway at the Gallagher Retail Park.

1.4.11. The section of the A4019 covered by the Scheme runs from just west of the M5 Junction 10 eastwards through to the existing dual carriageway at Gallagher Retail Park.

1.4.12. As part of the highway improvements incorporated into the Scheme, the A4019 will be widened from Withybridge Lane, eastwards through to the Gallagher Retail Park, where the Scheme will tie into the existing dual carriageway. Widening of the A4019 through Uckington will be to the southern side of the A4019. Widening to the east of Uckington will be to the northern side of the A4019.

1.4.13. Two new signalised junctions will be created on the A4019 (between Uckington and the Gallagher Retail Park) as accesses from the A4019 into the future North-west Cheltenham Development site (also referred to as the Elms Park Development site). Changes will also be made (as part of the Scheme) to the layout of the junction of the A4019 with the B4634 at the eastern end of the Scheme (referred to as the Gallagher junction).

1.4.14. For residents and businesses whose current access is directly onto the A4019 (for example those in Uckington, and along the southern side of the A4019 in north-west Cheltenham), short sections of new access roads will be created alongside the widened A4019 to facilitate ease of access both westbound and eastbound. This includes a new access road connecting Cooks Lane with Moat Lane (to the south of the A4019 at Uckington). The layout and design of these access roads is ongoing and further details will be provided as part of the ES.

1.4.15. The Scheme will include a segregated cycleway and footway adjacent to the A4019, which will extend for the full length of the proposed A4019 widening, and will provide connectivity for pedestrians and cyclists between north-west Cheltenham and the junction of the A4019 and Stanboro Lane (west of M5 Junction 10), where it will connect to an existing footway.

1.4.16. The layout of the Gallagher junction on the A4019 is still under review, and design work is continuing with this junction. At present it is proposed that in the opening year of the Scheme (2025) left and right turns will be possible off the A4019 at this junction (from both a westbound and eastbound direction). However, in order to maintain a necessary flow of traffic along the A4019 in the future, then the right turn options at this junction (from both a westbound and eastbound direction) will be closed in a future year of operation (potentially within six years of opening). The assessment presented in this PEIR has been made on the opening year design. The assessment of other layout options for this junction will be provided in the ES, after the design work has been completed.

1.5. Flood risk scope and context

1.5.1. The Scheme has the potential to increase flood risk and change floodplain dynamics. Detailed hydraulic modelling has therefore been undertaken to:

- understand the baseline flood risk in the area;
- determine the impact of proposed Scheme on flood risk; and
- determine the flood risk to the proposed Scheme.

1.5.2. Reporting of flood risk has been separated into stages to enable individual updates and timely delivery throughout the project. This FRA is described, in the context of this reporting, as:

- a **Baseline Hydraulic Modelling Report**[2] describes the development of a flood model for the baseline associated with the River Chelt and Leigh Brook in the vicinity of the Scheme.
- a **Scheme Hydraulic Modelling Report**[3] reflecting the development and testing of a with-Scheme flood model.
- This **FRA report** documenting the assessment of flood risk for the Scheme in line with regulatory guidelines and requirements.
- The **Preliminary Environmental Information Report**[4] (PEIR) documenting the interim/early environmental impact assessment specifically here in relation to flood risk.
- The **Environmental Statement**[5] (ES) documenting the environmental impact assessment specifically here in relation to flood risk.

[2] Gloucestershire County Council, February 2021, Baseline Hydraulic Modelling Report, GCCM5J10-ATK-WEV-ZZ-RP-LW-000001, Atkins.
[3] Gloucestershire County Council, date TBA 2021, Scheme Hydraulic Modelling Report, ref TBA, Atkins.
[4] Gloucestershire County Council, September 2021, Preliminary Environmental Information Report, GCCM5J10-ATK-WEV-ZZ-RP-LW-000002, Atkins.
[5] Gloucestershire County Council, date TBA 2022, Environmental Statement, ref TBA, Atkins.

1.5.3. This FRA report documents the assessment of flood risk with regards to the National Planning Policy Framework (NPPF). Section 2.2 below describes this policy with regards to flood risk.

1.5.4. The December 2014 National Policy Statement for National Networks[6] (NN NPS) sets out the need for, and Government's policies to, deliver development of nationally significant infrastructure projects (NSIPs) on the national road and rail networks in England. This relates back to the NPPF and guidance from the Environment Agency. Hence this FRA complies with any relevant requirements in the NN NPS.

1.5.5. The purpose of this FRA report is to:

- support the Preliminary Environmental Information Report
- set out the flood risk policy and legislation relevant to this Scheme
- consider all sources of flooding and screen those relevant to the Scheme
- assess the actual flood risk and how it might change over the lifetime of the development
- consider how flood risk may be managed
- describe the residual risks of flooding beyond the design standard.

River Chelt catchment

1.5.6. In its headwaters, the River Chelt's catchment is steep and rural, before it flows into Dowdeswell reservoir, which is managed by Severn Trent Water (STW). The catchment then becomes urbanised as it flows through the town of Cheltenham, which suffered severe flood damage in the summer of 2007.

1.5.7. West of Cheltenham, both the River Chelt and Leigh Brook catchments are low-lying and rural. Both watercourses are culverted under the existing M5 motorway. Downstream of the M5, the channel becomes perched on both the Leigh Brook and the River Chelt with raised embankments separating the farmland from the conveyance channels.

1.5.8. There was previously one gauging station within the study area on the River Chelt (Slate Mill, NRFA number 54026). However, the Slate Mill gauge was decommissioned and removed in 2010 due to its poor quality of data.

PEIR FRA limitations

1.5.9. The main purpose of this PEIR FRA is determined by Regulation 12(2)(b) of the Environmental Impact Assessment (EIA) Regulations 2017, which requires a PEIR to contain information that is 'reasonably required for the consultation bodies to develop an informed view of the likely significant environmental effects of the development (and of any associated development)'.

1.5.10. This PEIR FRA is preliminary and represents the extent of our findings to date. This necessarily reflects the ongoing development of the Scheme. As a consequence, this PEIR FRA is subject to a number of limitations, which are set out below, along with commentary on how these will be addressed in the final FRA supporting the Environmental Statement. Despite these limitations, it is considered that this PEIR version of the FRA presents a sufficient level of assessment to meet the requirements of Regulation 12(2)(b) of the EIA Regulations 2017.

1.5.11. Due to the continual evolution of the Scheme design, the hydraulic modelling that underpins this assessment of fluvial flood risk may not fully match the plans on which the assessment is based. This will be developed for the Environmental Statement.

[6] Department for Transport (December 2014) National Policy Statement for National Networks. Reference ID P2689507 12/14

1.5.12. The assessment of fluvial risk to infrastructure elements is for the 1% annual exceedance probability event (1 in 100-year return period) with climate change scenario, as required by the NPPF. It is acknowledged that less extreme annual exceedance probability events (1 in 2-year, 1 in 5-year, 1 in 10-year, 1 in 25-year and 1 in 50-year return periods), will need to be considered for the final FRA and presented in the Environmental Statement.

1.5.13. Assessments of residual risk arising from exceedance events (i.e. those of greater magnitude than the design event), and from blockage scenarios at the Scheme (culverts etc) are not yet considered. This is due to the need for further design work on these structures to take place before any quantitative model-based assessment can be carried out.

1.5.14. This FRA considers surface water (pluvial) flood risk as based on existing Environment Agency mapping which does not reflect the with-Scheme topography (and thus flow paths). The assessments of with-development risk and effects are therefore qualitative. No direct rainfall modelling has been undertaken for this project, relying instead on overland flooding predicted via detailed fluvial modelling.

1.5.15. This PEIR FRA presents a quantitative appraisal of the risk and effects associated with surface water management and drainage infrastructure. This reflects the current stage of the Scheme design development. Ongoing flood modelling work will provide further quantitative data for the assessment.

Assessing flood risk

1.5.16. An FRA should consider all types of flooding to satisfy the following three key objectives:

- To assess flood risk to the proposed development and to demonstrate that any residual risks to the development and its users would be acceptable;
- To assess the potential impact of the proposed development on flood risk elsewhere and to demonstrate that the development would not increase flood risk elsewhere; and,
- To satisfy the requirements of the National Planning Policy Framework (NPPF) (see Section 2.2).

1.5.17. Flood risk should be considered alongside other spatial planning issues such as transport, housing, economic growth, natural resources, regeneration, biodiversity, the historic environment and the management of other hazards.

1.5.18. CIRIA C624[7] , from 2004, provides guidance on the implementation and good practice in assessing flood risks through the development process. The aim of C624 is to promote developments that are sustainable with regard to flood risk. The document recommends that an FRA should be undertaken in phases so that the type of development corresponds with the detail required.

1.5.19. There are three levels of assessment:

- **Level 1 FRA (Screening Study):** To identify if there are any flooding issues related to a development site which may warrant further consideration. The screening study will ascertain whether a Level 2 or Level 3 FRA is required;
- **Level 2 FRA (Scoping Study):** Undertaken if a Level 1 study indicates that the site may lie within an area which is prone to flooding or that the site may increase flood risk due to increased runoff; and to confirm the possible sources of flooding which may affect the site. The Scoping Study will identify any residual risks that cannot easily be controlled and, if necessary, will recommend that a Level 3 FRA is undertaken. It is typically a qualitative assessment using available data;
- **Level 3 FRA (Detailed Study):** Undertaken if the Level 2 study concludes that quantitative analysis is required to assess flood risk issues related to the development site. This may include detailed hydraulic modelling of rivers or drainage systems.

[7] Lancaster, J.W., Preene, M. & Marshall, C.T. (2004) Development & Flood Risk – Guidance for the Construction Industry. CIRIA publication C624.

1.5.20. This report forms a Level 3 FRA. Hence this report provides a site specific assessment of the risks arising to the Scheme as a result of its location and design. Further quantitative assessment will be made to assess the risk from the Scheme as the flood modelling progresses. Specifically, this report seeks to address the 'key questions':

- Is the site likely to be at risk of flooding from: a watercourse, the sea, an estuary, groundwater, overland flow, an artificial drainage system, infrastructure failure?
- Is the proposed development likely to obstruct the maintenance access requirements or affect the integrity of an existing flood defence?
- Is the proposed development likely to increase flood risk elsewhere due to increased runoff rates and volumes from the site?
- Given the above and the nature of the development, is continued promotion of a possible development at the site appropriate?

1.5.21. The report has been completed in line with the NPPF and makes use of readily available information from the following sources:

- Environment Agency Spatial Data Catalogue (Environment Agency, 2016a)
- Environment Agency online flood map for planning
- Environment Agency online long term flood risk map
- Environment Agency online historical flood map
- LiDAR data for the site obtained from the .Gov website

Consultation and regulatory review

1.5.22. Consultation with the Environment Agency on flood risk has been undertaken. Further details are included in Section 2.3. Similarly, consultation has also been started with Gloucestershire County Council as the Lead Local Flood Authority (LLFA), although principle matters have been dealt with by the Environment Agency.

1.5.23. The Baseline and Scheme models feeding the FRA need to be reviewed by the Environment Agency to ensure that it meets with their approval having adhered to their guidelines, and applies and agrees with their local knowledge of the River Chelt, a designated Main River. This is important, as the Flood Risk Assessment with the Environmental Statement will be used to support of the planning process. Gloucestershire County Council, as Lead Local Flood Authority, will also be asked to review the work, as it includes the Ordinary Watercourse of the Leigh Brook.

2. Flood Risk Policy

This section outlines flood risk planning policy and guidance.

2.1. National planning policy overview

2.1.1. The National Planning Policy Framework[8] (NPPF) is the overarching document in relation to development and flood risk and sets out the Government's policy on development relating to flood risk for planning in England. It was published by the Department for Communities and Local Government (DCLG) in March 2012 and revised on 24 July 2018, 19 February 2019 and 19 June 2019 .

2.1.2. The NPPF is supported by the Planning Practice Guidance (replacing the NPPF technical guidance which was withdrawn from use in March 2014). The Planning Practice Guidance is a web-based resource that was launched by the Department for Communities and Local Government (DCLG, March 2014) to support the NPPF. Guidance relating to flood risk is provided in the Flood Risk and Coastal Change document.

2.1.3. The aim of the NPPF is to ensure that development is not at an unacceptable risk of flooding. Where development is unavoidable in areas at risk from flooding, the NPPF ensures that the development is safe without increasing flood risk elsewhere and where possible reducing flood risk overall.

2.1.4. In accordance with Paragraph 103 of the NPPF, a site-specific FRA is required for development:

- in Flood Zone 2 or 3 including minor development and change of use
- more than 1 hectare (ha) in Flood Zone 1
- less than 1 ha in Flood Zone 1, including a change of use in development type to a more vulnerable class (for example from commercial to residential), where they could be affected by sources of flooding other than rivers and the sea (for example surface water drains, reservoirs)
- in an area within Flood Zone 1 which has critical drainage problems

2.1.5. The FRA must then satisfy five objectives. These are listed below in Table 2-1, along with how this report addresses those objectives.

Table 2-1 - Site-specific Flood Risk Assessment (FRA) objectives

Objective from the NPPF	How the objective is addressed in this FRA
Establish whether a proposed development is likely to be affected by current or future flooding from any source.	Assessment of the existing sources of flood risk to the proposed Scheme.
Establish whether it will increase flood risk elsewhere.	Assessment of the impact on flood risk to third party receptors as a result of development of the Scheme.
Establish whether the measures proposed to deal with these effects and risks are appropriate.	Identification of any mitigation measures to manage the above risks that could be incorporated into the detailed design.
Establish the evidence for the Local Planning Authority to apply (if necessary) the Sequential Test.	Summary of evidence which supports the Sequential Test[9].
Establish whether the development will be safe and pass the Exception Test, if applicable.	Assessment of whether the Exception Test is required and, if required, whether the proposed development meets the requirements of the Exception Test.

[8] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/810197/NPPF_Feb_2019_revised.pdf

[9] Gloucestershire County Council, February 2021, West Cheltenham Link Road Route Corridor Assessment, GCCM5J10-ATK-HSN-L2-TN-CH-000002, Atkins.

2.1.6. The promoter of a development must prove to the Local Planning Authority and the Environment Agency that any existing flood risk or flood risk associated with the proposed development can be satisfactorily managed. The national guidance also requires that assessment of flood risk must be carried out considering the potential impacts of climate change on flooding over the lifetime of the development.

2.1.7. The NPPF assigns a vulnerability classification to land use in terms of its vulnerability to the impact of flooding. The vulnerability types range from water-compatible to essential infrastructure. The vulnerability of the proposed development will dictate the flood risk zones within which it is compatible. The definitions for vulnerability type, and Flood Zone compatibility, is available on the gov.uk website.

Flood zones

2.1.8. The Environment Agency's Flood Map is divided into three separate Flood Zones. These Flood Zones are used by NPPF in determining the appropriateness of proposed developments when considering flood risk through the application of the Sequential Test. They represent the probability of flooding without flood defences in place.

2.1.9. The Flood Zones are defined in Table 2-2 .

2.1.10. The Environment Agency's Flood Map also defines Areas Benefitting from Defences (ABDs) within Flood Zone 3, however this category is not expressly determined within NPPF or the Sequential Test process.

2.1.11. The assessment of Flood Zone for the proposed Scheme is in Section 3.2.

Table 2-2 - Definitions of Environment Agency Flood Zones

Flood Zone	Definition
Flood Zone 1: Low Probability	Land where the annual chance of flooding is lower than 0.1% for either fluvial or sea flooding.
Flood Zone 2: Medium Probability	Land where the annual chance of flooding is between 0.1 and 1.0% for fluvial flooding. Or, land where the annual chance of flooding is between 0.1 and 0.5% for flooding from the sea.
Flood Zone 3a: High Probability	Land where the annual chance of flooding is 1.0% or greater for fluvial flooding. Or, land where the annual chance of flooding is 0.5% or greater for flooding from the sea
Flood Zone 3b: Functional Floodplain	Land where water has to flow or be stored in times of flooding. Local planning authorities identify in their Strategic Flood Risk Assessments areas of functional floodplain and its boundaries accordingly, in agreement with the Environment Agency.

Vulnerability classification

2.1.12. NPPF provides guidance on assessing the vulnerability of land uses in relation to flood risk and classifies new developments into one of five categories. These are described on the. Gov website :

- Essential Infrastructure;
- Water Compatible;
- Less Vulnerable;
- More Vulnerable; and
- Highly Vulnerable.

2.1.13. The assessment of vulnerability for the proposed Scheme is described in Section 4.3.

Compatibility

2.1.14. The table below (Table 2-3) sets out the NPPF flood risk vulnerability and Flood Zone compatibility assessment, as taken from Table 3 of the NPPF Planning Practice Guidance. The definitions for vulnerability type, and Flood Zone compatibility, are available on the gov.uk website.

2.1.15. The table indicates which development types are appropriate within each Flood Zone.

2.1.16. More vulnerable development, for example residential, would be unsuitable for construction in areas at risk from flooding, however water-compatible development types such as water based recreation might be considered acceptable (if the development does not increase flood risk elsewhere).

Table 2-3 - Flood Risk Vulnerability and Flood Zone Compatibility

Flood Zones	Flood Risk Vulnerability Classification				
	Essential Infrastructure	**Highly vulnerable**	**More vulnerable**	**Less vulnerable**	**Water compatible**
Zone 1	✓	✓	✓	✓	✓
Zone 2	✓	Exception Test required	✓	✓	✓
Zone 3a †	Exception Test required †	X	Exception Test required	✓	✓
Zone 3b *	Exception Test required *	X	X	X	

✓ Development is appropriate X Development should not be permitted

† In Flood Zone 3a essential infrastructure should be designed and constructed to remain operational and safe in times of flood.

* In Flood Zone 3b (functional floodplain) essential infrastructure that has to be there and has passed the Exception Test, and water-compatible uses, should be designed and constructed to:

- remain operational and safe for users in times of flood;
- result in no net loss of floodplain storage;
- not impede water flows and not increase flood risk elsewhere.

2.1.17. The assessment of Flood Zone compatibility for the proposed Scheme is described in Section 4.3.

Sequential test

2.1.18. The Sequential Approach is a simple decision-making tool designed to ensure that areas at little or no risk of flooding are developed in preference to areas at higher risk.

2.1.19. The NPPF states that the risk-based Sequential Test should be applied at all stages of planning. Its aim is to steer new development to areas with the lowest probability of flooding. Development should be directed to Flood Zone 1 wherever possible, and then sequentially to Flood Zones 2 and 3, and then to the areas of least flood risk within Flood Zones 2 and 3.

2.1.20. The Sequential Test is a key component of the hierarchical approach to avoiding and managing flood risk. It is a decision making tool designed to ensure that sites at little or no risk of flooding are developed in preference to areas at higher risk. The Sequential Test can be applied at a number of levels – from Local Authority Planning decisions to site specific flood risk assessments:

- Local Authority level – the Sequential Test will assist in the defining of development zones, seeking to locate all new development to Flood Zone 1. If a development zone was selected that was in a higher flood risk zone, there would be a requirement to demonstrate that there are no less vulnerable sites available to accommodate the development, and that the development provides wider sustainability benefits which outweigh the risk from flooding (the Exception Test).
- Site Specific level – A Sequential approach should also be applied on a site specific basis, providing a tool to ensure the correct placement of development. Consideration of flood risk at the earliest opportunity in the planning process will enable the location, layout and design of the development to deliver maximum reductions in flood risk.

2.1.21. Appendix A.1 provides information relating to application of the Sequential Test for this Scheme. Section 4.3 provides information relating to application of the Sequential Test with regards to flood risk.

Exception Test

2.1.22. The Exception Test should be informed by a strategic or site-specific flood risk assessment, depending on whether it is being applied during plan production or at the application stage. For the Exception Test to be passed it should be demonstrated that:

- the development would provide wider sustainability benefits to the community that outweigh the flood risk; and
- the development will be safe for its lifetime taking account of the vulnerability of its users, without increasing flood risk elsewhere, and, where possible, will reduce flood risk overall. This report is the first stage in this process

2.1.23. Both elements of the Exception Test should be satisfied for development to be allocated or permitted.

2.1.24. Appendix A.2 provides information relating to application of the Exception Test. Section 4.3 provides information relating to application of the Exception Test with regards to flood risk.

Climate Change

2.1.25. The NPPF sets out how the planning system should help minimise vulnerability and provide resilience to the impacts of climate change. This includes demonstrating how flood risk will be managed now and over the development's lifetime, taking climate change into account. Local planning authorities refer to this when preparing local plans and considering planning applications.

2.1.26. Climate change allowances are predictions of anticipated change for: peak river flow; peak rainfall intensity; sea level rise; offshore wind speed and extreme wave height. They are based on UK climate change projections. There are different allowances for different epochs or periods of time over the next century.

2.1.27. In July 2021 the Environment Agency updated its climate change guidance (described in 0 and 2.1.29 below) in line with the UKCP18 data. This has resulted in a downgrade of the climate risk profile for the Scheme and a decrease in the required peak river flow allowances: the guidance no longer requires applying an Upper End climate change allowance (which was +70% increase in flow) but now recommends using a Higher Central climate change allowance (which is now +53% increase in flow). However, the modelling results at the time of writing applied +70% increase in peak flows, and so this former (now precautionary) allowance has been used in this PEIR FRA, ensuring consistency and true comparison to the baseline assessment. As a result, this assessment uses higher flood flows than will be described in the final FRA supporting the Environmental Statement.

2.1.28. A range of allowances is provided based on percentiles. A percentile is a measure used in statistics to describe the proportion of possible scenarios that fall below an allowance level. The 50th percentile is the point at which half of the possible scenarios for peak flows fall below it and half fall above it. The:

- Central allowance is based on the 50th percentile
- Higher Central allowance is based on the 70th percentile
- Upper End allowance is based on the 90th percentile

2.1.29. An allowance based on the 50th percentile is exceeded by 50% of the projections in the range. At the 70th percentile it is exceeded by 30%. At the 95th percentile it is exceeded by 5% of the projections in the range.

2.1.30. The flood risk vulnerability classification (above and Section 4.3) is used to decide which allowance applies to the development, be it the Central, Higher Central or Upper End allowances.

2.1.31. The Environment Agency advice includes climate change requirements for the sizing of compensatory floodplain. Compensatory floodplain storage is proposed with this Scheme due to the loss in available floodplain caused by the alignment of the relief road and the raising of road levels above the current floodplain.

2.1.32. An explanation of the climate change allowances applied to this project is given in Section 4.4 below.

Design flood

2.1.33. The National policies focus attention on the Design Flood. This is a flood event of a given annual flood probability, which is generally taken as:

- fluvial (river) flooding likely to occur with a 1% annual exceedance probability event (1 in 100-year return period) or;
- tidal flooding with a 0.5% annual exceedance probability event (1 in 200-year return period), against which the suitability of a proposed development is assessed and mitigation measures, if any, are designed.

2.1.34. These annual probabilities must be designed for over the lifetime of the development, and hence must include for the impacts of climate change. See above, and Section 4.4.

2.1.35. Whilst the various engineering elements for the Scheme are based on different life expectancies (traffic using a 15 year growth prediction, surfacing designed for 20 years, and structural elements for 120 years) the true period of time the works are anticipated to be in existence is in excess of 100 years. This is because they will serve the planned residential and commercial developments around the existing Junction 10 site.

The design flood for this Scheme is the 1% annual exceedance probability event (1 in 100-year return period) with allowance for climate change.

2.2. Ministerial Statement (HCWS161)

2.2.1. Paragraph 103 of National Planning Policy Framework has been updated to give priority to the use of sustainable drainage systems. The requirements of the policy are set out in the Written Ministerial Statement (HCWS161), whereby all ‘major’ planning applications being determined from April 2015 must consider sustainable drainage systems. As a national infrastructure project passing through the Development Consent Order process, the Scheme is by definition Major development. Consequently, a drainage strategy that considers the SuDS is required.

2.2.2. Approved document Part H of the Building Regulations 2010 defines the hierarchy for disposing of surface water as follows:

- Discharge to the ground (for example using soakaways). Where the intention is to discharge to the ground it must be shown to be feasible through an assessment carried out under the Building Research Establishment Digest 365 (BRE 365).
- Discharge to a surface water body (for example a river or lake).
- Discharge to a surface water sewer, highway drain, or another drainage system. Discharge to a combined sewer.

2.2.3. The Lead Local Flood Authority in the study area is Gloucestershire County Council.

2.3. Environment Agency advice

2.3.1. The Environment Agency advice for a flood risk assessment are available at: https://www.gov.uk/guidance/flood-risk-assessment-for-planning-applications.

2.3.2. Consultation with the Environment Agency on flood risk has been undertaken. At this stage, the consultation has included:

- Telephone meeting 7 August 2019
- Telephone meeting 17 January 2020
- Telephone meeting 9 February 2021
- Telephone meeting 29 April 2021

2.3.3. The Environment Agency was supplied with a copy of the baseline model and its accompanying report for review. This model and the hydrology was reviewed by external consultants on behalf of the Environment Agency (14 April 2021).

2.3.4. Consultation has also been undertaken with Gloucestershire County Council as the Lead Local Flood Authority (LLFA).

2.4. Local planning policy overview

Joint Core Strategy

2.4.1. The adopted Joint Core Strategy (JCS) is a strategic development plan that has been prepared through a partnership between Gloucester City Council, Cheltenham Borough Council and Tewkesbury Borough Council. The JCS provides a co-ordinated strategic plan for this joint administrative area during the period up to the year 2031. The JCS has an extensive and up-to-date evidence base, including Strategic FRAs which provide a detailed assessment of multiple flood sources for specific broad locations within the JCS area.

2.4.2. Whilst the JCS provides the strategic level policies for development in the area, this will be supplemented at individual district level by locally specific plans. In Tewkesbury Borough, the council has begun preparation of the Tewkesbury Borough Plan, which is at a relatively early stage of development.

Supplementary Planning Document

2.4.3. The Flood and Water Management Supplementary Planning Document[10] details guidance on the approach that should be taken to manage flood risk and the water environment as part of new development proposals. The SPD highlights the documents which will be required to accompany planning applications including site specific FRAs and Drainage Strategies (incorporating an appropriate approach to surface water drainage including suitability evidence).

[10] Tewkesbury Borough Council (2018), Flood and Water Management Supplementary Planning Document

2.4.4. The SPD restates the definition of a 'Design Flood' as, "the fluvial flood level likely to occur with a 1% annual probability, or 0.5% tidal, plus climate change allowance, should be used to inform the sequential approach, including appropriate location of built development; consideration of flood risk impacts, mitigation/enhancement and ensure 'safe' development."

2.4.5. The document requires an assessment of the 1% annual probability flood event, with 70% allowance added to 'peak river flows' to account for climate change. For surface water drainage design it advocates the same allowance when sizing attenuation storage [70%] but as a minimum, a 40% allowance [on rainfall] to be made as per Environment Agency guidance for the 'upper estimate' in their [2011] 'Adapting to Climate Change' document…"

Gloucestershire standing advice

2.4.6. The Standing Advice and Development Guidance by Gloucestershire County Council Lead Local Flood Authority advises that, "*the National Planning Policy Framework (NPPF) and accompanying Technical Guidance (TG) provides guidance on the consideration of flood risk. It includes information on climate change (Section 10 of NPPF and para. 11 of TG).*" Note that the references here are out of date and do not reflect the right paragraphs in the current published material.

2.4.7. The remainder of the guidance is written around drainage design. Contrary to the SPD it only requires attenuation feature to be designed for flows up to and including the 1 in 100 year event + 40% for climate change.

2.5. LLFA advice

2.5.1. LLFA officers from Gloucestershire County Council, have been consulted with in relation to the flood modelling and concept development for the Scheme.

2.5.2. Specific consultation with the LLFA on flood risk has been undertaken on:

- Telephone meeting 17th September 2020
- Telephone meeting 14th May 2021

3. Sources of Flooding

The NPPF states that all types of flooding should be considered in the development framework. The extent to which these should be considered will vary and depends on whether they are considered as significant at the spatial planning scale, and in setting constraints on development in certain areas. This section of the report assesses the risk of flooding to the proposed development and identifies those sources of flooding that require further consideration.

3.1. History of flooding

3.1.1. Past evidence of flooding at or near the site helps to reinforce flood risk information provided by the Risk Management Authorities (RMAs). For example, the fact that the site has been reported to have flooded twice in the last 50 years, even if the actual flood levels and flows are unknown, is useful and can be used as a broad 'sensibility' check on any modelling results. However, the fact that a site has not flooded, even for the last 50 years (for example) is not in itself evidence that it will not flood.

3.1.2. The Environment Agency holds a GIS dataset containing historic flood risk information. This dataset has been interrogated to establish if the proposed development site has been identified as flooding in the past. The figure below, Figure 3-1, shows the historical flooding outline in the vicinity of the proposed Scheme.

3.1.3. The data shows previously occurring flooding associated with the River Chelt. Much of this data is referenced as being from July 2007. The historic flood outline shows flooding:

- from the River Chelt to the west of the M5 motorway, covering the farmland as far as the existing Junction 10 of the M5 motorway;
- upstream of the River Chelt culvert under the M5 and the fields alongside the river to the east; and
- of the Moat residences in Uckington.

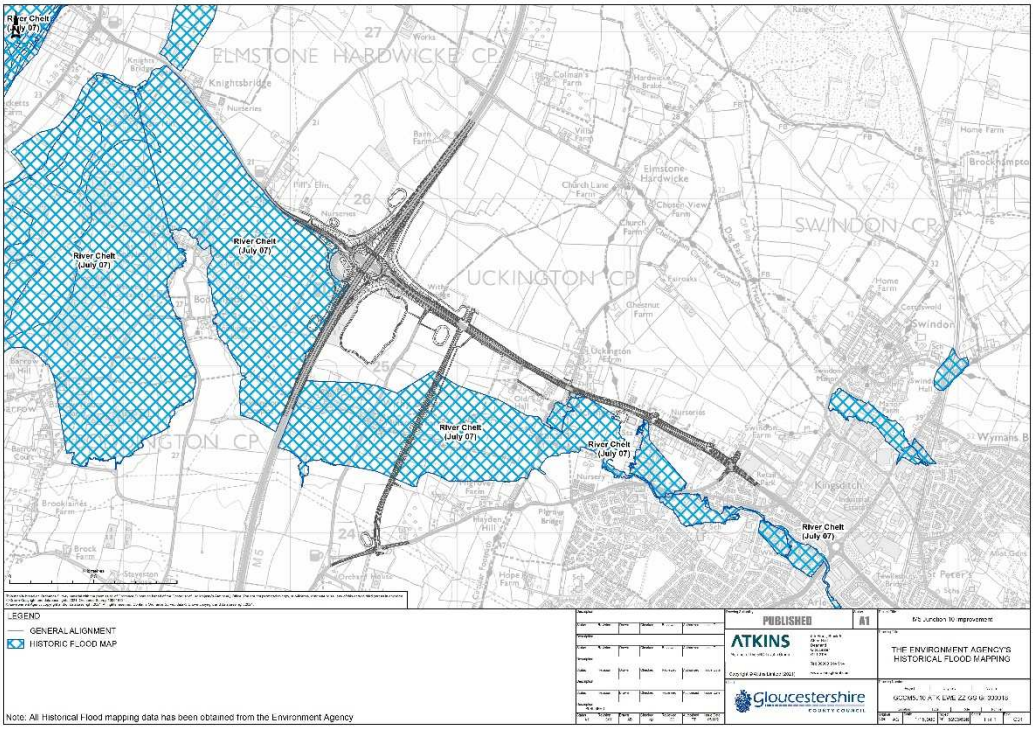


Figure 3-1 - EA Historical flood mapping

3.1.4. Flooding of this area in July 2007, and at other times, was also recorded by local landowners. During the project we have engaged with local landowners to validate the assessment of risk based on their observations and anecdotal evidence.

3.1.5. The Cheltenham Surface Water Management Plan[11] reports, "*The summer of 2007 represented one of the most significant flooding incidents across England, and significant flooding occurred throughout Cheltenham. The June flood has been assessed as having a 1.33% (or 1 in 75 year) probability of occurring in any year.* ***The July flood has been assessed as having less than 0.8% (or 1 in 125 year) likelihood of occurring in any year****. Property flooding occurred in Cheltenham from surface water, the River Chelt and other rivers, including Hatherley Brook and Wymans Brook...*".

3.2. Flooding from rivers

3.2.1. Flooding from rivers (fluvial flooding) occurs following exceedance of the flow capacity of river channels, leading to overtopping of the riverbanks and inundation of the surrounding land.

3.2.2. The Environment Agency Flood Map for Planning identifies Flood Zones, ignoring the presence of defences. Flood Zone 1 has the lowest probability of flooding from the rivers or sea, whereas Flood Zone 3b has the highest probability of flooding[12] . The Figure below (Figure 3-2) indicates that both route options associated with the Scheme cross Flood Zone 3 and Flood Zone 2.

3.2.3. The Environment Agency map for Flood Risk from Rivers or the Sea identifies the probability of river and sea flooding, accounting for the presence of defences.

- Low risk means that each year this area has a chance of flooding of between 0.1% and 1%.
- Medium risk means that each year this area has a chance of flooding of between 1% and 3.3%
- High risk means that each year this area has a chance of flooding of greater than 3.3%.

3.2.4. The Environment Agency flood map for planning is shown below in Figure 3-2 below. This flood map was updated in November 2020, indicating a much smaller Flood Zone related to the River Chelt on the west of the M5 motorway.

3.2.5. The Environment Agency flood map for planning indicates that the Scheme will cross areas of Flood Zone 3 and 2. This relates to the link road which crosses the River Chelt, and the improvement works at the motorway junction.

3.2.6. The land to the north of the A4019, alongside the Leigh Brook, is identified within Flood Zone 1. However, this relates to the Ordinary Watercourse and it is likely that no flood mapping has been undertaken for that area.

3.2.7. Significant areas of land just south of the A4019 and east of the M5 motorway are classified as Flood Zone 2 and 3. These floodplain areas are associated with the River Chelt. Part of the residential area at Withybridge Gardens, is classified as Flood Zone 3, although some is predicted in Flood Zone 1. To the south of the River Chelt, the floodplain is less extensive and most of the land is identified as Flood Zone 1.

3.2.8. Land to the west of the M5 J10, including the hamlets of Knightsbridge, Coombe Hill and Boddington, is classified as Flood Zone 2 with narrower areas under Flood Zone 3.

[11] Gloucestershire County Council (December 2011). Cheltenham Surface Water management Plan. Halcrow & Richard Allitt Associates

[12] The Flood Zones shown on the Environment Agency's Flood Map for Planning (Rivers and Sea) do not take account of the possible impacts of climate change and consequent changes in the future probability of flooding.

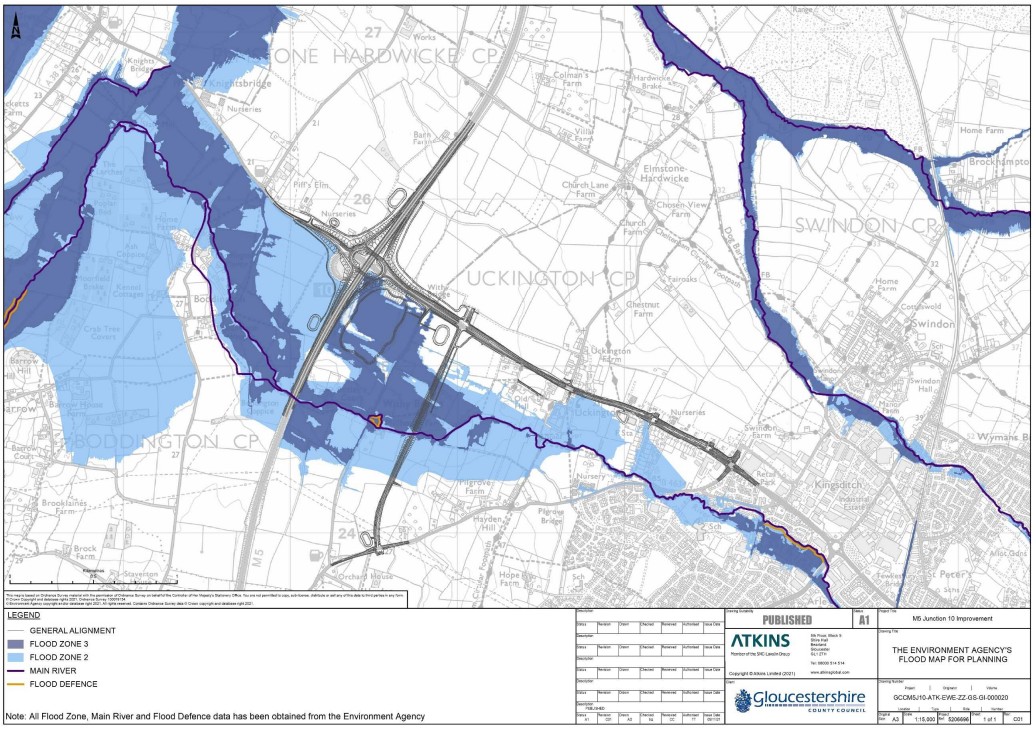


Figure 3-2 - Environment Agency flood map for planning

3.2.9. The following table quantifies the Scheme footprint by Environment Agency Flood Zone.

Table 3-1 - The Scheme and Environment Agency Flood Zones

Note that the Environment Agency Flood Zones do not reflect the full extent of flooding.
Scheme footprint based on Design Fix 2.3 design in August 2021.

Flood Zone	Footprint of the Scheme
1	336,818 m^2
2	62,161 m^2
3	39,021 m^2
Total	438,000 m^2

The Scheme crosses Environment Agency Flood Zone 3 and 2

3.2.10. The Environment Agency's Flood Risk from Rivers or the Sea mapping (Figure 3-3) indicates a similar pattern of flooding, although reflects the risk west of the M5 as per the former Environment Agency flood map for planning.

3.2.11. The flood risk from the River Chelt to Boddington and the surrounding area was modelled by Edenvale Young Associates[13]. This work was undertaken to challenge the published Environment Agency flood map, and was subsequently approved by the Environment Agency. The work (identified a much greater floodplain to the east of the M5 motorway with floodwater being held behind the highway embankment. The work also identified areas of flood risk associated with the Leigh Brook, showing large areas at risk of flooding in the 1% annual exceedance probability event (1 in 100-year return period).

3.2.12. Flood risk from the River Chelt and Leigh Brook has been identified as a major consideration in this area by the Environment Agency.

The Scheme crosses areas at a high risk of fluvial flooding

[13] Edenvale Young, 2019. Boddington Model Report - Flood map challenge.

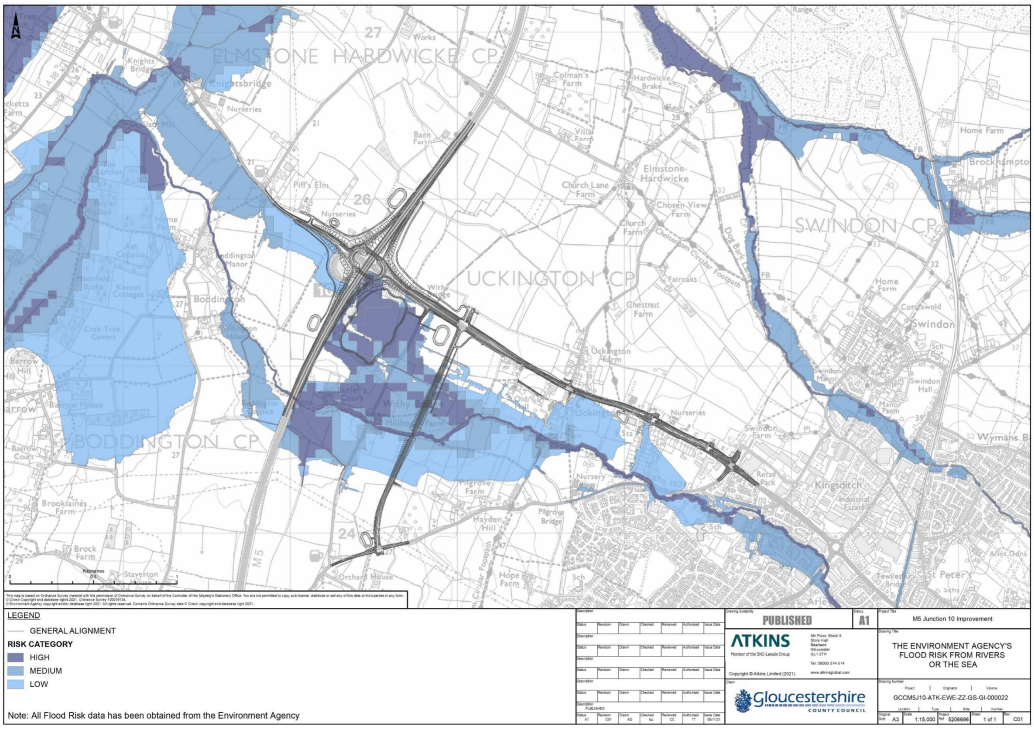


Figure 3-3 - Flood Risk from Rivers or the Sea

3.3. Flooding from surface water

3.3.1. The presence of a Critical Drainage Area alone would indicate that a detailed FRA was required. Surface water flooding (sometimes referred to as pluvial flooding) can be caused by overland flow / runoff, and includes water flowing over the ground that has not reached a natural or artificial drainage channel. This can occur when intense rainfall exceeds the infiltration capacity of the ground because rainfall has fallen on ground so highly saturated that it cannot accept any more water.

3.3.2. Surface water flooding can also be caused when intense rainfall exceeds the surface water drainage capacity in an urban area, such that ponding and overland flow occurs. This can also be referred to as surface water sewer flooding. Surface water flooding can be caused by water originating from either on-site or from adjacent sites.

3.3.3. The Environment Agency's map showing the Risk of Flooding from Surface Water (Environment Agency, 2020) categorises it into a Low, Medium and High category.

- Low risk means that each year this area has a chance of flooding of between 0.1% and 1%
- Medium risk means that each year this area has a chance of flooding of between 1% and 3.3%.
- High risk means that each year this area has a chance of flooding of greater than 3.3%.

3.3.4. The mapping, shown on Figure 3-4, indicates medium and high flood risk (i.e. 1% to 3.33% Annual Exceedance Probability (AEP) events respectively) in areas immediately north-east and south-east of the M5 Junction 10, with the highest risk located against the motorway embankment. In particular, surface water appears to pond along the north-east border of the M5 Junction 10 southbound off slip road and extend approximately 750 m north from the junction. This ponding is shown to affect properties on the north bank of the Leigh Brook.

3.3.5. An area of low to high surface water flood risk (0.1% to 3.33% AEP) is located at the M5 motorway crossing of the River Chelt, approximately 800 m south from the M5 Junction 10. Surface water is shown to pond within this area, sitting beside the motorway off either bank and extending south to the unnamed watercourse that passes through the Staverton culvert. This flooding affects several residential properties at Butlers Court.

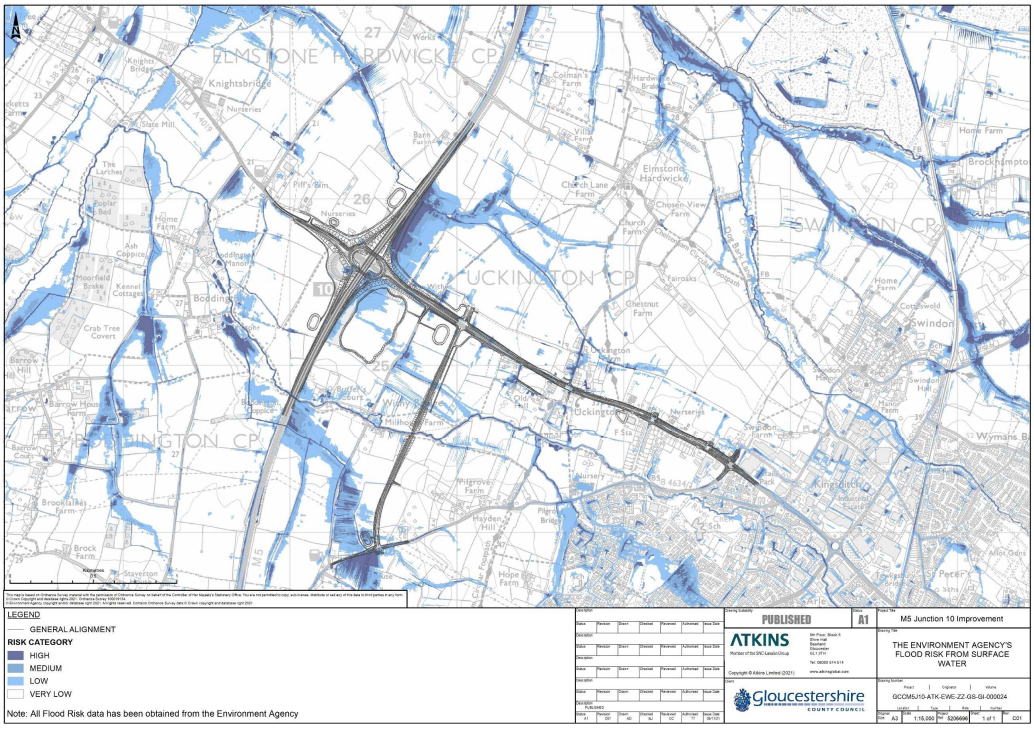


Figure 3-4 - Environment Agency Risk of Flood from Surface Water mapping

Parts of the Scheme are at high risk from surface water flooding.

3.4. Flooding from the sea

3.4.1. Inundation by high tides, storm surges and waves along coastal regions is described as coastal flooding. The propagation of high tides and storm surges up estuarine channels can lead to overtopping of the river banks and inundation of the surrounding land. This is referred to as tidal flooding.

3.4.2. The study area is located over 9 km from the nearest tidal watercourse (the River Severn at Gloucester), and is not at risk of flooding from the sea.

The Scheme is outside a Flood Zone associated with coastal/tidal flooding

3.5. Flooding from groundwater

3.5.1. Emergence of groundwater at the surface (and subsequent overland flows) or into subsurface voids as a result of abnormally high groundwater levels is referred to as groundwater flooding. This can have a direct impact on buildings and buried services, as well as an indirect impact by increasing infiltration of groundwater into sewers and soakaways (reducing their capacity to convey surface water runoff).

3.5.2. According to the 1:50,000 mapped geology (BGS, 2020[14]), there is moderate superficial deposit coverage, consisting of Alluvium and Cheltenham Sand and Gravel. The eastern portion of the study area is largely underlain by the Charmouth Mudstone Formation bedrock with the western portion underlain by the Rugby Limestone Member.

3.5.3. Lithological descriptions of both superficial and bedrock geology and a generalised geological sequence are provided in Table 3-2 below. Further detail particularly regarding made ground, soils and local geology can be found in PEIR Chapter 10 (Geology and Soils).

Table 3-2 - Generalised geological sequence for the Scheme

Period	Formation / Sub-unit	Lithological Description (BGS, 2020)	Environment Agency Aquifer Designation (EA, 2020b)
Quaternary	Cheltenham Sand and Gravel	Fine-medium grained of quartroze sand with seams of poorly sorted limestone gravel.	Secondary A
	Alluvium	Unconsolidated clay, sand and silt.	
Triassic	Charmouth Mudstone Formation	Dark grey laminated shales, blue/grey mudstones with local concretions and argillaceous limestone beds with some sandy layers at the base of the stratigraphy.	Secondary Undifferentiated
	Rugby Limestone Member	Grey argillaceous mudstones and limestones.	Secondary A

3.5.4. The study area is underlain by Secondary A and Secondary (undifferentiated) bedrock aquifers (Environment Agency, 2020b). These bedrock aquifer designations are associated with the Charmouth Mudstone Formation and the Rugby Limestone Member. The Scheme is also underlain by discreet areas of Secondary A superficial aquifer associated with the Alluvium and Cheltenham Sand and Gravel. Secondary A aquifers are defined as “permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers”. Secondary B aquifers are defined as “predominantly lower permeability layers which may store and yield limited amounts of groundwater due to localised features such as fissures, thin permeable horizons and weathering”. Secondary (undifferentiated) aquifers are assigned by the EA where it has not been possible to attribute either category A or B to a rock type.

3.5.1. Site specific ground investigations are ongoing, Therefore the baseline conditions have been identified using online publicly available data. When site specific groundwater data become available these will be incorporated into the groundwater flood risk assessment.

3.5.2. The BGS susceptibility to groundwater flooding maps show that the Scheme is at high to medium-high risk of groundwater flooding.

The proposed development is at medium risk from groundwater flooding

[14] British Geological Survey (BGS). Geology Of Britain Viewer [online]. Available at: https://mapapps.bgs.ac.uk/geologyofbritain/home.html [Accessed 02 October 2020].

3.6. Flooding from sewers

3.6.1. Flooding from sewers (open or culverted) is caused by exceedance of sewer capacity and / or a blockage in the sewer network. In areas with a combined sewer network system there is a risk that land and infrastructure could be flooded with contaminated water. In cases where a separate sewer network is in place, sites are not sensitive to flooding from the foul sewer system. Sewer flooding can occur for a number of reasons including blockage or localised infrastructure failure.

3.6.2. National Highways Drainage Data Management System (HEDDMS) has records of eight flood events occurring on the motorway and trunk roads in the area of the M5 J10 since 2011. These flood events typically occur in late summer/autumn (August to November), and vary in severity with a rating of 0 to 7 (where 10 is the maximum flood severity). The flood events are shown in Figure 4.10.5. The A4019 within the study area has been classified with a 'very low' flood hotspot status. The status of flood events is shown in Figures Figure 3-5 and Figure 3-6 below.

3.6.3. According to the Strategic Flood Risk Assessment[15] , the study area is considered to have a low level risk of flooding from sewers. Mapping of historical incidents of sewer flooding the vicinity of the Scheme (as mapped in the SFRA) has been obtained from Gloucestershire County Council.

3.6.4. It is not known whether there are other sewers within the study area; no records of sewer flooding have been seen. However, the risk of sewer flooding in this rural location is low.

3.6.5. Given the low number of incidents shown, it is considered likely that previous incidents on the M5 motorway were due to a localised problem rather than a wider capacity issue. The risk of sewer flooding impacting on users of the proposed Scheme is therefore considered to be negligible. Furthermore, detailed drainage work is being undertaken for the Scheme which will comply with the relevant statutory and local requirements.

The proposed development is not risk from sewer flooding

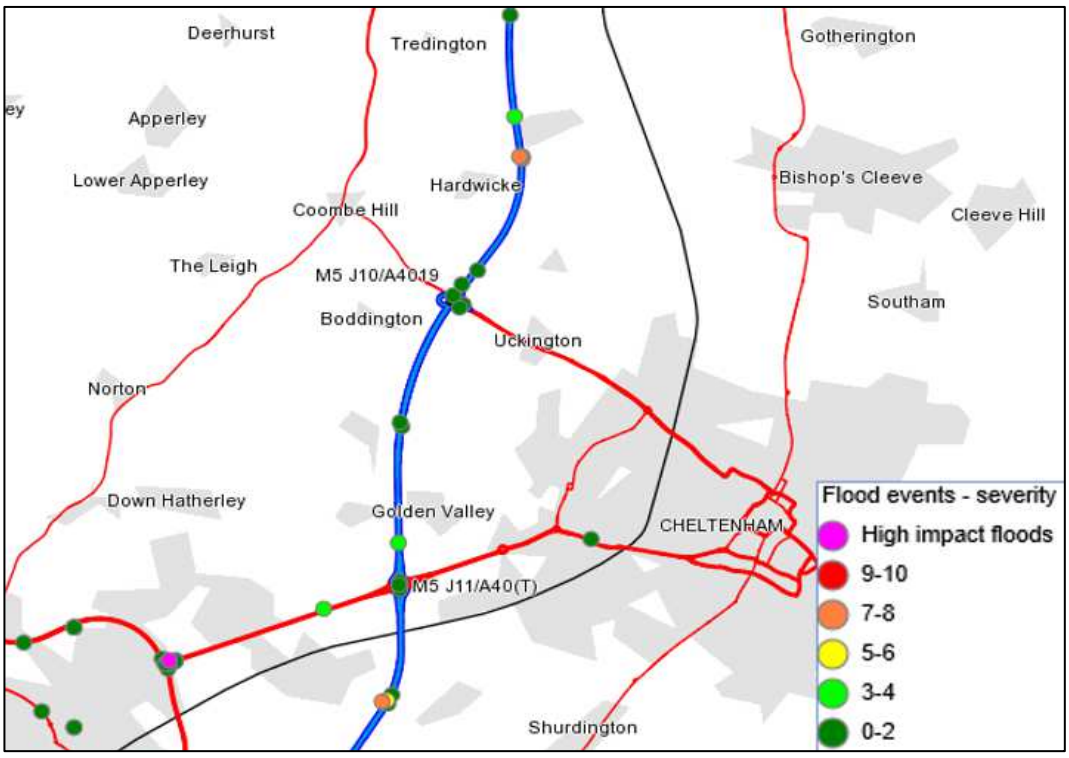


Figure 3-5 - National Highways DDMS Flood Events Severity

[15] Cheltenham Borough Council (2008) Strategic Flood Risk Assessment, Halcrow Group Limited

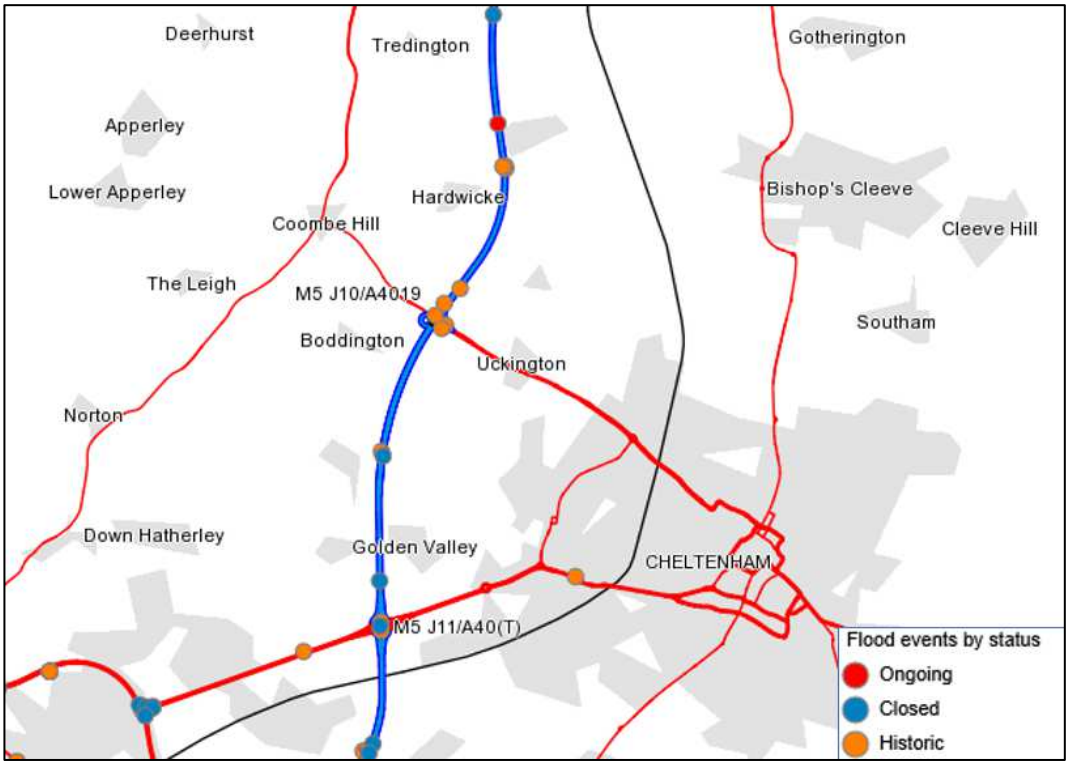


Figure 3-6 - National Highways DDMS Flood Events by Status

3.7. Flooding from other sources

Flooding from water transmission infrastructure

3.7.1. Flooding from water transmission infrastructure is caused by a blockage, failure or generally an under-capacity system. Water companies are required to report on the current number of properties in their areas at risk of flooding within the DG5 register.

3.7.2. It is assumed that Severn Trent Water, as sewerage and water undertaker in this area, manage the potential failure of their systems to an acceptable level and hence the flood risk from water transmission infrastructure is considered low.

3.7.3. Nevertheless, the location of water transmission infrastructure will be determined prior to commencement of the works. If water transmission infrastructure is located in this area, the construction method statement will propose an approach to ensure no impact on this existing infrastructure.

Flooding from reservoirs

3.7.4. The Environment Agency's Flood risk from Reservoirs map (Figure 3-2) indicates that the study area is at risk of flooding from the Dowdeswell reservoir, should the dam fail. This reservoir is located approximately 10 km to the south west of M5 Junction 10, on the eastern side of Cheltenham. This artificial waterbody is regulated by the Reservoirs Act 1975, and as such the risk of breach (dam failure) is very low.

The proposed development is not at risk from flooding by reservoir failure

3.7.5. It should be noted that whilst this published map, and the above flood data, indicates that the M5 motorway impounds floodwater from the River Chelt and Leigh Brook, that the floodplain is not described as a large, raised reservoir under the Reservoirs Act 1975. Existing road embankments are exempt from the Act unless actions are undertaken to impound additional volumes. The implications of the Reservoirs Act is discussed in this FRA.

The proposed development is not at risk from water transmission infrastructure

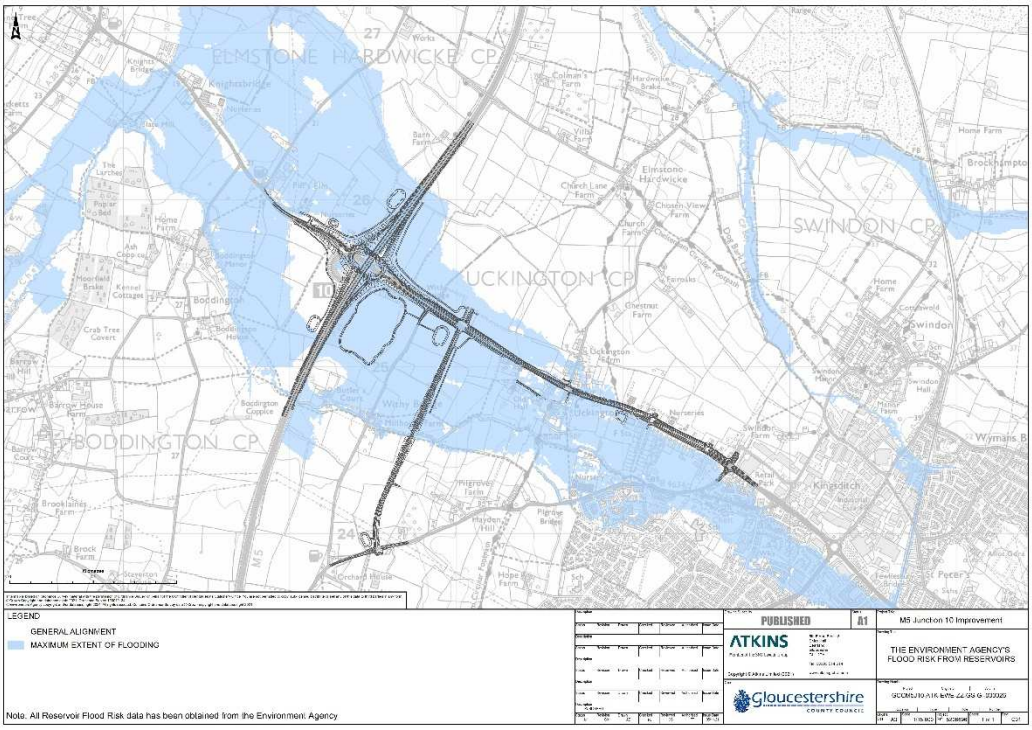


Figure 3-7 - Environment Agency Risk of Flood from Reservoirs mapping

Flooding from canals

3.7.6. There are no canals in the vicinity that may otherwise pose a flood risk to the site. The proposed development is more than 2.5km away from the disused canal at Coombe Hill and thus it is not considered to be at risk.

The proposed development is more not at risk from a canal

Failure of flood defences

3.7.7. The proposed development is outside an Area Benefiting from Defences, and hence would be unaffected by any failure of an existing flood defence. There are raised defences indicated by the Environment Agency mapping at Withy Bridge, although these provide service to the properties there and would not affect the Scheme.

The proposed development is not at risk from any flood defence failure

3.8. Summary of flood risk sources

3.8.1. Table 3-3 below summarises the likely sources of flood risk to this proposed development.

Table 3-3 - Sources of flood risk summary

Flood risk	Baseline risk	Commentary
Fluvial		Flood risk from the River Chelt and its tributaries.
Tidal	n/a	Not applicable - no tidal influences.
Surface Water		Surface water flood risk arising from runoff from the south. Road alignment intercept overland flow paths
Groundwater	Medium	Medium risk. Given the presence of Secondary A and B aquifers underlying some of the study area there is potential for flooding from groundwater. A groundwater assessment is required to consider likely effects of proposed Scheme on groundwater flood risk.
Sewers	n/a	Low risk in rural area
Other sources	Low	Risk of flooding from the Dowdeswell Reservoir should failure occur. Reservoirs Act requirements reduce this risk to an acceptable level.

3.8.2. The predominant risk of flooding to the site arises from fluvial and surface water flooding.

4. Assessment of flood risk

The previous section identified those sources of flooding requiring further consideration based on a desk study review of published data. This section details the investigations undertaken to assess the flood risk posed by those sources.

This assessment is written in support of the PEIR and will be updated as work continues.

4.1. Study area

4.1.1. The M5J10 study area defined for flood risk is shown in Figure 4-1 and contains:

- the extents of the material works;
- a downstream (outlet) boundary sufficiently remote from the Scheme to ensure any uncertainties would not impact on model predictions of Scheme impact or performance; and
- an upstream (inflow) boundary sufficiently remote from the Scheme to ensure is represents the contributing watershed.

4.1.2. This starts in its upstream extent at the roundabout of the B4634 Old Gloucester Road with the A4019 near the retail park at Kingsditch. The study boundary follows the B4634 south west towards Hayden, under the M5 motorway, before joining Church road to Staverton, and then extending due North to Boddington, meeting the A4019 at Piffs Elm. The boundary then passes north along the B class road towards Hardwicke, crossing the Leigh brook before turning east and following the watershed close to the C class road to Elmstone Hardwicke along the road named “The Green”. The boundary then continues to follow the catchment boundary of the Leigh Brook, back to the A4019 and B4634 roundabout.

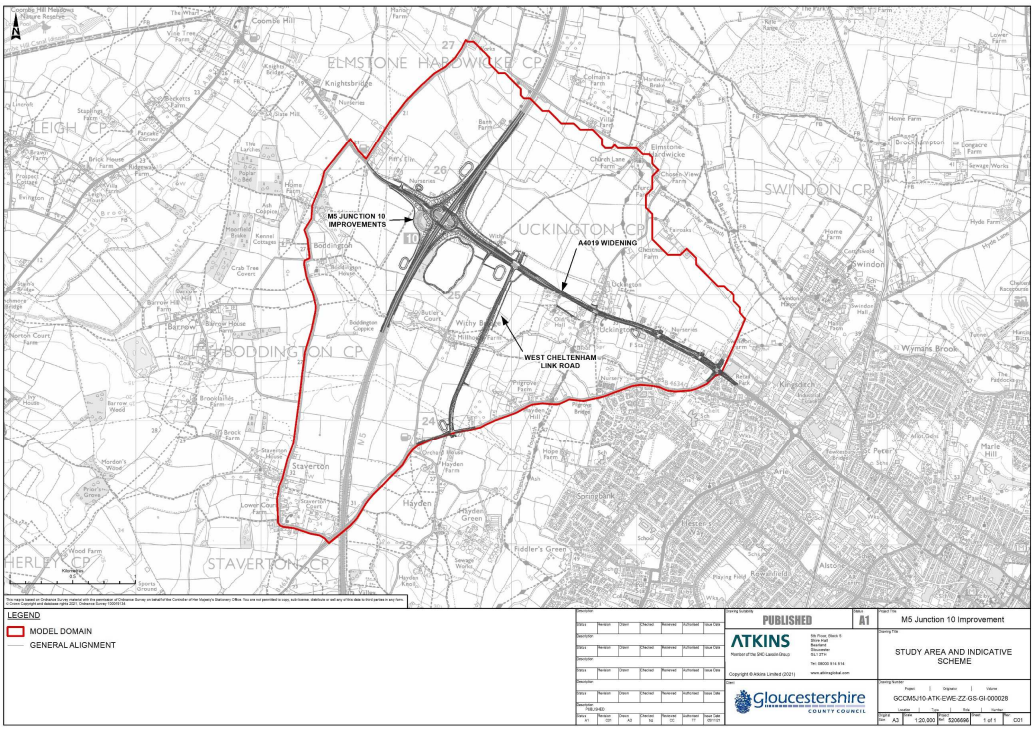


Figure 4-1 - Study area

4.2. Existing site topography

4.2.1. The existing topography reflects a wide floodplain associated with both the River Chelt and Leigh Brook. The land falls from east to west with the River Chelt being the main conveyance channel. The Leigh Brook has its headwaters in the study area but flattens to a wide floodplain at the M5 motorway. The M5 motorway runs on a raised embankment across the floodway.

4.2.2. The key features of the site topography, as defined by LiDAR (2019) and shown in Figure 4-2 are as follows:

- The minimum ground level in the study area is approximately 18 m AOD near the downstream boundary towards the former Slate Mill gauging station.
- The maximum ground level in the study area is 36 m AOD at the upstream boundary by the B4634 Old Gloucester road.
- The M5 motorway runs across the study area falling from south to north, with a level at the River Chelt crossing of 26.8 m AOD, and at the Leigh Brook crossing of 25.5 m AOD.
- The M5 motorway is raised across the topography, running north-south over the general east-west fall of the land.
- The maximum difference in ground levels across the study area study area is 18m

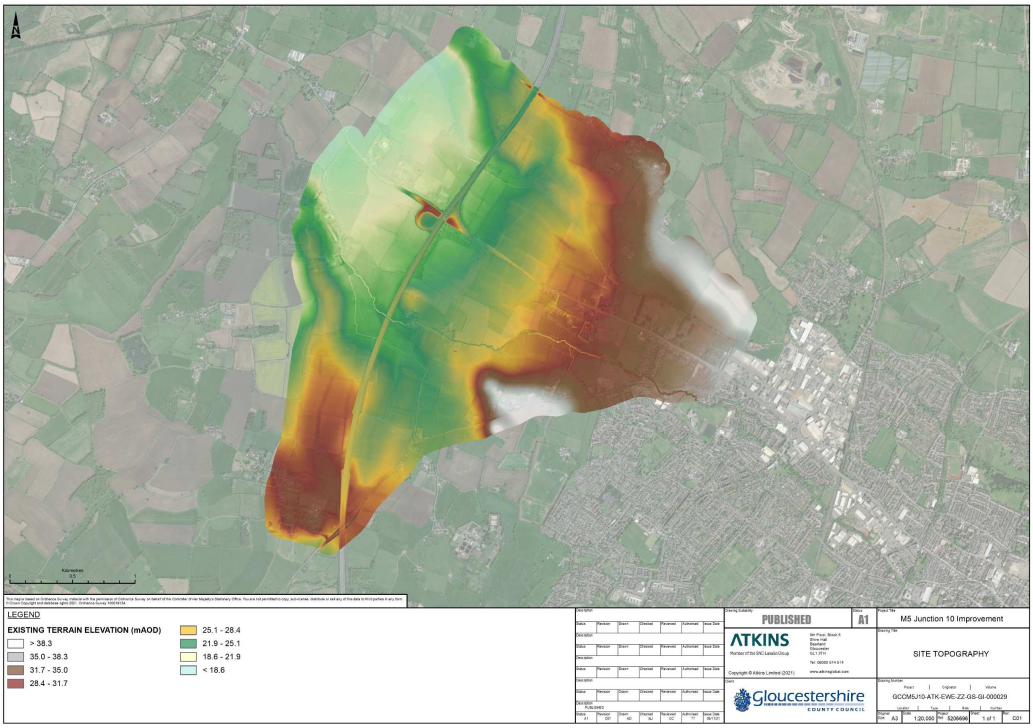


Figure 4-2 - Site topography (LiDAR)

4.2.3. The upstream boundary of the study area with a ground level of ~38 m AOD) is more than 14 m higher than the land beside the M5 motorway (~24 m AOD) and nearly 13 m higher than the estimated 1% annual exceedance probability event (1 in 100-year return period) flood level (of approximately 25 m AOD). The boundary is located sufficiently far away from the Scheme for it not to have an impact on it. This is demonstrated in the Baseline Hydraulic Modelling Report[2].

4.2.4. The downstream boundary for the study area is some 950 m west (downstream) of the M5 motorway. It is located upstream of the confluence with a minor watercourse arising from Boddington, and some 600 m upstream of the former river gauge at Slate Mill. The terrain falls towards the downstream boundary at a typical slope of 1 in 211 away from the M5 motorway.

4.2.5. Based on the inference from the Environment Agency published flood mapping, there is a depth of water on the floodplain of approximately 600mm besides the Boddington Lane during the 1% annual exceedance probability event (1 in 100-year return period). The influence of water levels at this boundary on flood risk at the Scheme is described in the Baseline Hydraulic Modelling Report[2]: variation in water levels at the downstream boundary do not influence flooding at the Scheme.

4.3. Initial assessment

4.3.1. The primary source of flood risk for consideration with the proposed Scheme is fluvial and surface water. The risk of surface water flooding is connected with the fluvial flood risk. These have been described more below.

4.3.2. The Scheme will be part of a transport infrastructure that can be described as a key transport link with junctions to the existing road network. Under the NPPF guidance, the development can be classified as Essential Infrastructure.

The proposed development is considered by this FRA to be classified as Essential Infrastructure

4.3.3. Given the presence of Secondary A and B aquifers underlying some of the study area for the two proposed Scheme options), there is potential of flooding from groundwater. A groundwater assessment is required to consider likely effects of proposed Scheme. The BGS susceptibility to groundwater flooding dataset has been requested and will be used to inform the groundwater assessment at a later stage. Site specific intrusive groundwater investigation/monitoring is ongoing therefore online publicly available data has been used to inform the preliminary assessment. Site specific data will be used to inform the assessment when data are available.

Sequential test

4.3.4. The Scheme has been designated as a 'critical' development to improve transport infrastructure at both a regional (by Gloucestershire County Council) and national (by National Highways) level.

4.3.5. Alternative options were considered for the Scheme. These are described in the Technical Appraisal Report[16] prepared at the option identification stage.

4.3.6. The Route Assessment Reports undertaken for the Scheme[17] indicates that the proposed Scheme satisfies the application of the sequential test to justify the location of the development. Appendix A provides some of the investigations that explain how the sequential test was applied.

4.3.7. Table 4-1, below, addresses the steps in the sequential test.

Table 4-1 –NPPF Sequential Test application on proposed junction

Sequential Test step	Test step question	Test outcome
1	Can development be allocated in Flood Zone 1?	No, the road has to cross the floodplain. See options assessment reports (ref [16 and 17])
2	Can development be allocated in Flood Zone 2?	No, the road has to cross the floodplain. See options assessment reports (ref [16 and 17])
3	Can development be allocated within lowest risk sites available in Flood Zone 3?	No ,the road has to cross the floodplain at this location to serve the intended developments and traffic. See options assessment reports (ref [16 and 17])

[16] GCCM5J10-ATK-GEN-XX-RP-ZM-000001 (September 2020) M5 Junction 10 improvement scheme: Volume 1 report - Technical Appraisal Report, Atkins
[17] GCCM5J10-ATK-HGN-XX_L1-RP-CX-000001 (April 2021) West Cheltenham Link Road route assessment report, Atkins

Sequential Test step	Test step question	Test outcome
4	Is development appropriate in remaining areas?	Yes. Development considered to be "Essential Infrastructure" (NPPF, Table 2, Paragraph 066) Located in Flood Zone 3b "Functional Floodplain (NPPF, Table 1, Paragraph 065 Development should be allocated to area subject to passing of Exception Test (NPPF, Table 3, Paragraph 067)

4.3.8. Based on its Essential Infrastructure vulnerability classification and crossing Environment Agency Flood Zone 3 (Section 3.2 above Flooding from rivers), Table 2-3 indicates that the proposed Scheme is compatible with the flood risk but requires the Exception Test.

The proposed development is compatible with the flood risk but requires application of the Exception Test.

Exception test

4.3.9. As the proposed development site requires application of the exception test, the Scheme will require further assessment to demonstrate:

- wider sustainability benefits to the community that outweigh the flood risk; and
- that the development will be safe for its lifetime taking account of the vulnerability of its users, without increasing flood risk elsewhere, and, where possible, will reduce flood risk overall.

4.3.10. It is also noted in the NPPF that as the Scheme crosses Flood Zone 3a it should be designed and constructed to remain operational and safe in times of flood. Furthermore, as it crosses Flood Zone 3b (functional floodplain and watercourse) it should be designed and constructed to:

- remain operational and safe for users in times of flood;
- result in no net loss of floodplain storage;
- not impede water flows and not increase flood risk elsewhere

4.3.11. If this can be demonstrated and appropriate mitigation measures are undertaken as may be required, the proposed development will be acceptable.

4.3.12. The application of the Exception Test for the M5 Junction 10 Improvements Scheme is outlined below in Table 4-2.

Table 4-2 - NPPF Exception Test application on proposed junction.

Exception Test Part	Part description	Application to proposed junction
1	It must be demonstrated that the development provides wider sustainability benefits to the community that outweigh flood risk, informed by a Strategic Flood Risk Assessment where one has been prepared	The proposed Scheme will aid in unlocking economic potential and encourage growth and job creation, otherwise restricted by limited accessibility to the area. The Scheme will allow for improved climate change resilience in the area. A sustainability assessment/report will need to be prepared to support the first part of the exception test

Exception Test Part	Part description	Application to proposed junction
2	A site-specific flood risk assessment must demonstrate that the development will be safe for its lifetime taking account of the vulnerability of its users, without increasing flood risk elsewhere, and, where possible, will reduce flood risk overall.	A site specific FRA has been undertaken, as documented in this report. It has been demonstrated by computational modelling that the Scheme will not increase flood risk elsewhere.

The Scheme passes the exception test subject to implementation of the flood mitigation measures as per this FRA and drainage strategy, and an acceptable sustainability appraisal.

4.4. Climate change allowances

4.4.1. The Scheme will be designed to be flood free during the 1% annual exceedance probability event (1 in 100-year return period) with climate change allowance, ensuring hydraulic conveyance of both fluvial and surface water flows. As such, climate change should have no specific impact on this Scheme.

4.4.2. The Environment Agency advice on climate change for a flood risk assessment is available at: Flood risk assessments: climate change allowances - GOV.UK (www.gov.uk). It is this that is referred to in Clause 156 of the NPPF, *"… and take account of advice from the Environment Agency and other relevant flood risk management authorities, such as lead local flood authorities and internal drainage boards."*

4.4.3. Environment Agency guidance on climate change was updated in line with the UKCP18 data in July 2021. For this PEIR stage FRA, the former climate change allowances have been applied: these will be updated in time for the Environmental Statement

Peak river flow allowances for fluvial/river assessment

4.4.4. Peak river flow allowances show the anticipated changes to peak flow by river basin district. The proposed Scheme lies in the Severn river basin district. With a flood risk vulnerability classification of 'Essential Infrastructure' and the site crossing Flood Zone 3, it is required to use the **Higher Central allowance** for climate change. This means a +53% increase in peak flows for the years 2070 to 2115.

4.4.5. It should be recalled that modelling results at the time of writing have applied +70% increase in peak flows, and this former (now precautionary) allowance has been used in this PEIR FRA.

4.4.6. Assuming a 100 year life for the Scheme, into the 2120s, requires extension of the third epoch (from the 2080s) to cover the lifetime of this assessment. This is standard practice at the time of writing. Future Environment Agency guidance may provide additional data.

4.4.7. It is noted that further sensitivity testing is encouraged with the Upper End scenario (credible maximum), which at this location is a +94% increase in peak flows. This will be included in the final FRA for the Environmental Statement.

4.4.8. The table below contains the climate change allowances for the Severn River Basin district, which indicates the range of allowances which need to be considered.

Table 4-3 - Climate change predictions on river flow for the proposed development site

Allowance category	Total potential change anticipated for the '2020s' (2015 to 2039)	Total potential change anticipated for the '2050s' (2040 to 2069)	Total potential change anticipated for the '2080s' (2070 to 2115)
Peak river flows (Severn Basin)			
Higher central	20%	28%	53%
Upper end (credible maximum)	34%	52%	94%

At present, +70% increase in peak flow has been applied to design for flood risk arising from future climate change over the next 100 years which relates to the Environment Agency guidance (Upper End allowance) in early summer 2021. The assessment will be updated to used +53% in due course.

Peak rainfall intensity allowances for pluvial/surface water assessment

4.4.9. Increased rainfall affects river levels and land and urban drainage systems.

4.4.10. The anticipated changes in peak rainfall intensity in small catchments (less than 5 km^2), or urbanised drainage catchments are shown below in Table 4-4. For flood risk assessments the Environment Agency advice is to assess both the central and upper end allowances to understand the range of impact.

Table 4-4 - Climate change predictions on rainfall intensity for the proposed development site

Allowance category	Total potential change anticipated for the '2020s' (2015 to 2039)	Total potential change anticipated for the '2050s' (2040 to 2069)	Total potential change anticipated for the '2080s' (2070 to 2115)
Rainfall intensity in small catchments (less than 5km^2), or urbanised drainage catchments			
Upper end	10%	20%	40%
Central	5%	10%	20%

4.4.11. The Design Manual for Roads and Bridges[18] (DMRB) technical note on the Design of Highway Drainage Systems[19] states that drainage designs shall be developed on the basis that all new road drainage has a minimum design lifetime of 60 years, unless otherwise instructed. And with a 20% uplift in peak rainfall intensity as the basic climate change factor. It also recommends a sensitivity test with 40% uplift in peak rainfall intensity to establish a robust drainage design that accounts for the inherent uncertainty in the estimation of flow and climate change impacts on rainfall.

4.4.12. For this project, the more onerous guidance set out in the Tewskesbury SPD[10] has been applied, using +40% in peak rainfall intensity, and +70% as a sensitivity test. The latter value has been applied in design to test the 300 mm freeboard in the drainage attenuation ponds.

a +40% increase in peak rainfall intensity was applied to design for flood risk arising from future climate change over the next 100 years.

[18] National Highways et al.
[19] National Highways et al (March 2020 Revision 2) Design of Highway Drainage Systems, CG501 formerly HD 33/16, TA 80/99

4.5. Baseline flood risk: fluvial/surface water

4.5.1. The Baseline Hydraulic Modelling Report[2] describes how the fluvial systems were numerically modelled using UK standard approaches and following the published guidance of the Environment Agency. The location of the main hydraulic features are indicated in Figure 4-3.

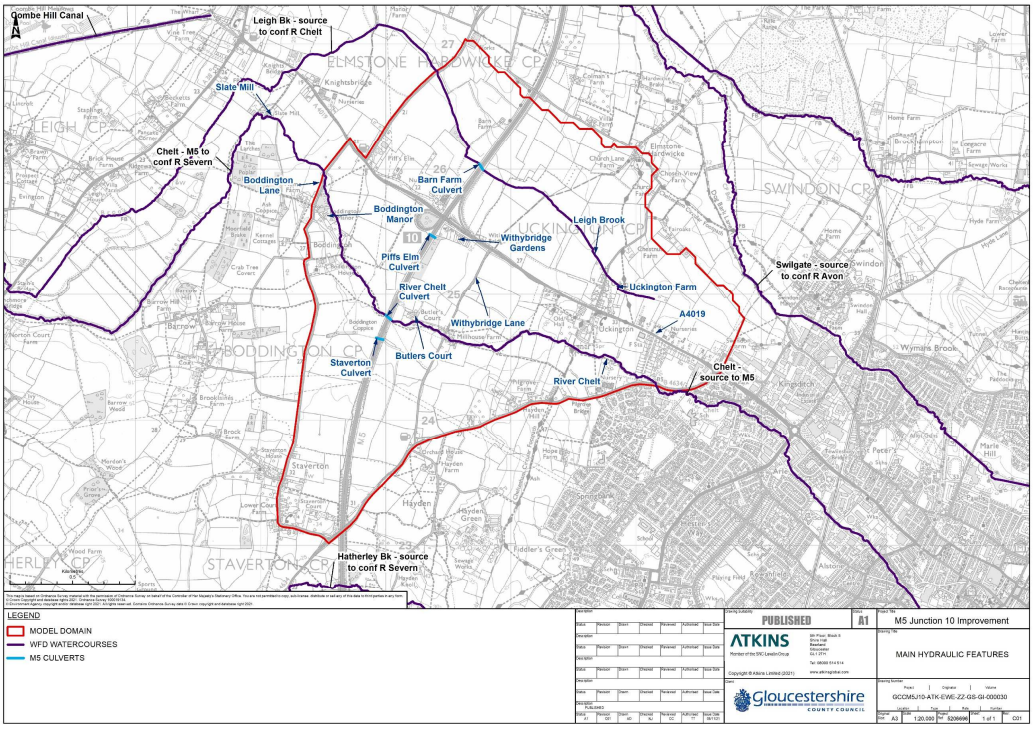


Figure 4-3 - Hydraulic features

4.5.2. All flood modelling for the Scheme was based on a model developed for Boddington (downstream of the M5 motorway) in 2019. This model was approved by the Environment Agency in 2020 for a flood map challenge. The model was itself developed from the available Environment Agency models of the River Chelt through Cheltenham.

4.5.3. The 1D-2D linked hydraulic model was developed further using the industry standard ESTRY-TUFLOW software. Fundamentally this now incorporates the Leigh Brook (and its interactions with the River Chelt) which was missing form all previous hydraulic modelling in this area.

4.5.4. The hydraulic model uses the following input data in addition to that contained in the Boddington model – more detail is provided in the Baseline Hydraulic Modelling Report[2] :

- LiDAR – Composite DTM 2019, 1m resolution;
- cross sections – Environment Agency Middle Chelt Model (2012);
- cross sections – Infomap surveys and Mapping (December 2017) survey of River Chelt near Boddington;
- cross sections – Infomap surveys and Mapping (November 2019) survey of Leigh Brook
- hydraulic structures – Infomap surveys (November 2019); and
- aerial survey – Atkins (March 2021) survey of critical areas near M5J10.

4.5.5. The hydraulic model is driven by hydrology derived using the UK's Flood Estimation Handbook (FEH) and following the Environment Agency Flood Estimation Guidelines[20]. The following input data was applied - more detail is provided in the Baseline Hydraulic Modelling Report[2] :

- Recorded rainfall for the Environment Agency Dowdeswell rainfall gauge
- Recorded stage and flows for the former Environment Agency gauge at Slate Mill
- Design rainfall parameters from the FEH web service accessed 29 September 2020
- Catchment descriptors from the FEH web service accessed 29 September 2020
- Hiflows database (version 9), which includes data for water year 2019/2020 Released on 24 September 2020
- Combined sewer overflow data from Severn Trent Water for its outfall at Arle
- ReFH 2.3 version (version 3.0.7270.30847) software; and
- WINFAP (version 4) software.

4.5.6. The hydrology and hydraulics were calibrated using event data from:

- 20 July 2007 (as the largest event on record);
- 13 December 2008 (as recommended by the Environment Agency; and

4.5.7. Data from the now discontinued river flow gauge at Slate Mill was used to calibrate the hydrology with the hydraulic model. The 1% annual exceedance probability event (1 in 100-year return period) was estimated to generate a peak flow of

- 24.5 m^3/s in the River Chelt at the M5 motorway; and
- 2.5 m^3/s in the Leigh Brook at the M5 motorway.

4.5.8. The hydraulic model was then calibrated with field observations (landowner reports and photographs) and Environment Agency recorded wrack mark data for the River Chelt.

4.5.9. The results of the hydraulic modelling demonstrate the baseline (actual) flood risk in the study area. Further details are described in the Baseline Hydraulic Modelling Report[2].

4.5.10. The results show that flooding occurs on the Leigh Brook floodplain during the 1% annual exceedance probability event (1 in 100-year return period). There is out of bank flooding just west of the upstream point of the Leigh Brook watercourse, resulting in flooding to the properties near Uckington Farm. There is also flooding in the Leigh Brook floodplain just upstream of Barn Farm culvert, under the M5 motorway, as well as downstream of the motorway, continuing west along the watercourse to the downstream model boundary. Widespread flooding occurs on the Chelt floodplain in the same event. Water exits the River Chelt channel at the eastern end of the Chelt floodplain and 10.2 m^3/s passes over Withybridge Lane into the fields east of the motorway. Flooding is largely contained in the Chelt floodplain. No water overtops the A4019 and there is minor flow passing under the road through the A4019 culverts (0.006 m^3/s), which results in only a minor flood extent downstream of this structure.

4.5.11. There is significant flooding held east of the motorway, particularly upstream of the Piffs Elm, River Chelt and Staverton culverts under the M5 motorway. Flows of 17.2 m^3/s pass through the River Chelt culvert under the M5 during this event (0.6 m^3/s more than that in the 4% annual exceedance probability event (1 in 25-year return period)).

4.5.12. Flooding upstream of the Staverton culvert extends south to the upstream point of the Staverton tributary and spreads east to Withybridge Lane. Downstream of the Staverton culvert there is further flooding which extends to the confluence between the River Chelt and the Staverton tributary and west up to Boddington Manor. There is also out of bank flooding in the fields to the east of Boddington Manor.

[20] Environment Agency (July 2020) Flood estimation guidelines. LT 11832

4.5.13. Flooding downstream of Piffs Elm culvert extends west to the downstream boundary at Boddington Lane, where 3.1 m^3/s overtops this road (3 m^3/s more than that in the 4% annual exceedance probability event (1 in 25-year return period).

4.5.14. The 1% annual exceedance probability event (1 in 100-year return period) with 70% increase in peak flows to account for future climate change is marginally bigger than the present day 0.1% annual exceedance probability event (1 in 1,000-year return period). This is evidenced with the peak flow passing through the River Chelt culvert, being 21.1 m^3/s compared to 20.5 m^3/s. The flood extent north of the A4019 is almost identical.

4.5.15. Perhaps the biggest impact of climate change in the River Chelt catchment at this location is the instigation of flow over the A4019 highway into the catchment of the Leigh Brook. This cross catchment transfer leads to much greater flooding on the easter (upstream) side of the M5 motorway at Barn Farm culvert. The impact was predicted in the sensitivity testing on both upstream inflow and climate change allowance, even with the lowest change tested (a +20% increase in inflow) causing this phenomenon. The increase in flow from 0m^3/s in the present days, to 2.5m^3/s in 100-years' time creates a significant increase in flood risk to the land north of the A4019.

4.5.16. Selected point results are tabulated below to give an indication of the flood depths (Table 4-5) and flood flows (Table 4-6). The location of these points are shown in Figure 4-4.

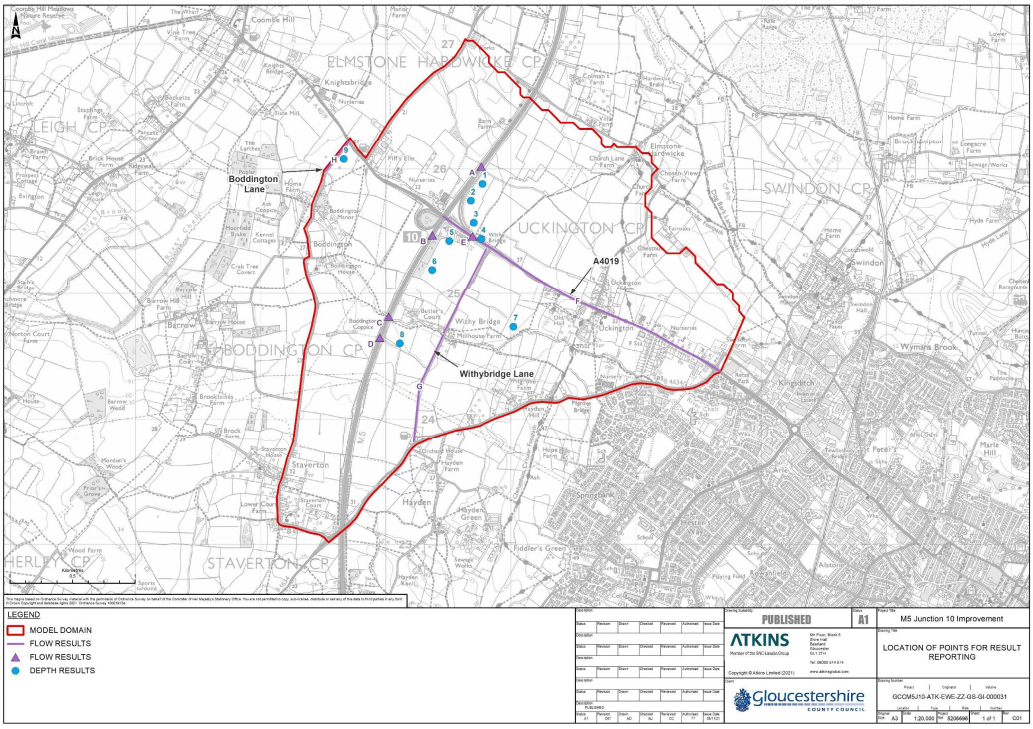


Figure 4-4 - Location of points for result reporting

Table 4-5 - Baseline flood depths

Location	Depth (m)		
	1% AEP	1% AEP with climate change	0.1% AEP
1 Leigh Brook nr Barn Farm culvert	0	1.24	1.21
2 Leigh Brook existing slip road	0	1.30	1.27
3 Leigh Brook nr A4019	0	0.55	0.52
4 A4019	0	0.23	0.22
5 Withybridge Gardens	0.96	1.60	1.58
6 north of Butlers Court	0.20	0.84	0.82
7 Eastern end of River Chelt floodplain	0.19	0.27	0.27
8 nr Staverton culvert	0.32	0.44	0.42
9 Boddington Lane	0.44	0.47	0.47

Table 4-6 – Baseline flood flows

Location	Flow (m^3/s)		
	1% AEP	1% AEP with climate change	0.1% AEP
A Barn farm culvert	2.2	10.4	10.3
B Piffs elm culvert	3.1	3.8	3.8
C River Chelt culvert	17.2	21.1	20.5
D Staverton culvert	2.8	2.9	2.9
E A4019 culvert	0.0	3.3	3.3
F A4019 over the top	0.0	16.0	14.7
G Withybridge Lane	10.2	26.5	24.6
H Boddington Lane	3.1	5.9	5.6

4.5.17. The flood extent, with depth, maps for the 1% annual exceedance probability event (1 in 100-year return period) with and without future climate change are shown overleaf in Figure 4-5 and Figure 4-6.

4.6. Baseline flood risk: groundwater

4.6.1. Site specific GI is currently ongoing therefore publicly available data have been used for the current preliminary assessment. This section will be updated using JBA groundwater flood risk mapping and site-specific GI for the Environmental Statement when further data are available.

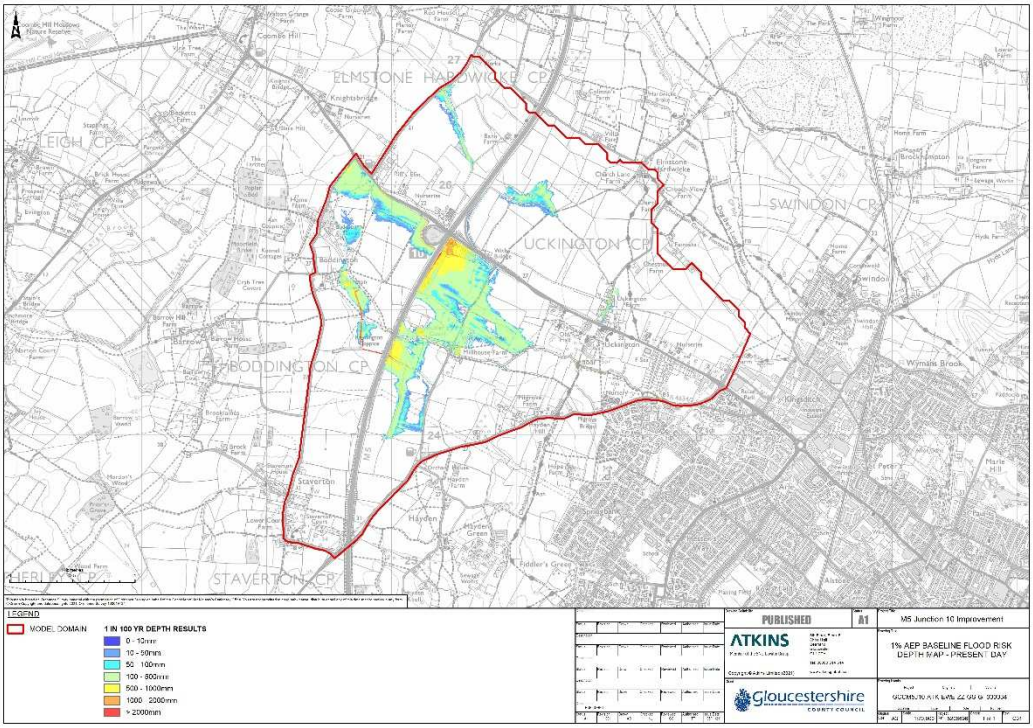


Figure 4-5 - 1% AEP baseline flood risk depth map – present day
1% annual exceedance probability event (1% AEP or 1 in 100-year return period)

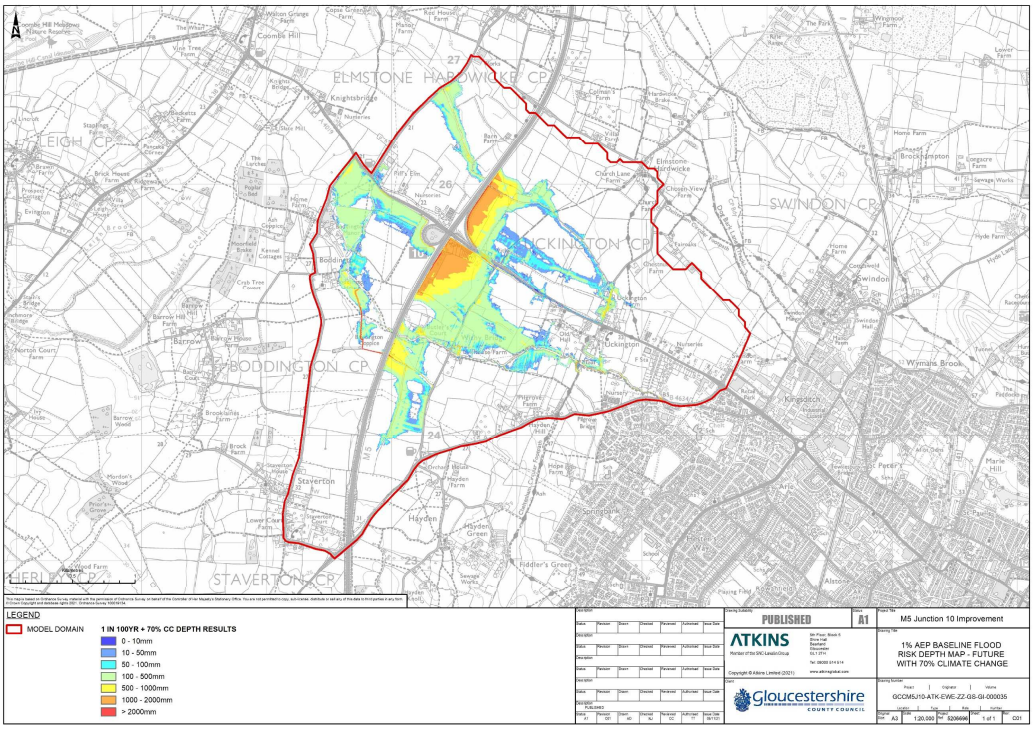


Figure 4-6 - 1% AEP baseline flood risk depth map – future with climate change
1% annual exceedance probability event (1% AEP or 1 in 100-year return period) with climate change

5. Managing flood risk

For flood risks in general, there is a hierarchy that should be applied for flood risk management, with avoidance or prevention being the preferred first measure to reduce flood risk. Table 5-1 presents the flood risk management hierarchy.

Table 5-1 - Flood risk management hierarchy

Flood Risk Management Hierarchy		What it means
1	Assess	Undertake studies to collect data at the appropriate scale and level of detail to understand what the flood risk is.
2	Avoidance / Prevention	Allocate development to areas of least risk and apportion development types vulnerable to the impact of flooding to areas of least flood risk.
3	Substitution	Substitute less vulnerable development types for those compatible with the degree of flood risk.
4	Control	Implement flood risk management measures to reduce the impact of new development on flood frequency and use appropriate design.
5	Mitigation	Implement measures to mitigate residual risks.

5.1. Assess

5.1.1. The baseline flood risk has been assessed through hydraulic modelling. This is described above in Section 4.

5.1.2. The Scheme Hydraulic Modelling Report[3] describes in detail how the Scheme was applied and tested in the hydraulic model, using UK standard approaches and following the published guidance of the Environment Agency. That report also describes in detail the results of the testing. The below text (Sections 5.1 to 5.7) is a summary of the with-Scheme flood risk.

5.1.3. The Scheme described in this report is based on Design Fix 2.3 (DF2.3) design in August 2021. This is under development and this FRA will be updated in line with future design changes which will modify the numbers reported, but not the conclusions of this FRA.

Scheme design

5.1.4. At this PEIR stage of the project the design information is limited to vertical and horizontal alignments of the proposed scheme options as part of a wider 3D CAD model (DF 2.3). Preliminary design information has been used to inform this report and make the assessment of flood risk. This includes

- M5 J10 All movements layout with engineering constraints, GCCM5J10-ATK-HGN-ZZ-DR-CH-00001, revision P02.3
- M5 J10 All movements layout with engineering constraints, GCCM5J10-ATK-HGN-ZZ-DR-CH-00002, revision P02.3
- M5 J10 All movements layout with engineering constraints, GCCM5J10-ATK-HGN-ZZ-DR-CH-00003, revision P02.3
- M5 J10 All movements layout with engineering constraints, GCCM5J10-ATK-HGN-ZZ-DR-CH-00004, revision P02.3
- A4019 Dualling 3D CAD model, GCCM5J10-ATK-HML-L1_ML_Z-MR-CH-000004, June 2021, revision P04.2.
- B4634 and Link Road Junction 3D CAD model, GCCM5J10-ATK-HML-J3_JN_Z-

MR-CH-000003, June 2021, revision P02.3.

- A4019 and Link Road Junction 3D CAD model, GCCM5J10-ATK-HML-J2_JN_Z-MR-CH-000003, June 2021, revision P03.1.
- West Cheltenham Link Road 3D CAD model, GCCM5J10-ATK-HML-L2_ML_Z-MR-CH-000003, June 2021, revision P03.1.
- M5 Junction 10 3D CAD model, GCCM5J10-ATK-HML-J1_JN_Z-MR-CH-000003, June 2021, revision P03.1.
- Gallagher Junction 3D CAD model, GCCM5J10-ATK-HML-J4_JN-MR-CH-000002, June 2021, revision P02.1.
- Access Roads 3D CAD model, GCCM5J10-ATK-HML-ZZ_SR-MR-CH-000003, June 2021, revision P03.2.

5.1.5. The Scheme provides a new elevated roundabout on the A4019 over the M5 motorway with four new slip roads connecting traffic with the M5 motorway below. To provide increase headroom over the motorway, the roundabout and its bridges will be raised. As such, the A4019 is also raised, and regraded, before reconnecting to existing road levels some distance from the motorway. The A4019 is then widened as far as the new Fire Station at Uckington. A new junction on the A4019 provides access onto the West Cheltenham Link Road, which passes south across the River Chelt floodplain, east of the existing Withybridge Lane, to the B4634 near Hayden Hill, south of the River Chelt.

Possible construction effects on flood risk

5.1.6. Implementation of the Scheme will see construction work on the floodplains of the River Chelt and Leigh Brook: this will require work in Flood Zone 2 and 3. No specific hydraulic modelling of temporary construction conditions has been undertaken.

5.1.7. A change in flood risk during construction of the Scheme, that may impact on the works or 3rd party receptors, could arise from:

- Blockages within the floodplains and/or narrowing of the watercourses themselves will reduce their floodwater storage and conveyance capacity. Excavation adjacent to the banks of the watercourses will increase the frequency of overtopping and/or the risk of breach of the bank (by locally lowering the level of protection or decreasing the integrity of the bank or flood risk asset). This can increase the flood risk to adjacent land and property. Many of the River Chelt banks in this area are slightly raised above the local floodplain.
- Temporary stockpiling of material in the floodplain could result in a loss of flood storage and/or divert existing overland flow routes to areas that are not currently affected.
- Sediment runoff from the site construction could settle in the watercourses and existing structures if not managed through standard site controls. Any temporary settlement lagoons to hold construction water and manage sediment could cause flooding in the event of overtopping or a breach. These temporary settlement lagoons should be located outside of the floodplain where possible.
- Construction activities that extend below ground have the potential to be affected by groundwater and affect groundwater flooding. Sections of the Scheme are located within areas susceptible to groundwater flooding. The effect of this will be considered once the ground investigation has completed.
- Construction of the proposed Scheme will take place over more than a year, with some works undertaken during winter when watercourse flows are typically highest. Any site compounds will need to be located outside Flood Zone 3, or on temporary works platforms with accompanying compensatory floodplain. An assessment of the temporary works access and haul roads will be required.

Possible operational effects on flood risk

5.1.8. Operation of the Scheme will see new roads and associated infrastructure on the floodplains of the River Chelt and Leigh Brook in Flood Zones 2 and 3.

5.1.9. Without any appropriate embedded mitigation the proposed Scheme would have significant impacts on flood risk to 3rd party land and local infrastructure. That impact can be summarised as:

- the footprint of the Scheme displacing floodwaters elsewhere, raising the depth, duration and frequency of flooding on 3rd party land and infrastructure;
- the obstruction of the existing culverts under the M5 motorway, blocking flow paths and increase flood depths to the east of the motorway;
- the proposed Link Road crossing blocking the River Chelt floodplain raising the depth, duration and frequency of flooding on 3rd party land and infrastructure upstream of it; and
- the raising of the A4019 severing the existing overland flow path between the River Chelt and Leigh Brook, causing increased flood levels to the south of the A4019 (immediately east of the M5 motorway) and over Withybridge Lane and the surrounding land.

5.1.10. The hydraulic modelling has demonstrated that the Scheme is not at risk of flooding itself from the 1% annual exceedance probability event (1 in 100-year return period) with a 70% increase in peak flow to account for future climate change (i.e. over lifetime of the development).

5.2. Avoid

5.2.1. The proposed M5 Junction 10 improvements and West Cheltenham Link Road cannot be allocated in areas of lower flood risk. It is not possible for the Scheme to avoid crossing the floodplain of the River Chelt or Leigh Brook.

5.3. Substitute

5.3.1. The proposed M5 Junction 10 improvements and West Cheltenham Link Road consist of transportation infrastructure. Less vulnerable development cannot be substituted with those compatible with the degree of flood risk predicted at this site.

5.4. Control

5.4.1. The Scheme includes for embedded mitigation and controls to reduce its impact on flood risk. These are described below (paragraphs 5.4.3 to 0).

5.4.2. Future flood risk assessment work on this Scheme will confirm the embedded mitigation to reduce, remove or compensate for adverse impacts identified on flood risk.

Construction phase

5.4.3. Measures to control effects during the construction period will include:

- Development of a flood management plan to ensure the proposed construction sites can be safely operated and evacuated and will not be unacceptably affected in the event of a flood. It will not be possible to avoid floodplain working.
- Development of a construction drainage strategy to address the temporary management of surface waters to ensure flood risk to the surrounding area is not increased (and pollution is controlled);
- Temporary land-take for the construction will need to include for adequate areas of land set aside for robust flood control measures, for example sustainable drainage control and additional landtake to compensate any haul roads etc;
- Appropriate management of sediment runoff from the site will be required during construction to reduce risk of blockage in the River Chelt and Leigh Brook culverts under the M5 motorway.

- Any temporary ponds constructed for runoff and sediment management will need to be located to avoid the risk of flooding watercourses or adjacent land in the event of overtopping or a breach;
- Temporary flood compensation areas will need to be put in place in advance of any earthworks resulting in loss of floodplain.
- The construction site should receive flood warning information from the Environment Agency, such that the site can be cleared of labour, plant and materials in advance of a forecast event.

5.4.4. As some of the construction works are located within and adjacent to a Main River, they will require a temporary Flood Risk Activity Permit (under the Environmental Permitting Regulations 2016). There may also be a requirement for a temporary Land Drainage Consent (under the Land Drainage Act 1991) in relation to the ordinary watercourse of the Leigh Brook. To obtain consent it will be necessary to demonstrate that construction of the Scheme will not have an adverse impact on flood risk – as documented in the FRA. Consideration will need to be given by the appointed contractor's method statement to aspects such as phasing of the works, the locations of construction compounds and storage areas, any other temporary works and flood warning and response procedures.

5.4.5. As flood risk during construction is to be considered as part of a separate consenting process it has not been assessed in detail in this FRA. Construction of the works in accordance with the relevant consents described above would mean that there is no significant adverse impact of the proposed Scheme on third parties.

Operation phase

5.4.6. Embedded mitigation measures are included in this Scheme to control the flood risk. The flood modelling has shown that the Scheme will displace floodwater and impact on the flood risk of its neighbours if the embedded mitigation is not implemented. The embedded mitigation included in the design is described below.

Embedded mitigation

5.4.7. The guidance is clear that embedded mitigation should be the best practice design approach. Embedded mitigation covers the project design principles adopted to avoid or prevent adverse environmental effects, whereas Essential/Additional mitigation are those measures subsequently required to reduce and if possible offset likely significant adverse environmental effects, in support of the reported significance of effects in the environmental assessment.

5.4.8. Thus, embedded mitigation covers good-practice environmental measures that would occur without input from the EIA feeding into the design process. It includes actions that would be undertaken to meet other existing legislative requirements, or that are considered to be standard practices or design principles. For example, embed mitigation could include: the appropriate design of river crossings or realignments; and the provision and design of compensatory floodplain storage.

5.4.9. Anything project specific is described as essential mitigation – being the extra-over to step away from a significant environmental impact.

5.4.10. For M5J10 in terms of flooding, the embedded mitigation includes:

- A drainage strategy to enhance the water quality of the surface water runoff and limit the peak rate and overall volume of discharge.
- Compensatory floodplain being provided to offset the volume of water displaced by the Scheme, prior to the removal of any existing floodplain.
- The new permanent watercourse crossing of the River Chelt being designed to convey the 1% annual exceedance probability event (1 in 100-year return period) including an allowance for climate change (currently +70% in flow) with a minimum of 600mm freeboard to soffit.

- The link road including a crossing, or crossings, of the River Chelt floodplain. The number/size of openings will be defined to balance impact with cost.
- All M5 and A4019 watercourse culverts being extended to suit the new roads at the same size & slope as the existing culverts, with buried inverts. The existing Staverton and Chelt culverts do not require extending as part of this Scheme.
- Any new channels or channel realignment being designed to appropriately accommodate flows (including flood flows), providing spatially variable aquatic habitat and with connectivity to a riparian zone.

5.4.11. These embedded mitigation features are discussed below.

5.4.12. Opportunities for enhancement and beneficial effects will also be identified at the next stage of assessment.

5.4.13. At this stage of the Scheme development (at the time of this PEIR FRA), the hydraulic modelling is advising the design of the embedded mitigation and has not been completed. The hydraulic modelling is being used to test various solutions to the obvious impacts that the Scheme could cause without embedded mitigation. Work will continue on this aspect with full results ready for inclusion in the final FRA supporting the Environmental Statement.

Drainage strategy

5.4.14. A detailed drainage design is being prepared in accordance with the various design standards to manage the risk of flooding of the road itself (i.e. from the Scheme's surface, drainage etc.). This is described in the Scheme's drainage strategy[21]. This will limit discharges from the new highways such that they do not exceed the present day greenfield runoff rates or volumes even when applying future climate change allowances.

5.4.15. The DMRB CG 501[19] outlines the standards relating to the design, assessment and operation of motorway and trunk roads in the United Kingdom. The DMRB states that for road runoff within drainage systems, the following criteria must apply:

- 100% annual exceedance probability event (1 in 1-year return period) – no surcharge of the drainage system;
- 20% annual exceedance probability event (1 in 5-year return period) – no flooding from the drainage system;
- All drainage systems shall be designed so that highway surface water flooding does not extend beyond the highway boundary up to the 1% annual exceedance probability event (1 in 100-year return period) rainfall event;
- Pre-earthworks ditches and filter drains will be designed against 1 in 75 year event with no flooding.
- All criteria apply to the lifetime of the development, and hence a 20% uplift in peak rainfall intensity together with a sensitivity test to 40% increase in rainfall.

5.4.16. The road drainage is being designed to restrict peak runoff from the new paved surfaces to the current greenfield runoff and provide additional betterment where possible. The developing Scheme design includes for six drainage attention ponds, fitted with flow controls. However, the design has not ruled out infiltration but is subject to infiltration testing being carried out as part of the ground investigation.

5.4.17. The agreement with the LLFA was that existing catchments would be restricted to existing rates, with new catchment areas restricted to greenfield rates with climate change allowance applied only to new areas. Whilst it is not feasible to restrict the existing road drainage catchments to greenfield runoff rates, due to space constraints for storage, betterment will be sought to those catchments where possible.

[21] Atkins (2021) M5 J10 Improvements Scheme – Drainage strategy report, ref GCCM5J10-ATK-HDG-ZZ-RP-CD-000001

5.4.18. In accordance with as per section 5.7.7 of Tewkesbury District Council's Flood & Water Management Supplementary Planning Document[10], peak outflows from the attention ponds will be limited to greenfield runoff rate (QBAR) for all events up to the 1% annual exceedance probability event (1 in 100-year return period) with an allowance of 70% applied for climate change. In practice this means that the ponds will store the 1% annual exceedance probability event (1 in 100-year return period) plus 40% increase in rainfall for climate change with a 300mm freeboard, and the Freeboard checked to ensure that it holds the +70% increase in rainfall with no flooding.

5.4.19. A volumetric restriction will be applied to control the additional volume of runoff generated by the new road surfaces. This will either be applied, as above, by reducing all peak flows to no more than the present day mean-annual flood, or providing separate design elements to deal with long term storage.

5.4.20. Under these design rules, the road drainage will not increase the rate or volume of runoff being discharged into the existing watercourses.

5.4.21. The drainage design will be applied to the Scheme hydraulic modelling as will be described in the Scheme Hydraulic Modelling Report[3]. In essence:

- No discharges from the attenuation ponds will be added to the hydraulic model. With the design standards ensuring no increase in greenfield runoff (rate or volume) modification of the FEH catchments to reflect field scale changes was not necessary.
- The attenuation ponds will be included in the with-Scheme terrain model, reflecting any changes in ground levels, hence enabling an assessment of their impact on flood risk and their safety from river flooding.

5.4.22. The potential effect of the proposed drainage scheme on the existing surface water drainage system will also been assessed where flood levels are predicted to be increased. Mapping of surface water outfalls (using the Environment Agency's AIMS database) and of the surface water sewer system (obtained from Severn Trent Water) could be used to identify whether there are any locations where the Scheme could impact on the existing drainage system.

5.4.23. The fluvial flood risk requirements of the DMRB are independent of the requirements set out in LA 113.

Compensatory floodplain storage / flood storage

5.4.24. Compensatory flood storage works are required where the Project would otherwise reduce the available volume of flood storage. CIRIA 624[22] (Section A.3.3.10, 2004) states that:

"*Compensatory flood storage must become effective at the same point in a flood event as the lost storage would have done (McPherson 2002). It should therefore provide the same volume and be at the same level relative to flood level, as the lost storage. This requirement is often referred to as "level for level" or "direct" compensation*".

5.4.25. Replacement floodplain is required to offset the losses under the footprint of the Scheme. Losses are predicted on both the River Chelt and Leigh Brook floodplains. The hydraulic modelling was used to quantify the losses in terms of plan area and contained volume of floodplain.

- Area of Scheme footprint in the Flood Zone 3 = 39,021 m^2
- Area of Scheme footprint in the baseline floodplain[23] = 95,289 m^2
- Volume of the Scheme occupying the baseline floodplain[23] = 64,286 m^3

[22] CIRIA (2004) Development and flood risk – guidance for the construction industry, C624.
[23] Referenced here as the Design Flood, being the 1% annual exceedance probability event (1 in 100-year return period) with +70% allowance on peak flow for future climate change over the next 100 years. Note this will be revised for the Environmental Statement to use the July 2021 guidance of +53% increase in peak flow.

5.4.26. The issue of compensatory floodplain is complicated for this Scheme by the existing inter-catchment transfer at the design event (from the River Chelt into the Leigh Brook over the existing A4019), and the severance of this transfer by the raising and widening of the A4019. Severance of this flow path brings a notable reduction in flood risk to the Leigh Brook catchment, yet prevents over 220,000 m^3 of floodwater leaving the River Chelt floodplain that would otherwise flow north over the A4019. The Environment Agency has requested that compensatory floodplain is provided on a level for level basis for the West Cheltenham Link Road. It should be noted that once water leaves the River Chelt and flows towards the link road, that any displacement of floodwater by that road embankment will not affect the spillage of water from the river: in this way a level for level compensation is not necessary, although has been developed.

5.4.27. Compensatory floodplain for the West Cheltenham Link Road will thus be provided in the fields to the east (upstream) of the Link Road, adjacent to the existing floodplain.

5.4.28. A level for level assessment was applied to quantify the incremental losses for a range of flood events between the present day threshold (approximately 5% annual exceedance probability event (1 in 20-year return period) and the design event. It should be noted that Baseline flood levels vary across and along the floodplain and hence a level for level replacement is not straight forward. An approach was developed to assess the frequency of flooding and then apply a level-for-level assessment as described in CIRIA 624[22]:

- The hydraulic model was used to calculate the volume displaced by the embankment for a range of return periods;
- Incremental volumes for each incremental flood frequency band were calculated, giving a frequency-volume relationship;
- The corresponding volumes were re-provided for each flood frequency band, setting back the existing flood contours into dry land. Hence dry land of a certain area would be excavated to flood to a given depth in each frequency band, providing the same displaced volume over a new area.
- A CAD/GIS approach was used to shape the storage area; and,
- This shape was incorporated into the hydraulic model as a new terrain surface and tested (validated) for a range of return periods.

5.4.29. The Scheme design will ensure the hydraulic connectivity of the floodplain across the , West Cheltenham Link Road (from east to west) via a series of box culverts in the embankment, ensuring that the overland flow paths seen in the baseline case are maintained in the with Scheme scenario.

5.4.30. For the remainder of the Scheme in the floodplain (the motorway junction), the Environment Agency has agreed that level for level floodplain compensation is not appropriate, given the mechanism of flooding at this site where floodwater leaves the River Chelt and flows away from the watercourse with the general topography. Displacement of floodwater besides the M5 motorway and A4019 has no impact on the flow passing downstream along the River Chelt and Leigh Brook, and hence third party receptors. Without any compensatory storage, the impact of this would be to increase peak flood levels across the floodplain, increasing flows through the Piffs Elm culvert, widening the floodplain extents and impacting some built receptors.

5.4.31. Compensatory storage will thus be provided in the fields to the east (upstream) of the M5 motorway, immediately south of the A4019, where floodwaters accumulate in the Baseline. This will retain the same volume of water leaving the River Chelt and not displace it elsewhere, and fundamentally not change how water passes on to the floodplain.

5.4.32. The Scheme thus provides an excavated flood storage area which may be developed as a wetland bowl. The flood storage area will drain through the existing Piffs Elm culvert and hence a minimum excavated level similar to the invert of the existing Piffs Elm culvert (22.37 m AOD). Additional excavation below this level may be provided for biodiversity and habitat enhancement, enabling a permanent body of water to be retained. However, the storage provided beneath the invert level of the Piffs Elm culvert has not been included in the hydraulic model and does not affect the results.

5.4.33. The flood storage accommodates the volume of River Chelt floodwater displaced by the Scheme footprint, being 36,030 m^3. The full sizing also provides storage for the additional floodwater prevented from accessing the Leigh Brook floodplain, being 221,455 m^3. The maximum storage required is not the sum of these, as the relative timing of the inflows and outflows mean that the total volume cannot be simply combined (superposition of total volume is not appropriate).

5.4.34. The flood storage was thus developed with an iterative approach using the hydraulic model to seek no detriment to 3rd party receptors but balance the sustainability of implementation (land take, environment, cost). Tests were undertaken with different sized wetlands storage, varying the key parameters (plan area/shape, depth and cut slopes).

5.4.35. A balance was struck between oversizing the flood storage and a subsequent reduction in flood levels, and undersizing the flood storage and a subsequent increase in flood levels.

5.4.36. It is assumed that some of the land predicted to suffer increased flooding will have a Right to discharge surface water and floodwater or similar. The Scheme balances the sustainability of further excavation to provide extra flood storage with the magnitude of detriment and vulnerability of the receptors: the permanent scale, cost and impact of additional excavation would be significant when compared the temporary impact of the additional floodwater.

5.4.37. The resulting outline storage design was proven in the hydraulic model. It includes for nominal 1 in 3 side slopes around the wetland, with an 106,807 m^2 organic planform shape that includes bays, inlets and islands, so promoting a future wetland area. See Figure 5-1. The design requires a total excavation below existing ground level (and hence storage volume) of 197,440 m^3 (to Piffs Elm culvert invert level). This is an excavated depth of ~1.5 m along the western perimeter and ~3 m along the eastern perimeter.

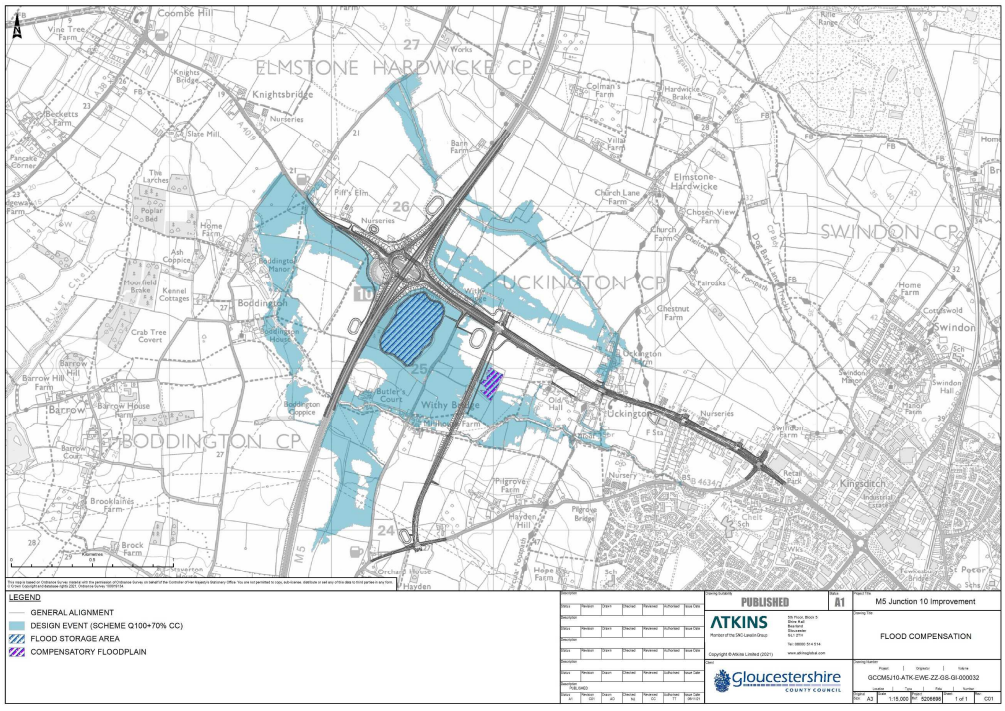


Figure 5-1 - Flood Compensation

River Chelt bridge

5.4.38. The Scheme requires the addition of a new bridge over the River Chelt, carrying the West Cheltenham Link Road.

5.4.39. Advice from the Environment Agency indicates that a 4m easement on the south bank and a 2m easement on the north bank would be acceptable for their regulatory requirements. It is recognised by the Environment Agency that this is a reduction of easement width to below 8 m to help reduce the span, although it would need to be supported by a small layby to allow operatives to pull off the road to safely access.

5.4.40. The current proposals are for a 24 m wide span with the deck soffit set at least 600 mm above the predicted design flood level of 27.75 m AOD. The abutments will be set back from the river banks by 4 m on the north and 8 m on the south, permitting access under the bridge on both banks if required.

5.4.41. Maintaining a bankside strip will additionally act as a mammal easement below the Link Road in most river level conditions. As part of any additional design measures higher level mammal passage may be required below the roadway. This will be assessed following the completion of the flood modelling work.

Chelt floodplain structure

5.4.42. From an early stage of design it was recognised that the West Cheltenham Link Road would need to cross the wide floodplain of the River Chelt. The early design concept was for a viaduct, being a tall slender structure (see example in Figure 5-2).

5.4.43. The results of the hydraulic modelling demonstrate that a viaduct type crossing is a costly and inefficient solution, with the floodplain housing only shallow flooding moving at relatively slow velocities.

Figure 5-2 - Example viaduct structure

5.4.44. A more efficient solution has been developed to use multiple openings or culvert barrels (see example in Figure 5-3). The number and sizing has been proven with the Scheme hydraulic model. The testing applies a series of 3 m wide box culverts. The depth of flow across the floodplain is 197 mm on average, with a maximum depth of 640 mm in an existing field ditch. This shallow flooding could readily be conveyed in low height culverts, for example comprising 3m wide by 1m high box unit. Based on the total width of floodplain, and accounting for construction sizing (wall thickness etc) some 37 separate culverts are required.

5.4.45. The current set up is as follows:

- 18nr 3m wide by 1m high box culverts, split into two groups of 9 culverts either side of the existing field ditch. All placed at around ground level with an upstream invert level of 27.1 mAOD and downstream invert level of 27 mAOD
- 1nr 6m wide by 1.35m high box culvert carrying the existing field ditch, placed at around ground level with an upstream invert level of 26.75 mAOD and a downstream invert level of 26.45 mAOD
- 18nr 3m wide by 1m high box culverts in a single group, with the southernmost culvert approximately 75m south of the existing field ditch. All placed at around ground level with an upstream invert level of 27.1 mAOD and downstream invert level of 27 mAOD

5.4.46. Design development was undertaken to optimise this solution, concentrating on areas of high flow across the floodplain. A consistent invert level of each culvert was assumed to improve constructability, but varied as part of the testing. The results indicated there was a balance between the number of culverts and the predicted changes (small increases and decreases in flood risk) either side of the link road.

5.4.47. A reduction in this number may be possible once the change in design flow (climate change) is applied.

5.4.48. It is assumed that the land outside the ownership of GCC, predicted to suffer increased flooding, will be subject to a Right to flood agreement or similar. The Scheme balances the sustainability of further culverts (or different configurations) to provide extra flood conveyance with the magnitude of detriment and vulnerability of the receptors: the permanent scale, cost and impact of an alternative configuration would be significant when compared the temporary impact of the additional floodwater.

Figure 5-3 - Example multi-span bridge/culverts

Culverts

5.4.49. Four separate culverts carry the floodway under the existing M5 motorway: the River Chelt culvert, the Leigh Brook culvert at Barn Farm, the Piffs Elm culvert collecting overland flow near Withybridge Gardens; and the Staverton culvert carrying the Staverton stream.

5.4.50. The Scheme requires extension of two of these to maintain their hydraulic connectivity. The culverts will be maintained at their existing sizing. The current design requires for culvert extensions as follows:

- Piffs Elm culvert to be extended from 47 m long to 148 m long (101 m extension)
- Barn Farm culvert to be extended from 54 m long to 70 m long (16 m extension)
- The River Chelt culvert remains at 43.4 m long with no extension.
- The Staverton culvert remains at 50 m long with no extension.

5.4.51. The existing A4019 culvert will also need to be extended to maintain drainage flows under the road once it is raised and widened. Given the existing skew angle and associated length, this will instead involve straightening the existing twin 750 mm diameter culverts to cross the highway at 90-degrees and reducing their length from 88 m to 78 m.

5.4.52. The existing Withybridge Lane twin culverts, adjacent to the A4019, will need to be realigned to suit the widened highway embankment and their length extended from 10 m to 27.5 m to maintain drainage flows under Withybridge Lane.

5.4.53. The ecological requirements for these culvert extensions are being considered and applied to the hydraulic modelling.

Resilience and resistance

5.4.54. The best practice advice recommends a strategy for keeping floodwater out of the construction/development. This could be through the use of low permeability construction materials or local landscaping for dwellings, or raising threshold levels. However, such is not relevant for this Scheme.

5.4.55. The Scheme design does take account of the risk of flooding in the selection of materials and design parameters. The geotechnical aspects account for saturated conditions in the new highway embankments, as well as a draw down effect during recession of a flood. Such measures ensure that there is flood resistant construction and resilient design.

Predicted with-Scheme flood risk: fluvial/ surface water

5.4.56. Hydraulic modelling was used to predict the with-Scheme flood risk in the study area (and hence change from the Baseline). The description below reflects flood risk during the design flood, being the 1% annual exceedance probability event (1 in 100-year return period) with +70% increase in peak flow to account for future climate change. this will be updated in line with the July 2021 Environment Agency climate change guidance for the Environmental Statement.

5.4.57. The current results indicate that the Scheme can sufficiently maintain the hydraulic connectivity, floodplain conveyance and volumetric storage.

5.4.58. The results mapping, shown in Figure 5-4 to Figure 5-7, indicates that the Scheme will affect the existing overland surface water flow routes (principally the A4019 overspill): but that the proposed Scheme will not increase flood risk - it does not divert overland flows towards receptors or generate any significant areas of increased flood level. The results of the hydraulic modelling demonstrate the predicted flood risk with the Scheme in place, across the study area (and hence change from the baseline). This is described in more detail below.

1% annual exceedance probability event (1 in 100-year return period)

5.4.59. The effect of the Scheme on the baseline conditions for the present day 1% annual exceedance probability event (1 in 100-year return period) are detailed below. Further details are described in the Scheme Hydraulic Modelling Report[3].

5.4.60. The Scheme results generally show no significant difference to baseline flood extents in the Leigh Brook catchment, upstream and downstream of the motorway, for the 1% annual exceedance probability event (1 in 100-year return period).

5.4.61. At Uckington, west of the headwaters of the Leigh Brook, a new roadside drainage ditch as part of the Scheme is predicted to reduce flood levels by between 10-50 mm and thus reducing flood risk to the properties there.

5.4.62. There is a minor increase in flood levels just upstream of Barn Farm culvert, under the M5 motorway, where peak flood levels are predicted to increase by between 10-30 mm.

5.4.63. Baseline flows through Barn Farm culvert, which carries the Leigh Brook under the M5 motorway, are unaffected by the Scheme during the 1 in 100 year event. Peak flow predictions through this culvert, for both Baseline and Scheme, are 2.2 m^3/s.

5.4.64. In the Chelt catchment, there are some changes to flood extents upstream and downstream of the M5 motorway. Existing flooding has been removed within the proposed Scheme footprint; at the proposed motorway junction, the A4019 widening and the West Cheltenham Link Road (by virtue of the raised ground levels).

5.4.65. There is a reduction in flood levels upstream of the M5 motorway embankment, south of the A4019, resulting from excavated (reduced) ground levels where the flood storage area is proposed. However, the associated flood levels have increased by between 10-40mm upstream and downstream of Withybridge Lane culverts. There is a minor decrease in peak flows through the River Chelt culvert; reducing from 17.2 m^3/s in the baseline to 17.1 m^3/s with Scheme.

5.4.66. The Scheme results show a widespread reduction in flood levels downstream of the motorway embankment, south of the A4019. Less extensive flooding is predicted downstream of the Piffs Elm culvert, extending west to Boddington Road. Flood levels immediately downstream of the Piffs Elm culvert are reduced from the baseline by around 150 mm, and flood levels west of this are also reduced. There is also a reduction in flood levels near Boddington House, where flood levels are reduced by around 10-20 mm, and east of Boddington Manor, where existing levels are reduced by an average of 50 mm.

5.4.67. There is a modification in flood extents immediately upstream and downstream of the proposed West Cheltenham Link Road, which comprises of a mix of increases and decreases in flooding associated with the proposed link road culverts.

Design flood

5.4.68. The effect of the Scheme on the baseline conditions for the present day 1% annual exceedance probability event (1 in 100-year return period) with allowance for climate change (the design flood) are detailed below. Further details are described in the Scheme Hydraulic Modelling Report[3].

5.4.69. The results for this event show that the Scheme severs the overland flow across the A4019 into the Leigh Brook floodplain and thus there is a significant reduction in baseline flood extents in this catchment. The most significant reduction in baseline flood extents is alongside the motorway embankment, where areas with existing flood depths of >1 m no longer flood. There is a widespread reduction in baseline flood levels across the Leigh Brook floodplain; flood levels have reduced by an average of 1 m, both upstream and downstream of the motorway.

5.4.70. There is consequently a reduction in peak flow through Barn Farm Culvert, under the M5 motorway, the predictions reducing from 10.4 m^3/s to 4.6 m^3/s with-Scheme. This results in decreased baseline flood levels downstream of the M5 motorway and a reduction in out of bank flooding which continues west to the model's downstream boundary.

5.4.71. The raising of the A4019 in the with-Scheme model retains more water in the Chelt floodplain (which would have previously entered the Leigh Brook catchment). This causes a minor widening of the existing flood extents but results in a significant increase in flood levels upstream of the M5 motorway embankment. Increases in flood levels are most significant in the fields between the motorway and Withybridge Lane, where the proposed flood compensatory area is currently located.

5.4.72. As intended, water enters the flood storage area by the M5 motorway and results in deeper flooding as a result of excavated (reduced) ground levels – although flood levels here are predicted to rise locally by 250 mm. Flood depths in the storage area south of Withybridge Gardens increase from 1.60 m in the Baseline to 2.98 m with Scheme, and at the southern end of the storage area, north of Butlers Court, from 0.84 m in the Baseline to 2.98 m with Scheme.

5.4.73. No water overtops the A4019 with the Scheme and there is also less flow passing under the road through the existing A4019 culverts (1.6 m^3/s) compared to Baseline (3.3 m^3/s). However there are small increases in flood levels in the vicinity: in the field ditch north of the A4019 (just east of the existing A4019 culvert outfall); and south of the A4019, near the Withybridge Lane culverts.

5.4.74. New flooding is predicted on the compensatory floodplain, upstream of the proposed West Cheltenham Link Road, with up to 300 mm depth of floodwater predicted to inundate this area. Increases and decreases in flood levels are predicted both upstream and downstream of the proposed link road culverts.

5.4.75. An increase in flood levels is predicted west of Piffs Elm (near Elmstone Business Park), downstream of the M5 motorway embankment, where flows overtop the existing A4019 and raises flood levels in the amenity pond by 120 mm. This appears to be a result of redirection of existing floodwater in that area, and the Scheme is predicted to alleviate the property flooding predicted in the baseline.

5.4.76. Where there is a potential change in risk to properties or infrastructure, the impact will be assessed further. A change in water level of less than +/-10mm is considered insignificant[24] and within the model tolerance and therefore only if the change is greater than 10mm will it be considered further. In such areas (>10 mm), the ongoing hydraulic modelling is investigating whether additional conveyance, flood storage or compensatory floodplain can reasonably offset any predicted detriment.

5.4.77. Where any properties/infrastructure are predicted to have an overall increased flood risk (>10 mm) the project will need to mitigate this (local protection, compensatory floodplain/storage or additional conveyance). This currently applies to a public house (The Old Spot) south of Elmstone Business Park, whereby peak flood levels are predicted to increase by 60mm. However, it is intended that this detriment will be designed out in the coming months.

5.4.78. Where there is an increase in flood level (>10 mm) that does not impact on properties or infrastructure (i.e. on farmland or similar), the Scheme will consider whether the frequency or duration of flooding would increase, or whether this would impact on the use of the land. The impact will either then be mitigated or an acceptance sought with the landowner via a legal Right to Flood (or both). The project will also pursue a Right to Flood agreement, or similar, with affected landowners where the sustainability or environmental impact of the required mitigation outweighs the impact on 3rd parties.

5.4.79. As described above for the design flood, the Scheme is predicted to vary the pattern of flooding particularly around the West Cheltenham Link Road. Localised areas are predicted to see increased flood levels, and others reduced flood levels. Right to Flood agreements will be sought in these areas, accounting for the net impact on the farmland. These areas are:

- 5 fields of existing farmland either side of the West Cheltenham Link Road (increases in flood level of up to 100 mm and reductions of more than 100 mm);
- The compensatory floodplain on the east of the West Cheltenham Link Road (new flooding of up to 100 mm depth)
- 1 field of existing farmland north of Butlers Court, south of the flood storage area (increase in flood level of up to 250 mm)

Selected point results are tabulated below to give an indication of the With-Scheme flood depths (

[24] LA113 describes a change in water level of less than 10mm as being negligible in EIA terms. furthermore, Natural Resources Wales' Guidance Note 028 reflects a 10mm tolerance when defining model predicted change. A 10mm tolerance was agreed with the Environment Agency for this project on 29 April 2021.

5.4.80. Table 5-2) and flood flows (Table 5-3). The location of these points are shown in Figure 4-4.

5.4.81. The results mapping, shown in Figure 5-4 to Figure 5-7, showing the flood risk depth map and the level difference map for the 1% annual exceedance probability event (1 in 100-year return period) both in present day, and with 100-years climate change allowance.

Table 5-2 - Scheme flood depths

Location	Depth (m)		
	1% AEP	1% AEP with climate change	0.1% AEP
1 Leigh Brook nr Barn Farm culvert	0	0	0
2 Leigh Brook existing slip road	0	0.11	0.11
3 Leigh Brook nr A4019	0	0.03	0.03
4 A4019	0	0	0
5 Withybridge Gardens	1.41	2.98	3.01
6 north of Butlers Court	1.41	2.98	3.01
7 Eastern end of River Chelt floodplain	0.19	0.27	0.27
8 nr Staverton culvert	0.33	0.44	0.42
9 Boddington Lane	0.36	0.45	0.45

Table 5-3 - Scheme flood flows

Location	Flow (m^3/s)		
	1% AEP	1% AEP with climate change	0.1% AEP
A Barn farm culvert	2.2	4.6	4.6
B Piffs elm culvert	0.8	2.6	2.6
C River Chelt culvert	17.1	21.1	20.5
D Staverton culvert	2.8	2.9	2.9
E A4019 culvert	0	1.6	1.6
F A4019 over the top	0	0	0
G Withybridge Lane	10.2	26.4	24.6
H Boddington Lane	0.2	4.4	4.1

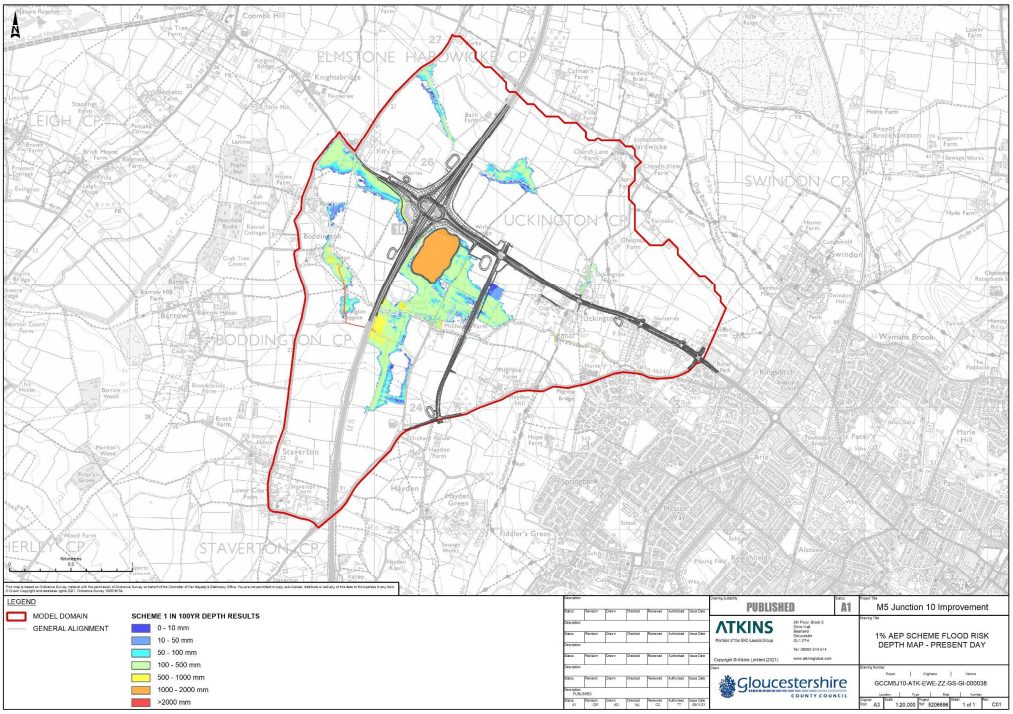


Figure 5-4 - 1% AEP Scheme flood risk depth map – present day

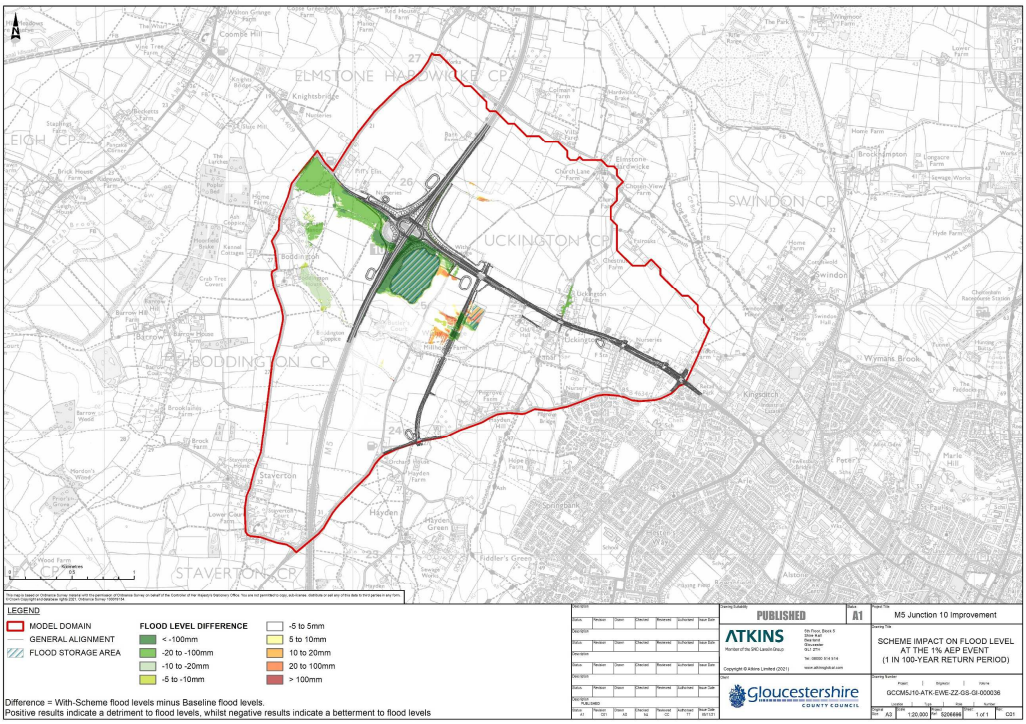


Figure 5-5 - 1% AEP level difference map – present day

Scheme flood levels minus Baseline flood levels. A + change is an increase in flood risk. A – change is a reduction in flood risk

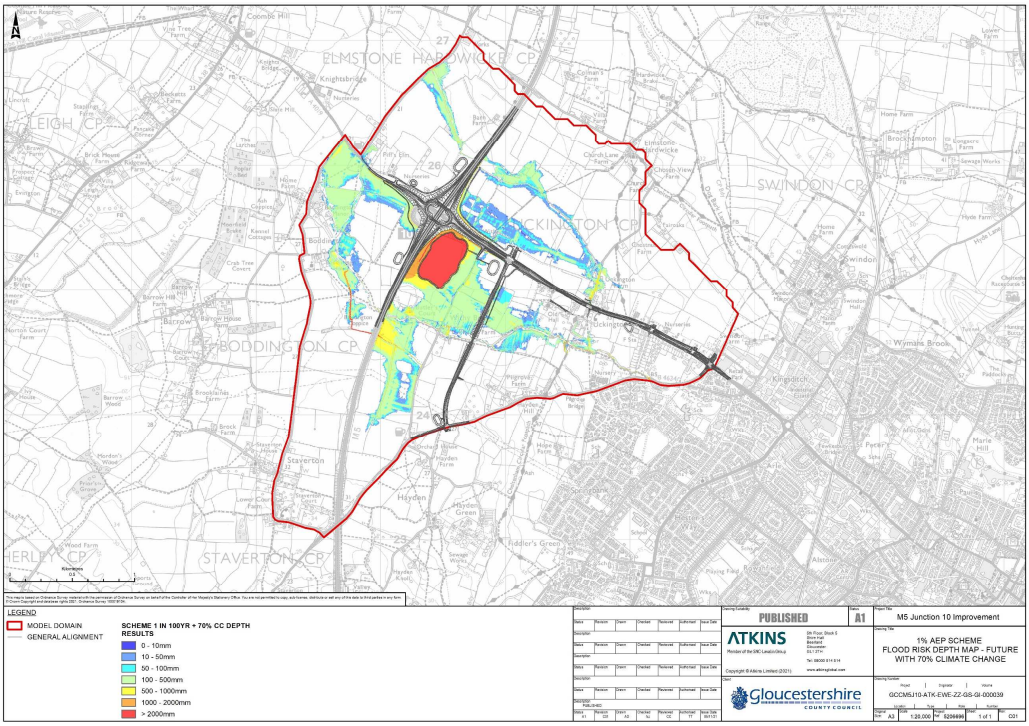


Figure 5-6 - 1% AEP Scheme flood risk depth map – future with climate change

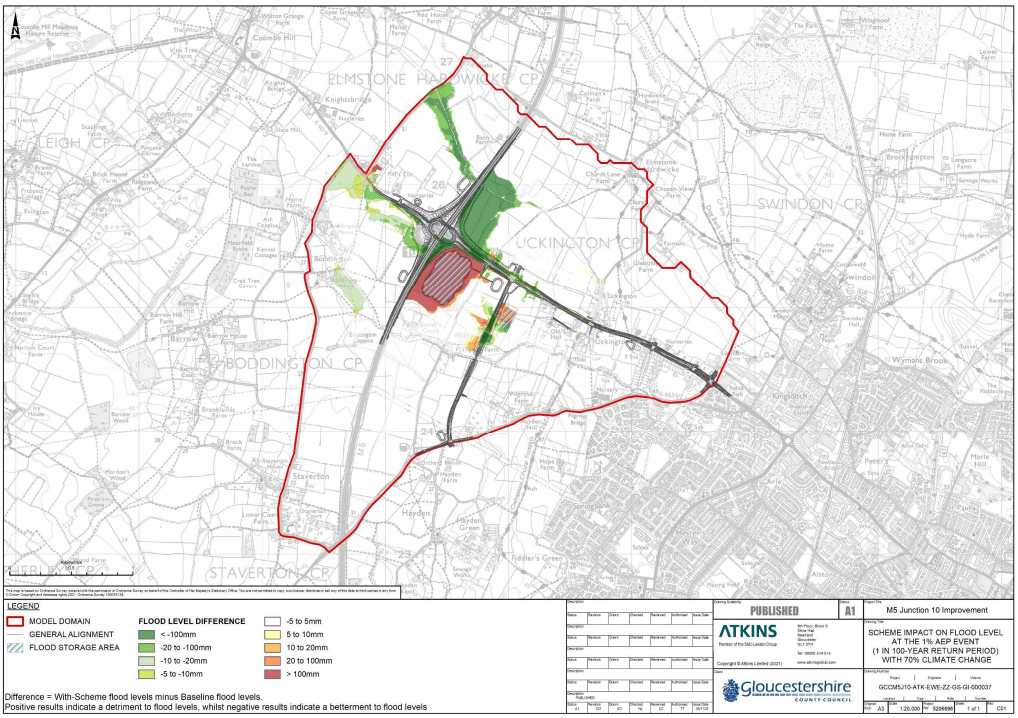


Figure 5-7 - 1% AEP level difference map – future with climate change

Scheme flood levels minus Baseline flood levels. A + change is an increase in flood risk. A – change is a reduction in flood risk

5.5. Mitigate

5.5.1. Where required essential (additional) measures will be required to manage/mitigate any unacceptable consequences. Essential mitigation on this Scheme might include for additional compensatory floodplain as may be required to offset the hydraulic impacts (afflux) of the crossing, or Right to Flood agreements with impacted 3rd party land owners.

5.5.2. At the time of the PEIR FRA, some essential mitigation is required by the Scheme for some small off site impacts (see Section 5.7 below). However, efforts will be made to design this out before publication of the Environmental Statement.

5.5.3. Right to Flood agreements will be required for various areas of farmland where small changes in flood risk are predicted. Future flood risk assessment work on this Scheme will quantify those local impacts in terms of extent, depth, frequency, and duration to enable acceptance of the effects or promote any essential mitigation.

5.6. Management of flood risk

5.6.1. The construction works have the potential to temporarily increase flood risk. Temporary works to enable the construction of the River Chelt bridge and its floodplain crossing may require a narrowing of the channel or floodplain for a short period. The increase flood risk caused by this activity could be managed by undertaking during normal flow conditions when inclement weather is not forecast, or having the appropriate measures in place to deal with flows.

5.6.2. It is recommended that the Contractor monitors weather conditions and river flows and makes due allowance for materials and plant storage should high rainfall be predicted. As described above for mitigation, advice from the Environment Agency should be sought and where possible the site manager register the works for Floodline Warnings Direct: by calling Floodline on 0845 988 1188 or Typetalk 0845 602 6340 or on the internet at https://fwd.environment-agency.gov.uk/app/olr/register

5.6.3. The contractor should also ensure that emergency plans are in place to maintain the defacto flood defences (raised river banks) during the works.

5.6.4. During operation of the Scheme it is likely that river borne debris will be deposited at the culvert inlets and bridge abutments as it is washed along the River Chelt or Leigh Brook. This will need to be cleared as part of a routine and event specific maintenance regime for the Scheme to reduce, to alleviate the risk of culvert blockage.

5.7. Off site impacts

5.7.1. The proposed Scheme has been tested in the hydraulic model to evaluate any impact on flood risk elsewhere. The Scheme with the embedded mitigation typically reduces the impact on flood risk to that of a slight or negligible adverse impact. There are also large areas where a betterment is predicted, significantly in the Leigh Brook catchment upstream of the M5 motorway.

5.7.2. However, there are currently areas outside the preliminary draft DCO pre-application site boundary, or Order Limits (known as the red line boundary) that may be impacted. At Uckington, the Scheme changes flood risk for two properties during the design flood by raising peak flood levels by 10 mm. This impact is within the hydraulic model tolerance and considered negligible. West of the motorway junction the Scheme is predicted to impact Elmstone business park with a mix of both small increases (up to +60 mm affecting the Old Spot public house) and decreases (up to -10 mm and hence limited to model tolerance) in peak flood level. Ongoing work will address the property impact and essential mitigation developed. The impact assessment is described in the PEIR[4].

5.7.3. Where the magnitude of impacts on 3rd party land is considered minor or moderate (10 mm to 100 mm) and/or it is economically or environmentally unsustainable to provide additional mitigation measures, the Scheme will propose the use of Right to Flood agreements. These will be legal agreements with the landowners to permit use of their land to hold more floodwater, be that over a wider extent, with deeper depths, for longer or more frequently. Much of the change in flood risk is currently defined inside the red line boundary, with both betterments and detriments arising in localised areas. This balance of a changing risk will be taken into account through any landowner agreements.

5.7.4. The final version of this FRA, supporting the Environmental Statement, will describe the offsite impacts predicted by the hydraulic modelling both inside and outside the red line boundary, and where Right to Flood agreements are being sought.

6. Residual Risks

There are always residual risks, caused by failure or over-design events. This section describes these in relation to the M5 Junction 10 Improvements Scheme.

6.1. Extreme event

6.1.1. The residual risks of the extreme event (0.1% annual exceedance probability event (1 in 1,000-year return period) as defined in the NPPF) are of deeper flooding and higher velocities in the river and on the floodplain. This event has been simulated in the hydraulic model and described in both the Baseline Hydraulic Modelling Report[2] and Scheme Hydraulic Modelling Report[3].

6.1.2. The hydraulic modelling demonstrates that the Scheme itself does not become flooded from the watercourse or overland flow during this extreme event. In fact, the 0.1% annual exceedance probability event (1 in 1,000-year return period) is marginally smaller than the 1% annual exceedance probability event (1 in 100-year return period) with 70% allowance for climate change (no comparison has yet been made with the July 2021 revised climate change guidance).

6.1.3. It is recognised that the highway drainage system will not cope with such intense rainfall and that water will be spilling off the carriageways onto the surrounding land. This water will be unattenuated. However, in such an extreme event, the paved areas are likely to respond in a similar way to the surrounding farmland, with no infiltration and all rainfall being held on the ground surface. In such a situation, this will be no change from the baseline condition.

6.1.4. The Scheme and other surrounding areas will remain at flood risk in the extreme event. Surrounding areas are predicted to flood in the current situation. This frequency will increase with the impacts of climate change – although it is not currently UK best practice to apply climate change allowances on the 0.1% annual exceedance probability event (1 in 1,000-year return period) given the uncertainty on both estimates.

6.2. Risk of breach

6.2.1. There are no formal existing raised defences in the study area that may breach in the future and impact on the Scheme. Those river banks along the River Chelt that are elevated are not at risk of breach, being natural features or non-continuous structures that are already outflanked by floodwaters.

6.2.2. Risk of breach or defence failure is not an issue for this FRA.

6.3. Access and egress conditions

6.3.1. The Scheme, particularly the West Cheltenham Link Road, will provide a link between developing urban areas. The design is intended to provide safe access, and will be designed to be flood free from fluvial sources during the design event (1% annual exceedance probability event (1 in 100-year return period) over the lifetime of the development).

6.3.2. The road is likely be flooded by overload of its own drainage system during an extreme event. The NPPF Planning Practice Guidance acknowledges this and states that "…where this [dry access] is not possible, limited depths of flooding may be acceptable…".

6.4. Management over development lifetime

6.4.1. There are lifetime management issues for the proposed Scheme related to the management and maintenance of the watercourses and its related infrastructure. It appears that the River Chelt channel through the M5 motorway culvert has suffered from accumulations of sediments and debris over the years. Any trash/debris deposited at or in the culvert will need to be removed from the site to maintain the hydraulic capacity, reducing the risk of blockage, which would otherwise raise flood level on the eastern side of the M5 motorway. It is a similar need for the Leigh Brook, Piffs Elm and Staverton culverts.

6.4.2. The new hydraulic structures for the West Cheltenham Link Road and A4019 will need regular inspection and maintenance. Accumulations of sediments and debris at these will increase flood risk on the surrounding land, and could cause property flooding. It should be noted that flood flows will increase with time in line with climate change. This will increase the frequency for channel and structure maintenance.

6.4.3. The risk of blockage of the existing river and floodplain crossings has been considered. Blockage runs were completed for the baseline conditions as described in the Baseline Hydraulic Modelling Report[2].

6.4.4. The risk of blockage of the new river and floodplain crossings will be considered separately at each of the two locations for the 1% annual exceedance probability event (1 in 100-year return period) to isolate the impacts of each and advise any operation and maintenance manual for the Scheme. Blockage runs will be completed based on the Environment Agency's Blockage management guide[25]. This indicates that, for culverts, up to a 100% blockage should be considered. Completion of 100% blockage runs in the hydraulic model may not be possible: it results in zero flow in the downstream channel, which may cause the hydraulic model to fail. Model runs will therefore be completed with a degree of blockage as close to 100% as possible without destabilising the model.

6.5. Flood warning and evacuation

6.5.1. At this stage of the project no specific flood warning systems are considered necessary for the Scheme, nor are any flood-focussed emergency evacuation plans except during the construction period. The contractor should allow for evacuation of the works and safe storage of all plant and materials out of the river and floodplain.

[25] Environment Agency, 2019. Blockage management guide, Guide – SC110005/R1.

7. Summary and conclusions

7.1.1. This PEIR FRA has presented a preliminary assessment of flood risk to the M5 Junction 10 Improvements Scheme, and the potential flood effects on external receptors arising from it. In so doing, it is acknowledged that the assessment is based on developing design information, and that final detailed assessments of risks and effects have not yet been completed.

7.1.2. This FRA concludes that:

- The Scheme crosses Environment Agency Flood Zone 2 and 3
- The vulnerability classification of the proposed Scheme is Essential Infrastructure.
- The Scheme vulnerability is compatible with the envisaged flood risk
- The Scheme satisfies the Sequential Test
- The Scheme satisfies the Exception Test (in accordance with the NPPF) as it has been demonstrated that flood risk can be managed satisfactorily over the lifetime of the development.

7.1.3. The proposed development is at risk from flood sources as summarised below, with the risk based on the published Environment Agency data and supported by the hydraulic modelling undertaken for the project.

Table 7-1 - Summary of flood risk

Flood risk Source	Yes/No	Risk	Further assessment?
Fluvial	Yes	High	Ongoing
Surface water	Yes	High	Ongoing
Groundwater	Yes	Medium	Yes
Coastal/tidal	No	N/A	No
Sewers	No	N/A	No
Other sources	No	Low	No

7.1.4. The Sequential Test is passed for the DCO Scheme, through demonstration of the site selection process that took flood risk into account alongside other constraints.

7.1.5. Increases in rainfall and river flow arising from future climate change will increase flood risk from all sources. The increase in flood risk off site, due to climate change, will not be exacerbated by the Scheme.

Fluvial flooding

7.1.6. Parts of the Scheme are shown to coincide with the predicted flood extents which requires mitigation (embedded or additional) to alleviate. The fluvial assessment demonstrates that the Scheme is appropriate in terms of flood risk, having passed Part B of the Exception Test, by demonstrating that flood risk is not increased elsewhere as a result of those measures. The remainder of the Scheme is appropriate on the basis of development vulnerability and Flood Zone compatibility.

7.1.7. On the basis of the information it is concluded for this PEIR assessment that the Scheme will be appropriate in that all applicable fluvial flood risks and effects are acceptable. This is on the basis that ongoing engineering design works (including compensatory floodplain and storage areas) will ensure that any fluvial flood effects are acceptable in the context of receptor vulnerability and sensitivity.

Surface water flooding

7.1.8. The assessment of surface water flood risk has shown that the Scheme is not at significant risk from this source of flooding. While there are parts that intersect areas of pluvial flood risk any flood risks associated with this can readily be mitigated through incorporating appropriate landform and drainage measures and sequentially siting site specific components in areas of least pluvial flood risk.

7.1.9. It is concluded that the Scheme is appropriate in terms of all applicable pluvial flood risks being acceptable. This conclusion is subject to due consideration being given in the design process to ensuring that designs won't affect the baseline pluvial flood risk (it being smaller than the fluvial flood risk for which impacts are being mitigated) and that the principles of designing for exceedance are adhered to, as guided by the outputs of this PEIR FRA and ongoing collaboration between the FRA and respective design teams.

Groundwater flooding

7.1.10. The appraisal of available information, and subsequent initial groundwater assessment of groundwater flood risk, has shown that, in general, there is the widespread potential for groundwater emergence at the surface due to the permeable geology and relatively flat topography. It should be noted that further groundwater details such as site-specific intrusive ground investigations are ongoing and will be used to inform the assessment further and enable a more robust analysis of the groundwater conditions when available. Based on the initial groundwater assessment, it is expected that land reprofiling and drainage measures will sufficiently mitigate the risks to the Scheme. As such, groundwater flood risk is likely to be acceptable.

7.1.11. While this is also likely to be an issue for foundations, it is anticipated that ongoing refinement of Scheme designs prior to the planning application will allow a conclusion that groundwater flood risk to subsurface structures is acceptably managed.

7.1.12. The risk to the Scheme will be updated as an iterative process as and when further data are available.

Highway drainage

7.1.13. The Scheme development of a new motorway junction, highway widening and link road, including new bridges and road embankments will increase the impermeable area across a partly greenfield environment. The increase in runoff rates, will be managed through the application of a drainage (SuDS) strategy.

Flooding from other sources

7.1.14. The residual risk associated with all sources of artificial flooding is evaluated to be very low and does not place any constraints or requirements for additional environmental measures on the Scheme. The flood risk associated with a number of existing infrastructure were considered including the Dowdeswell reservoir, canals, sewers. These features have been deemed to pose a very low residual risk based on the very low probabilities of any of the infrastructure failing. This in many cases is due to the requirements of the asset owners to inspect and maintain their assets.

Based on the assessment summarised above, the residual risk associated with all sources of artificial flooding is evaluated to be very low and does not place any constraints or requirements for environmental measures on the Scheme.

7.2. Answers to the key questions

7.2.1. The FRA can now address the questions defined by the scope in Section 1.5.

Is the site likely to be at risk of flooding from: a watercourse, the sea, an estuary, groundwater, overland flow, an artificial drainage system, infrastructure failure?

Yes, there is a risk of flooding from the River Chelt and the Leigh Brook.

Is the proposed development likely to obstruct the maintenance access requirements or affect the integrity of an existing flood defence?

No, the Scheme will provide maintenance access to the River Chelt from the West Cheltenham Link Road for maintenance of the crossings and river in general. Similarly, the maintenance access to the Barn Farm culvert on the Leigh Brook will be replaced. There are no existing flood defences that will be affected by the Scheme.

Is the proposed development likely to increase flood risk elsewhere due to increased runoff rates and volumes from the site?

No, whilst the Scheme could increase runoff and flood risk, controls on peak discharge rates and volumes are included in the design.

Given the above, and the nature of the development, is continued promotion of a possible development at the site appropriate?

Yes – the Scheme can satisfy the requirements of the NPPF with regards flood risk.

Furthermore, as a Scheme crosses the floodplains of the River Chelt and Leigh Brook the specific requirements for Flood Zone 3b should be designed and constructed to.

Will it remain operational and safe for users in times of flood?

Yes, the Scheme is being designed around the 1% annual exceedance probability event (1 in 100-year return period) with allowance for climate change on peak flow over the lifetime of the development. The current design and assessment is based on the now superseded peak flow allowance of +70%. The FRA to support the Environmental Statement will apply the July 2021 guidance of +53%.

Will it result in no net loss of floodplain storage?

The Scheme will present a footprint in the floodplain to carry the road/s over the watercourses and hence displace floodwater. The design will include compensatory floodplain, and flood storage, to replace this.

Will it not impede water flows, and not increase flood risk, elsewhere?

The proposed Scheme will impede water flows in the River Chelt preventing them from overtopping the A4019 into the Leigh Brook. The compensatory flood storage will ensure this does not increase flood risk elsewhere, except where agreed with those 3rd party owners though right to Flood agreements.

7.3. Concluding remarks

7.3.1. In conclusion, on the basis of the information provided in this PEIR FRA, it is concluded that the Scheme will not be at significant risk of flooding, subject to the implementation of site specific fluvial flood mitigation measures. Furthermore, the Scheme should not result in an increase in flood risk to third parties.

7.3.2. On this basis, for the purposes of this PEIR FRA, it is concluded that, subject to the adherence to the guiding water management principles, sufficient information will be provided in the planning application to ensure that there will be no increase in flood risk as a result of fluvial, surface or ground water arising from the Scheme during its construction and operational phases.

8. Recommendations

8.1.1. No recommendations are made from this FRA at this stage.

Appendices

Appendix A. Planning policy tests

A.1. Sequential test

Please refer to document:

Atkins, February 2021, West Cheltenham Link Road Route Corridor Assessment, GCCM5J10-ATK-HSN-L2-TN-CH-000002, revision P01

A.2. Exception test

The exception test should only be applied after the application of the Sequential test. For this site and proposed M5 Junction 10 Improvements Scheme, the Exception test is required.

Following the steps set out in the NPPF, paragraph 027, Table 3 and Diagram 3, for the Exception Test (set out in NPPF paragraph 102) to be passed the development must pass both parts of the Exception Test.

Source NPPF, Paragraph 067

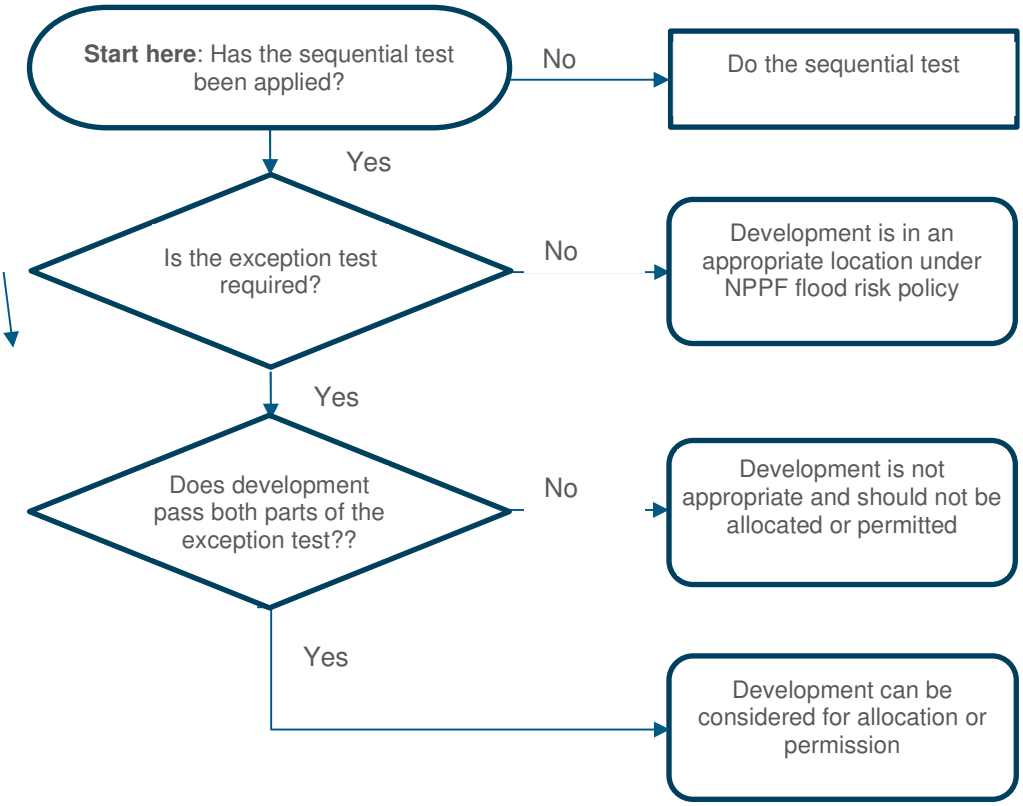


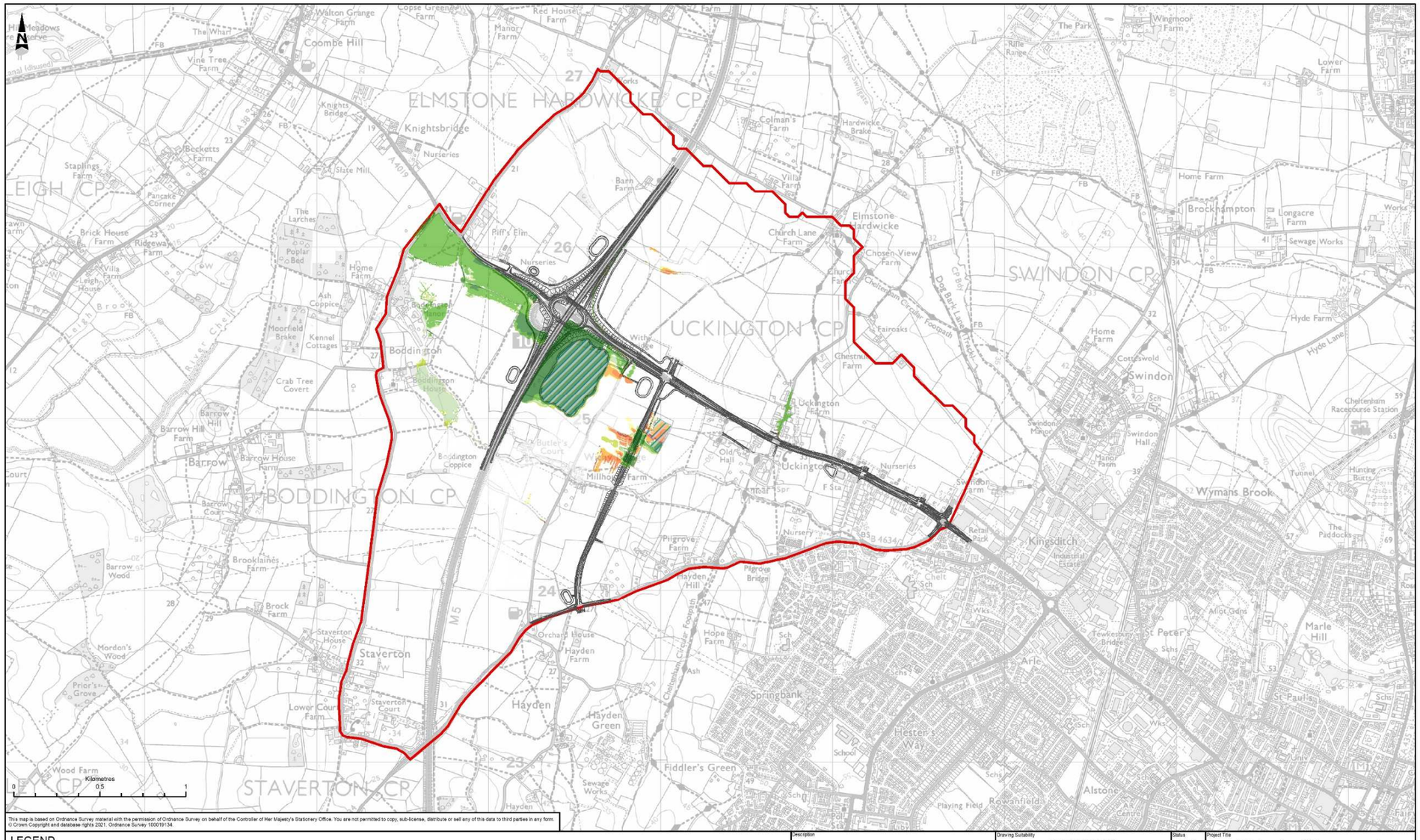
Figure A- 1 - NPPF Sequential Test application on proposed junction

Appendix B. Scheme drawings

Please refer to drawings:

- Atkins, M5 J10 All movements layout with engineering constraints, GCCM5J10-ATK-HGN-ZZ-DR-CH-00001, revision P02.3
- Atkins, M5 J10 All movements layout with engineering constraints, GCCM5J10-ATK-HGN-ZZ-DR-CH-00002, revision P02.3
- Atkins, M5 J10 All movements layout with engineering constraints, GCCM5J10-ATK-HGN-ZZ-DR-CH-00003, revision P02.3
- Atkins, M5 J10 All movements layout with engineering constraints, GCCM5J10-ATK-HGN-ZZ-DR-CH-00004, revision P02.3

Appendix C. Flood level difference grids



LEGEND

- MODEL DOMAIN
- GENERAL ALIGNMENT
- FLOOD STORAGE AREA

FLOOD LEVEL DIFFERENCE

- < -100mm
- -20 to -100mm
- -10 to -20mm
- -5 to -10mm
- -5 to 5mm
- 5 to 10mm
- 10 to 20mm
- 20 to 100mm
- > 100mm

Difference = With-Scheme flood levels minus Baseline flood levels.
Positive results indicate a detriment to flood levels, whilst negative results indicate a betterment to flood levels

Description	Status	Revision	Drawn	Checked	Reviewed	Authorised	Issue Date
PUBLISHED	A1	C01	AD	NJ	CC	TT	05/11/21

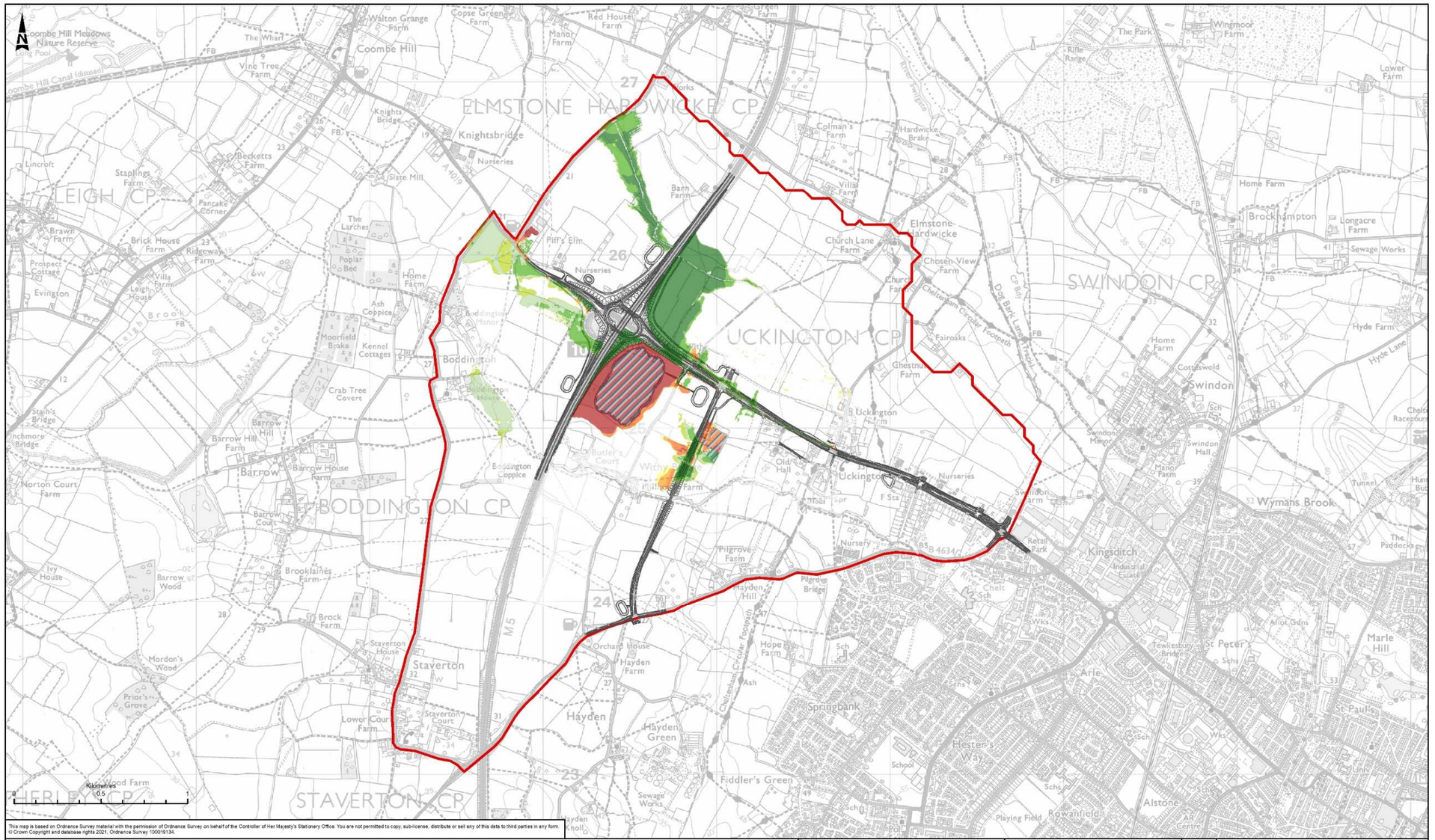
Drawing Suitability: PUBLISHED
Status: A1
Project Title: M5 Junction 10 Improvement
Drawing Title: SCHEME IMPACT ON FLOOD LEVEL AT THE 1% AEP EVENT (1 IN 100-YEAR RETURN PERIOD)

ATKINS
Member of the SNC-Lavalin Group
5th Floor, Block 5
Shire Hall
Bearland
Gloucester
GL1 2TH
Tel: 08000 514 514
www.atkinsglobal.com

Client: Gloucestershire County Council

Drawing Number: GCCM5J10-ATK-EWE-ZZ-GS-GI-000036

Original Size	Scale	Project Ref	Sheet	Rev
A3	1:20,000	5206696	1 of 1	C01



LEGEND

- MODEL DOMAIN
- GENERAL ALIGNMENT
- FLOOD STORAGE AREA

FLOOD LEVEL DIFFERENCE

- < -100mm
- -20 to -100mm
- -10 to -20mm
- -5 to -10mm
- -5 to 5mm
- 5 to 10mm
- 10 to 20mm
- 20 to 100mm
- > 100mm

Difference = With-Scheme flood levels minus Baseline flood levels.
Positive results indicate a detriment to flood levels, whilst negative results indicate a betterment to flood levels

Description	Status	Revision	Drawn	Checked	Reviewed	Authorised	Issue Date
	PUBLISHED	C01	AD	NJ	CC	TT	05/11/21

Drawing Suitability: PUBLISHED — Status: A1

ATKINS
Member of the SNC-Lavalin Group
5th Floor, Block 5
Shire Hall
Bearland
Gloucester
GL1 2TH
Tel: 08000 514 514
www.atkinsglobal.com

Client: Gloucestershire County Council

Project Title: M5 Junction 10 Improvement

Drawing Title: SCHEME IMPACT ON FLOOD LEVEL AT THE 1% AEP EVENT (1 IN 100-YEAR RETURN PERIOD) WITH 70% CLIMATE CHANGE

Drawing Number: GCCM5J10-ATK-EWE-ZZ-GS-GI-000037
(Project | Originator | Volume | Location | Type | Role | Number)

Original Size	Scale	Project Ref	Sheet	Rev
A3	1:20,000	5206696	1 of 1	C01

Appendix 8.2 – WFD Compliance Assessment

Contents

Tables

Figures

Document accessibility

If you need to access this report in a different format like accessible PDF, large print, easy read, audio recording or braille, please get in touch with our team who will do their best to assist.

You can contact us by email on M5Junction10@atkinsglobal.com, leave us a voicemail on 01454 667900 or write to us at M5 Junction 10 Team, Atkins, 500 Park Avenue, Bristol, BS32 4RZ. You can also view Gloucestershire County Council's Accessibility Statement on our website at https://www.gloucestershire.gov.uk/accessibility/

1. Introduction

1.1. Scheme Background

1.1.1. The M5 Junction 10 Improvements Scheme (The Scheme) is located 48 miles to the south of Birmingham, five miles to the south of Tewkesbury, four miles to the north-west of Cheltenham, and eight miles to the north-east of Gloucester. It is the northernmost of four junctions serving the Gloucester and Cheltenham urban areas. The A4019 connects northern Cheltenham to the motorway at junction 10. The Scheme proposes widening of the A4019 to improve traffic flow to and from junction 10 while upgrading the motorway junction to an all purpose, signalised roundabout will allow both northbound and southbound access. A link road will also run parallel to the M5 carriageway, connecting the A4019 to the A40: the connection between southern Cheltenham and junction 11 of the M5.

1.2. Purpose of the report

1.2.1. The Scheme is currently at the preliminary design stage (PCF Stage 3) with this Water Framework (WFD) compliance assessment and the Preliminary Environmental Information Report (PEIR) developed in tandem.

1.2.2. The purpose of this WFD assessment is threefold:

- Understand the Zone of Influence and baseline conditions;
- Understand which water bodies within the Zone of Influence have the potential to be impacted; and,
- Assess the potential impacts against the embedded mitigation and develop the Scheme design to ensure that appropriate additional mitigation is in place where significant impacts may occur.

1.3. Legislative Background

1.3.1. The European Union (EU) Water Framework Directive (Council Directive 2000/60/EC) - also transposed into English and Welsh law in 2003 through The Water Environment (Water Framework Directive) (England and Wales) Regulations 2017 - aims to protect and enhance the quality of the water environment across all EU member states. Whilst the United Kingdom is no longer a member of the EU (as of 31 January 2020), The Water Environment (Water Framework Directive) Regulations form the framework behind this WFD assessment. The WFD's principal aims are to protect and improve the water environment and promote the sustainable use of water. The headline environmental objectives of the WFD and its daughter directives are to:

- To prevent deterioration of the status of water bodies;
- To protect, enhance and restore all water bodies with the aim of achieving 'good status' by 2027 at the latest;
- To progressively reduce or phase out the release of individual pollutants or groups of pollutants and cease or phase out emissions, discharges and losses of priority hazardous substances;
- To prevent or limit the entry of pollutants to groundwater; and,
- To comply with the requirements of all WFD Protected Areas.

WFD compliance

1.3.2. There are three key objectives against which the impacts of proposed works on a water body need to be assessed to determine compliance with the overarching objectives of the WFD:

- Test A: The proposed scheme will not cause a deterioration in any element of water body classification;
- Test B: The proposed scheme will not prevent the WFD status objectives from being reached within the water body or other downstream water bodies; and,
- Test C: The proposed scheme will contribute to the delivery of the relevant WFD objectives. In this case, it will be what contribution the proposed scheme can make towards the water body reaching its objective GES through planned RBMP mitigation measures.

1.3.3. The first two obligations must be met to avoid infraction of the WFD. The delivery of the third objective is central to the EA's implementation of the WFD, where it can be supported through its operational activities.

Surface water bodies

1.3.4. The WFD sets a default objective for all rivers, lakes, estuaries, groundwater, and coastal water bodies to achieve Good Status by 2027 at the latest. For natural surface water bodies, Good Status is a function of both Good Chemical Status (GCS) and Good Ecological Status (GES). The River Basin Management Plans (RBMPs) outline the actions required to enable natural water bodies to achieve these objectives. Artificial and Heavily Modified Water Bodies (A/HMWBs) are considered unable to attain GES due to the modifications that are necessary to maintain their function for society or their 'human use' as they provide important socio-economic benefits. They are, however, required to achieve Good Ecological Potential (GEP), through the implementation of a series of Mitigation Measures. A/HMWBs still need to attain GCS which, along with GEP will collectively result in Good Status in these water bodies.

1.3.5. New activities and schemes that affect the water environment may adversely impact WFD quality elements that could lead to a deterioration in water body status. They may also preclude the implementation or effectiveness of the proposed improvement measures, leading to the water body failing to meet its WFD objectives for GES/GEP. Under the WFD, activities and schemes must not cause deterioration in water body status or prevent a water body from meeting GES/GEP by invalidating improvement measures.

1.3.6. The overall ecological status of a water body is primarily based on consideration of its biological quality elements (phytoplankton, macrophytes, phytobenthos, benthic invertebrates and fish) and is determined by the lowest scoring of these elements. These biological elements are supported by the physico-chemical (water quality) and hydromorphological quality elements.

1.3.7. To achieve GCS, a water body must pass a separate chemical status assessment, relating to pass/fail checks on the concentrations of various identified priority/dangerous substances.

Groundwater bodies

1.3.8. For groundwater bodies, good status has a quantitative and a chemical element. Both are measured on a scale of good, moderate or poor, and a confidence rating is assigned to the status assessment of high or low. Together, these provide a single final classification of either good or poor status. There is also a trend objective set for groundwater water bodies where environmentally significant and sustained rising trends in pollutant concentrations need to be identified along with a definition of the starting point (percentage of level or concentration) for trend reversal. Furthermore, the daughter directive of the WFD specifically concerning groundwater (the Groundwater Directive) also requires the

prevention of any input of priority substances and limiting (or control) of the input of all other substances to groundwater to prevent the deterioration of status.

2. Methodology

2.1.1. As the project will be designated as a Nationally Significant Infrastructure Project (NSIP) it would go through a Development Consent Order (DCO) process. As a result, the WFD Assessment follows guidance produced by The Planning Inspectorate (PINS) in advice note 18 on WFD (PINS, 2017) which was developed specifically for projects that fall within this process. The guidance suggests that a WFD assessment be comprised of three key stages:

- Screening assessment;
- Scoping assessment; and,
- Impact assessment.

2.1.2. Further details of these stages can be found in the sections below. In addition to this guidance, the Environment Agency (EA) position statement 488_10 (2016) has been used, where appropriate, to inform this assessment. This WFD compliance assessment includes all three stages outlined in both guidance documents.

2.2. Stage 1 – WFD screening

2.2.1. An initial screening assessment determined the Zone of Influence (ZoI) of the Scheme and identified the potentially affected surface and groundwater bodies.

2.2.2. An assessment was made to determine if there were any activities associated with the Scheme that do not require further consideration; for example, activities which have been ongoing since before the current RBMP cycle and have thus formed part of the baseline.

2.2.3. Water bodies where there was a high confidence of no impact were screened out from detailed investigation at this stage: including those water bodies which were considered too far upstream or downstream to be impacted and those with no hydrological connectivity to the Scheme.

2.3. Stage 2 – WFD Scoping

2.3.1. For the WFD scoping stage, a desk study presented the baseline characteristics of each WFD water body using Catchment Data Explorer (Environment Agency, 2021) and the RBMP. This includes current classification status for all elements, pressures affecting the water body, its sensitivity to change and identification of watercourses within each water body.

2.3.2. Field surveys were undertaken by an experienced fluvial geomorphologist and aquatic ecologist. Assessments were made to characterise (e.g. the form and processes) the receptors within the surface water bodies potentially affected by the Scheme, as identified in the screening assessment.

2.3.3. An assessment identified the mechanisms of impact from the Scheme to the surface water and groundwater receptors within the ZoI based on the relevant water bodies as identified during the Stage 1 screening. The mechanisms of impact which have been considered are presented in Table 2-1.

Table 2-1 - Mechanisms of impact

Mechanism of impact	Description	WFD element impacted				
		Biological	Physio chemical	Specific pollutants	Hydromorp-holgoical	Chemical
Direct loss of open channel	Any direct loss of watercourse or ditch. This could be from new culverts, culvert extensions or bridges which will have a significant impact on the receptor.	✓				
Habitat severance	Disconnection of habitats within the water body due to activities such as weirs, steep hydraulic gradients, or culverts.	✓				
Shading	Loss of light from the channel which is not associated with direct loss of habitat.	✓				
Changes in water quantity (due to discharge of surface water runoff to surface water body)	Changes in the flow in the receiving watercourses due to any alterations to the impermeable area and drainage system.	✓	✓	✓		✓
Changes in water quality (due to changes in surface water runoff during flood to surface water body)	Changes in water quality in the receiving water courses due to increased runoff, and pollutants from routine runoff and spillages.	✓	✓	✓		✓
Creation of new habitats	Any additional habitat creation as part of the Scheme. For example, enhancements of water courses or creation of new ditch length.	✓				
Changes to water body hydromorphology leading to changes in river processes and habitats upstream and downstream	Changes to the channel bed and bank which is not associated with a direct loss of habitat. For example, this could be due to higher flows, reduced vegetation coverage or installation of hard bed or bank protection.				✓	

2.3.4. At this stage, there is not sufficient information on the Scheme activities to identify mechanisms of impact to groundwater bodies.

2.3.5. Scheme activities were scoped in and out based on the mechanisms of impact identified and the low risk categories in the EA position statement 488_10 (2016).

2.4. Stage 3 – WFD impact assessment

2.4.1. Once the Scheme activities had been scoped in or out during Stage 2 Scoping, a WFD impact assessment (Stage 3) was undertaken.

2.4.2. A “Red, Amber, Yellow, Green, Blue” (RAYGB) coding system was used in a risk based approach. Definitions for the colour coding were assigned to indicate the level of risk of objective non-compliance within each water body, accounting for a) mitigation already “embedded” into the preliminary design (as summarised in section 5.2 of this document) and b) additional mitigation to be integrated into later phases of the design (as set out in section 6.2). The definitions are outlined in section 6.

2.4.3. The Highways England Water Risk Assessment Tool (HEWRAT) assessment was also undertaken to understand the water quality impacts from the Scheme. The results of the HEWRAT assessments have been used to inform the potential impacts on the surface water bodies and watercourses for this WFD assessment.

Table 2-2 - Definitions of the colour coding system used to determine impacts

Type of impact	Impact of scheme element on WFD element i.e. in individual cells	Impact on WFD element i.e. at end of row	Impact on WFD water body i.e. the combined impact on the water body as a result of all the impact on WFD elements	Examples	Outcome
Moderate Beneficial	Impacts when taken on their own have the potential to lead to significant improvement.	Impacts in combination with others have the potential to lead to the improvement in the class of a WFD element.	Impacts in combination with others have the potential to lead to the improvement in the WFD status of the water body.	Creation of significant areas of riparian habitats (for example, within a river diversion) which enhance the value of the water body. Removal of hard bank protection. Removal of barriers to fish species. Major improvement to groundwater quality or improved quality of GWDTE due to groundwater contributions.	Increase in status class for that water body.
Minor / localised beneficial	Impacts when taken on their own have the potential to lead to a minor localised or temporary improvement.	Impacts in combination with others have the potential to lead to a minor localised improvement of the WFD element.	Impacts in combination with others have the potential to lead to a minor localised or temporary improvement that does not affect the overall WFD status of the water body.	Minor habitat creation measures such as creation of marginal berms up/downstream of a structure. Minor improvement to groundwater quality or improved quality of GWDTE due to groundwater contributions.	Localised improvement, no change in status of WFD water body.
Green (no impact)	No measurable change to any quality elements.	No measurable change to any quality elements.	No measurable change to any quality elements.	Clear span bridge which causes no significant light shading. Changes to flow with no likely impact in macroinvertebrate community/contamination in areas with highly tolerant invertebrate community (e.g. Average Score Per Taxon <4). Minor, temporary encroachment into the channel Improvement in the existing surface water quality through improvement to existing drainage systems. Minor, temporary changes to groundwater levels	No change
Yellow – Localised/ temporary adverse impact	Impacts when taken on their own have the potential to lead to a minor localised or impact.	Impacts in combination with others have the potential to lead to a minor localised or temporary impact on the WFD elements. Consideration will be given to habitat creation measures.	Impacts in combination with others have the potential to lead to a minor localised or temporary impact on the WFD elements. Consideration will be given to habitat creation measures.	Loss of macrophytes/phytobenthos due to shading from a bridge or other structure. Temporary loss of invertebrates/macrophytes etc. during channel re-alignment Estimated loss in diversity of invertebrates for e.g. <100m of water body (due to habitat loss, changes to flow etc.). Localised loss of fish habitat/numbers of fish. Reduction in water quality with negligible knock on effects to biological elements Localised changes to groundwater levels or quality with no impact to GWDTE or protected water bodies.	No change in status of WFD water body when balanced against mitigation embedded in the scheme.
Amber – adverse widespread or prolonged impact	Impacts when taken on their own have the potential to lead to a widespread or prolonged impact. Consideration will be given to habitat creation measures.	Impacts in combination with others have the potential to have an adverse impact on the WFD element. Additional mitigation will be applied.	Impacts in combination with others have the potential to have an adverse impact on the WFD water body. The current WFD risk category will be taken into account when assessing these combined impacts. Consideration will be given to habitat creation measures.	Loss of macrophytes/phytobenthos for a significant length of water due to shading from a long (e.g. >200m) culvert or other similar structure. Likely significant drop in invertebrate diversity over e.g. >300m of water body (due to habitat loss /siltation or combination of various impacts etc.). Obstruction to upstream migration of fish to spawning grounds in a salmonid river therefore affecting fish in the whole of the WFD water body. Reduction in water quality with potential to cause knock on effects to biological elements. Adverse changes to GWDTE or baseflow contributions to protected surface water bodies.	Adverse impact but risk of status change needs to be considered with any additional mitigation and taking into account the level of confidence.
Red – adverse impact on an individual quality element and/or overall status of water body	Impacts when taken on their own have the potential to lead to a widespread or prolonged impact even with mitigation in place.	Impacts in combination with others have the potential to have an adverse impact on the WFD element and change its class. Consideration will be given to habitat creation measures.	Impacts in combination with others have the potential to have an adverse impact on the WFD water body and change its status. The current WFD risk category will be taken into account when assessing these combined impacts. Consideration will be given to habitat creation measures.	Loss or extensive change to a fishery Significant loss of hydromorphological diversity likely to impact the water body scale such as channelisation of a natural watercourse using hard engineering for a significant length. Creation of barriers which will inhibit migration and movement of fish within the system. Significant decline in water quality resulting in knock on effects to biological elements at the water body scale. Loss of or extensive change to GWDTE or baseflow contributions to protected surface water bodies. Any significant change in groundwater quality reducing WFD status.	Decrease in status of WFD water body when balanced against additional mitigation. Outcome is considered to be certain.

3. Stage 1 – WFD Screening

3.1. Scheme Description

3.1.1. The current Red Line Boundary (RLB) of the Scheme extends approximately 2 km north and south of the proposed works to Stoke Orchard and Old Gloucestershire Road respectively. The extension of the RLB to this distance north and south is to incorporate any works that will be undertaken to update signs along the M5 Carriageway. There are expected to be no structural works any further north or south than the Villa Farm M5 Road Bridge or the existing River Chelt Crossing.

3.1.2. Figure 3-1 illustrates the location of the Scheme and the RLB.

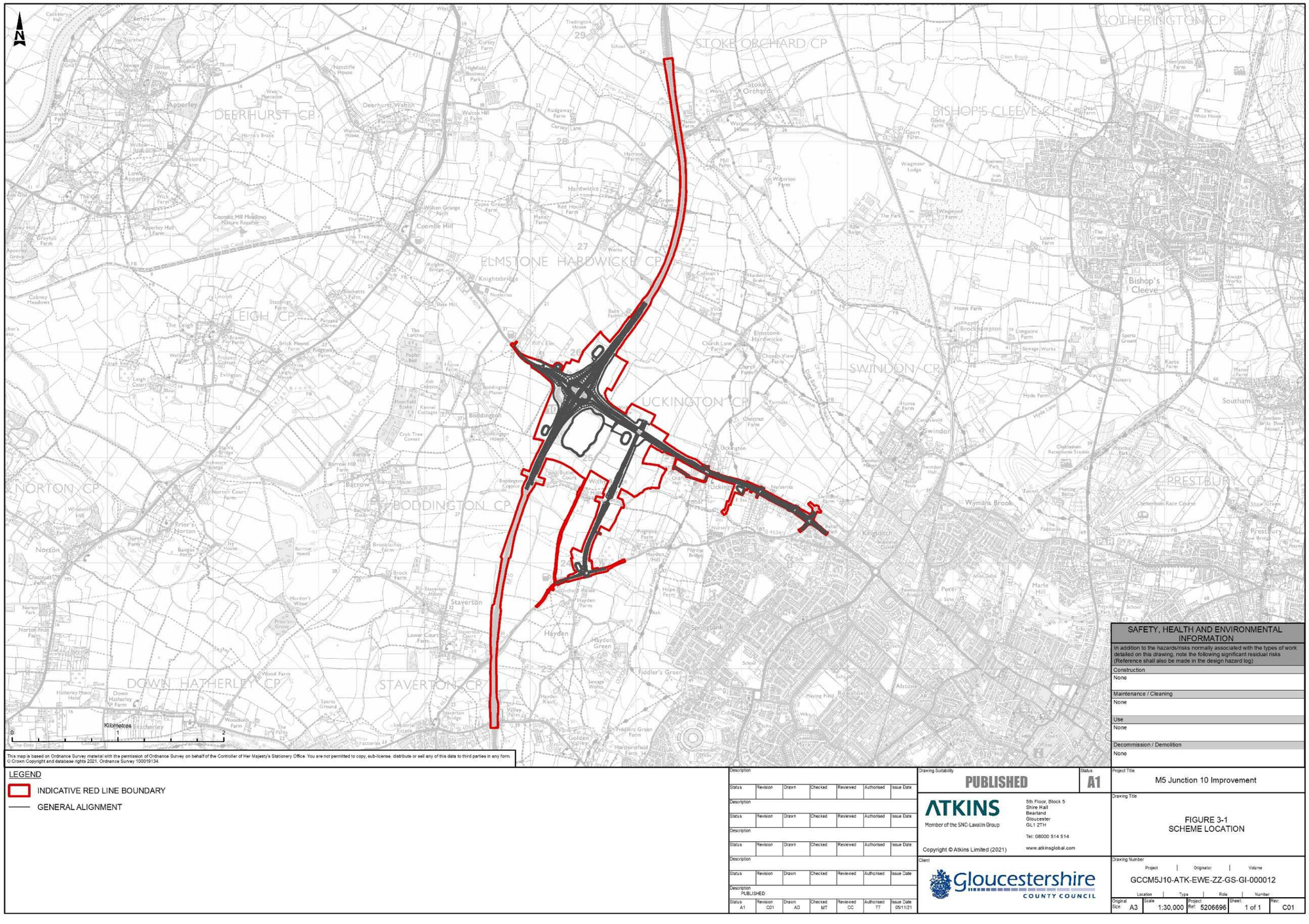


Figure 3-1 - Scheme location

3.2. Zone of Influence

Surface water

3.2.1. The Zone of Influence (ZoI) has been determined throughout this assessment as part of the Screening and Scoping stages. The ZoI consists of the WFD surface water catchments which have been screened and scoped into this assessment. Entire water body catchments which have the potential to be impacted have been outlined as the ZoI to ensure that the impacts are assessed at the water body scale.

3.2.2. Baseline information, survey work, design details and professional judgement have been used to screen and scope out waterbodies which are unlikely to be impacted. This includes those which are not hydrologically connected downstream or where impacts are unlikely to propagate upstream or downstream.

Groundwater

3.2.3. Due to the lateral extent of groundwater bodies in comparison to surface water bodies, a different approach has been utilised. The ZoI for groundwater receptors has been limited to 1 km from the RLB. This study area has been adopted as a minimum for the groundwater assessments as, in line with DMRB LA113, the conceptual understanding indicates any impacts to groundwater flow will also be dissipated within 1 km.

3.3. Water body screening

3.3.1. A screening assessment has been carried out to identify which water bodies have the potential to be impacted by the Scheme.

3.3.2. All water bodies which intersect the Scheme's RLB have been identified. Additionally, any surface water bodies which are hydrologically connected downstream have been identified up to the point where impacts are expected to have dissipated.

3.3.3. Impacts from the Scheme are not expected to extend any further downstream than the Severn – conf R Avon to conf Upper Parting water body. Although there is the potential for catastrophic spillage events to extend this distance downstream, the likelihood of these events occurring is minimal to the extent that an assessment of the impacts of catastrophic spillage is not within this scope.

3.3.4. These WFD water body catchments are presented in Appendix A and summarised below in Table 3-1 with a summary of the screening outcome. Figure 3-2 provides a map of the water bodies which were identified in this screening assessment.

Table 3-1 - Summary screening of WFD water bodies intersecting the red line boundary

Water body Name	Water body ID	Water body type	Overall status (2019)	Screening (in/out)	Reason for Screening
Chelt – source to M5	GB109054032820	River	Moderate	In	
Chelt – M5 to conf. R. Severn	GB109054032810	River	Poor	In	
Leigh Bk – source to conf. R. Chelt	GB109054039770	River	Moderate	In	
Swilgate – source to conf. R. Avon	GB109054039780	River	Moderate	Out	No hydrological connectivity to physical works*
Hatherley Bk - source to conf R Severn	GB109054032801	River	Moderate	Out	No hydrological connectivity to physical works*
Severn – conf R Avon to conf Upper Parting	GB109054044404	River	Moderate	In	Included following consultation with EA
Severn Vale - Secondary Combined	GB40902G204900	Groundwater	Good	In	
Warwickshire Avon - Secondary Mudrocks	GB40902G990900	Groundwater	Good	In	

** These water bodies fall within the area of the RLB where works will only be carried out on signage. As this is expected to have no impact on the water environment, the water bodies have been screened out.*

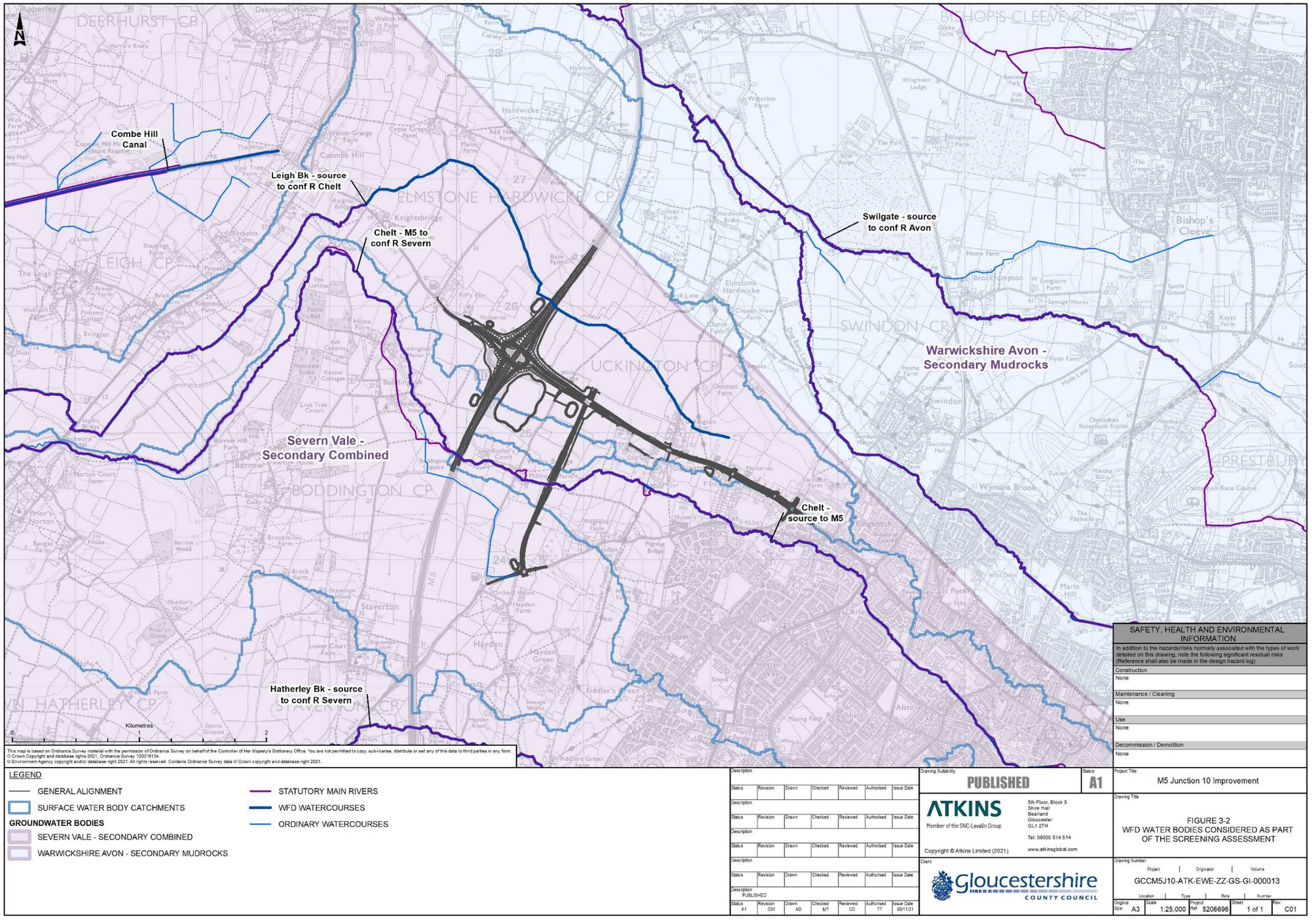


Figure 3-2 - WFD Water bodies considered as part of the screening assessment

Screening summary

3.3.5. The Swilgate – source to conf. R. Avon and the Hatherley Bk - source to conf R Severn have been screened out of this assessment as they have no hydrological connectivity to the footprint of the physical works.

4. Stage 2 – WFD Scoping

4.1. Surface water baseline

WFD reportable reaches

4.1.1. The following four WFD surface water bodies (as identified in Table 3-1 and Figure 3-1) are included in this scoping:

- Chelt – source to M5;
- Chelt – M5 to conf. R. Severn;
- Leigh Bk – source to conf. R. Chelt; and,
- Severn – conf R Avon to conf Upper Parting.

4.1.2. The Severn – conf R Avon to conf Upper Parting is the only surface water body which does not lie within the Chelt Hatherley and Normans Brook Operational Catchment. Instead, it lies within the Severn River and Trib Operational Catchment. All four surface water bodies lie within the Severn River Basin Management Plan (RBMP).

4.1.3. The River Chelt is Main River and flows east to west through Cheltenham before flowing under the M5 carriageway approximately 0.9 km south of the existing junction 10.

4.1.4. Although the Leigh Brook is not a Main River at its crossing point with the M5 (NGR SO907260), it is reportable under the WFD throughout its length between its source at Uckington, to its confluence with the River Chelt. Downstream of the A4019 the watercourse is designated Main River.

4.1.5. The River Severn is Main river and WFD reportable through the Severn – conf R Avon to conf Upper Parting WFD water body catchment.

4.1.6. The current (2019, Cycle 2) status for the WFD river water bodies are summarised in Table 4-1 along with objectives, designations, reasons for not achieving good (RNAG) status and linked protected areas.

Table 4-1 - Summary of WFD information for the four scoped surface water bodies

Water Body Name	Chelt – source to M5	Chelt – M5 to conf. R. Severn	Leigh Bk – source to conf. R. Chelt	Severn – conf R Avon to conf Upper Parting
Water Body ID	GB109054032820	GB109054032810	GB109054039770	GB109054044404
Hydromorphological Designation	Heavily modified	Not designated heavily modified or artificial	Not designated heavily modified or artificial	Heavily modified
Classification (2019 Cycle 2)	Moderate	Poor	Moderate	Moderate
Objectives	Good by 2027 (Disproportionate Burdens)	Good by 2027 (Disproportionate Burdens)	Moderate by 2015 (Unfavourable balance of costs and benefits)	Moderate by 2015 (Unfavourable balance of costs and benefits)
Ecological	Moderate	Poor	Moderate	Moderate
Supporting elements (surface water)	Moderate	-	-	Moderate
Biological quality elements	Good	Poor	Moderate	Bad
Macrophytes and Phytobenthos	Good	Poor	Moderate	-
Fish	High	-	-	-
Invertebrates	Good	Good	Good	Bad
Hydromorphological supporting elements	Supports Good	Supports Good	Supports Good	Supports Good
Physico-chemical quality elements	Good	Moderate	Moderate	Moderate
Acid Neutralising Capacity	High	High		High
Ammonia (Phys-Chem)	High	High	High	High
Biochemical Oxygen Demand (BOD)	High	Poor	-	High
Dissolved Oxygen	High	High	High	High
pH	High	High	High	High
Phosphate	Good	Poor	Poor	Moderate
Temperature	Good	High	High	High
Specific pollutants	-	High	-	High
Chemical	Fail	Fail	Fail	Fail
Priority substances	Does not require assessment	Good	Does not require assessment	Good
Other pollutants	Does not require assessment	Does not require assessment	Does not require assessment	Good
Priority hazardous substances	Does not require assessment	Good	Does not require assessment	Fail
RNAG (2019)	Physical modifications from Local and Central Government and Urban transport	Diffuse and Point source pollution from Agricultural land management, Water industry and Urban and transport	Diffuse and Point source pollution from Agricultural land management, Domestic general public and Urban and transport	Local and Central Government and Urban transport, Urban and transport, Navigation, Water Industry
Linked Protected Areas	Thames (Churn to Coln) NVZ S457 River Chelt NVZ S580 River Swilgate NVZ S582 Hathley Bk - conf Norman's Bk to conf R Severn NVZ S579	River Chelt NVZ S580 Hathley Bk - conf Norman's Bk to conf R Severn NVZ S580 River Chelt Urban Waste Water Treatment Directive (UKENRI46)	River Chelt NVZ S580 River Swilgate NVZ S582	River Chelt NVZ S580 River Swilgate NVZ S582 Hathley Bk - conf Norman's Bk to conf R Severn NVZ S579 R Leadon - Glynch Bk to conf R Severn (W Channel) NVZ S578 River Chelt Urban Waste Water Treatment Directive (UKENRI46) River Avon (Warwickshire) Urban Waste Water Treatment Directive (UKENRI10)

Surface water body summary sheets

4.1.7. Extended water body summary sheets have been received from the EA. For the Chelt – source to M5, Chelt – M5 to conf. R. Severn and Leigh Bk – source to conf. R. Chelt. The extended water body summary sheet was not requested for Severn – conf R Avon to conf Upper Parting as it has been added into the assessment following consultation.

4.1.8. The Leigh Bk – source to M5 highlights three measures downstream of Knightsbridge: improve habitat diversity through large woody debris, improve watercourse profile and increase habitat diversity.

4.1.9. Mitigation measures for the River Chelt – source to M5 have been noted. A number of water body level measure actions have been stated and include channel improvement works, weir improvements, culverts and improvement to fish passage. Mitigation measures which have been highlighted as possible for this water body are listed in Table 4-2. Those which are proposed as being relevant to this Scheme have been identified in bold.

4.1.10. The Chelt – M5 to conf. R. Severn does not highlight the potential mitigation measures within the extended water body summary sheets.

Table 4-2 - Mitigation measures for the River Chelt - source to M5 water body

Mitigation category	Flood protection and urbanisation designated uses
working with physical form and function	Remove obsolete structure Re-engineer river Remove or soften hard bank **Preserve or restore habitats** **In-channel morph diversity** **Bank rehabilitation** Re-opening culverts **Alter culvert channel bed** **Flood bunds** **Set-back embankments** **Floodplain connectivity**
Re-engineer river	Fish passes Fish pass flow releases Reduce fish entrainment **Enhance ecology** Changes to locks etc
Remove or soften hard bank	**Selective vegetation control** **Vegetation control** Vegetation control timing **Invasive species techniques** Retain habitats Sediment management strategy Maintain channel bed/margins **Woody debris** Water level management
Preserve or restore habitats	**Align and attenuate flooding**
In-channel morph diversity	Educate landowners

Initial site walkover survey

4.1.11. A watercourse walkover was undertaken on 23rd and 24th July 2019 by an experienced fluvial geomorphologist and aquatic ecologist. The River Chelt was surveyed between the River Chelt Culvert and the West Cheltenham Link Road Bridge locations (approximately 800m of the channel). The Leigh Brook was surveyed along 500m upstream of the Barn Farm Culvert. MW3 was also surveyed downstream of the M5 for approximately 200m. Spot checks were also completed on:

- The River Chelt approximately 650m downstream of the River Chelt Bridge;
- Drain 12 at the proposed crossing with the West Cheltenham Link Road;
- Drain 10 west of Withybridge Lane; and,
- Drain 14 and 15 south of Old Gloucester Road.

4.1.12. The site work comprised a walkover collecting georeferenced photographs and recording features that characterise the potentially affected watercourses, including planform, bed substrate and bank materials, modifications, flow types, habitat provisions and vegetation types (riparian and aquatic).

4.1.13. Access was available using public rights of way (PRoW) and to specified private land parcels within the RLB. Several sites were not accessible due to land access not being granted or health and safety concerns. The locations which were not seen were:

- Directly downstream of the River Chelt Culvert;
- Directly downstream of the Barn Farm Culvert;
- Drain 21; and,
- Drains 20 and 16 around Old Gloucester Road.

4.1.14. Following the watercourse walkover, detailed ecological surveys were undertaken on the River Chelt and Leigh Brook. Details of the survey screening approach, methods used, and survey locations can be found in PEIR Appendix 7.12.

4.1.15. The detailed surveys comprised:

- two electric fishing surveys on the River Chelt, centred on the proposed new West Cheltenham Link Road River Chelt Bridge and the River Chelt Culvert;
- four macroinvertebrate surveys on the River Chelt upstream and downstream of the Scheme interactions (West Cheltenham Link Road River Chelt Bridge and the River Chelt Culvert). One macroinvertebrate survey on the Leigh Brook downstream of the existing Barn Farm Culvert;
- two macrophyte surveys on the River Chelt, at the proposed new West Cheltenham Link Road River Chelt Bridge and the River Chelt Culvert and the River Chelt Culvert. One macrophyte survey on the Leigh Brook downstream of the Barn Farm Culvert;
- two River Habitat Surveys (RHS) on the River Chelt, centred on the proposed new West Cheltenham Link Road River Chelt Bridge and the River Chelt Culvert and the River Chelt Culvert. One RHS on the Leigh Brook downstream of the Barn Farm Culvert; and,
- two River Corridor Surveys (RCS) on the River Chelt, centred on the proposed new West Cheltenham Link Road River Chelt Bridge and the River Chelt Culvert and the River Chelt culvert. One RHS on the Leigh Brook downstream of the Barn Farm Culvert.

4.1.16. A summary description for each WFD water body along with available relevant EA routine monitoring data and Scheme ecological survey data are below with photographs presented in Table 4-3 to Table 4-5.

Chelt – source to M5

4.1.17. This water body receives a large amount of light due to minimal tree cover on the banks resulting in the establishment of both terrestrial herbs and scrub along with marginal macrophyte growth. Within the upstream surveyed reach (upstream of Withybridge), the river contained discrete areas of fine sediment deposition in deeper waters, as well as cobble outcrops in shallower areas. Gravel and pebble substrates were also evident within this reach and water was clear and free flowing. Large stands of stream water crowfoot were present indicating the channel flows relatively quickly all year round. Some isolated trees in the upstream reach provide a dappling effect adding diversity to the channel habitat. Within these more shaded areas small fish were observed. Although there is slightly more ecological growth in this channel, it is still straightened and channelised in some sections. The weir causes discontinuity for fish movement and the concrete bed and banks have reduced biodiversity.

4.1.18. At the River Chelt Culvert, a large box culvert restricts high flows demonstrated by fine sediment depositions immediately upstream and within the structure. There is a slightly higher proportion of fine sediments and more extensive marginal macrophyte growth is evident at the base of the banks in this reach compared with the reach upstream of Withybridge Lane.

Background records

4.1.19. No ecological monitoring data less than 5 years old are available for the water body.

Aquatic macroinvertebrates

4.1.20. Three EA macroinvertebrate monitoring sites (EA Site ID 49705, 52020 and 52939), with survey data since 2010, are located within the water body. The closest of these to the Scheme is EA Site ID 49705, which is located approximately 0.5 km upstream of the red line boundary (as the crow flies). The most recent surveys at this site were undertaken in May and October 2019 and biotic indices indicate that the macroinvertebrate community comprises a relatively species rich community (WHPT NTAXA 30 and 34) living in good water quality (WHPT 144.2 and 178.8). However, average scores per taxon of 4.81 and 5.26 indicate that the overall WHPT score may be driven by number of scoring species rather than the presence of extremely sensitive species[1]. Biotic indices are also indicative of a moderately sedimented to sedimented bed (PSI[2] scores of 45.36 and 36.49) and a community moderately to highly sensitive to reductions in flow (LIFE[3] index scores of 7.33 and 7.14).

4.1.21. EA Site ID 52020 is situated within 2 km of the Scheme, but approximately 4 km upstream of the existing M5 crossing and was most recently surveyed in April and September 2014.

[1] WHPT is the Whalley Hawkes Paisley Trigg metric which assesses the degree to which a community is sensitive to organic pollution. NTAXA is the number of scoring taxa that contribute to the overall total WHPT score. ASPT is the Average Score Per Taxon for the WHPT metric (i.e. the total WHPT divided by the NTAXA. Further information on WHPT can be found in: WFD-UKTAG (2014), River Assessment Method. Benthic Invertebrate Fauna. Invertebrates (General Scoping of surface water receptors is outlined in section 4.5 following the identification of Scheme activities.
There are no other designated sites within the surface water study area.
Degradation): Whalley, Hawkes, Paisley & Trigg metric in River Invertebrate Classification Tool (RICT) UKTAG Method Statement. ISBN: 978-1-906934-62-0.

[2] PSI is the proportion of sediment sensitive invertebrates and is based on known ecological responses of different aquatic macroinvertebrate species or family groups to the accumulation of sediment on riverine substrata. Information on PSI can be found in: Extence, C.A., Chadd, R.P., England, J., Dunbar, M.J., Wood, P.J. and Taylor, E.D. (2013). The assessment of fine sediment accumulation in rivers using macro-invertebrate community response. River Research and Applications, 29, pp. 17-55.

[3] LIFE is the lotic invertebrate index for flow evaluation. The metric was developed as a means of assessing flow as a stressor on aquatic macroinvertebrate communities. LIFE score categories identify the community as having a low, moderate or high sensitivity to flow reduction. With a lower score indicating a community made up of proportionally more taxa with a preference for low flows. Further information on LIFE scores can be found in: Extence, C.A., Balbi, D.M. and Chadd, R.P. (1999). River flow indexing using British benthic macroinvertebrates: A framework for setting hydroecological objectives. Regulated Rivers: Research and Management 15, pp. 543-574.

This site contains a slightly higher proportion of flow sensitive taxa (LIFE index scores of 7.8 and 7.77) than EA Site ID 49705, but has a community indicative of similar if not slightly lower water/habitat quality (WHPT NTAXA 21 and 25, WHPT total 138.3 and 159.6). It should be noted that since the data were collected in different years, they are not directly comparable.

4.1.22. EA Site ID 52939 is the furthest upstream site within the water body, approximately 6 km from the red line boundary (as the crow flies). Most recent surveys at this site were undertaken in March and September 2014. These surveys returned similar WHPT and NTAXA scores as the other two sites within the water body (WHPT NTAXA 27 and 24, WHPT total 168.9 and 147.9) indicating relatively good water quality. This site has the highest PSI (71.74 and 73.33) and LIFE index (7.96 and 8.32) scores across the water body, indicating that the community here is more sensitive to low flows and only minimally sedimented.

Aquatic Macrophytes

4.1.23. One EA macrophyte monitoring site (EA Site ID 47049), which has been surveyed within the last ten years, is located within the water body. This site is located approximately 20 m from the red line boundary and 0.5 km downstream of the existing M5 crossing. It was most recently surveyed in July 2014. This survey indicates that the plant community within the River Chelt typically comprises species associated with moderate to high nutrient levels and predominantly slow flow (River Macrophyte Nutrient Index (RMNI) 7.59 and River Macrophyte Hydraulic Index (RMHI) 7.14).

Fish

4.1.24. Four EA fish monitoring sites (EA Site ID 51183, 51184, 56463 and 10409) which have been surveyed within the last 10 years are located within the water body. The closest to the Scheme is EA Site ID 51183 which is located approximately 0.4 km from the red line boundary. EA Site ID 51184 is approximately 100 m further upstream and most recent survey for both sites was undertaken in September 2013. Only four species were caught during the surveys at this site, namely bullhead, three-spined stickleback, brown trout and European eel. Whilst limited species richness, the species present are considered to be important. European eel is a Critically Endangered species on the International Union for Conservation of Nature (IUCN) Red List of Threatened Species (2010), species of Principal Importance under section 41 of the Natural Environment and Rural Communities (NERC) Act 2006, and a UK Biodiversity Action Plan (BAP; 2007) priority fish species. Brown trout is a species of principal importance under section 41 of the NERC Act 2006 and a UK BAP (2007) priority fish species. Bullhead is a European Commission Habitats Directive Annex II non-priority species[4].

4.1.25. The same species were recorded at the two other EA fish monitoring sites within the water body.

Survey results

RHS/RCS

4.1.26. The RHS returned a habitat modification score of 2120 which indicates the reach is severely modified. Within the surveyed reach (centred on the proposed River Chelt Bridge) the downstream 100 m has been extensively lined with walls, the access road to the house crosses here and there is a weir at the upstream end of the walls. This modification is likely driving the habitat modification score. Upstream of this, the river has a more natural channel but appears to have been over-deepened. The banks are fenced more or less throughout and the vegetation is consequently dominated by trees, scrub and tall ruderals.

[4] Animal and plant species of Community interest (i.e. endangered, vulnerable, rare or endemic in the European Community) whose conservation requires the designation of special areas of conservation. Note that the contents of this annex have been updated in April 2003 following the Treaty of Accession.

Aquatic macroinvertebrates

4.1.27. 52 mixed level taxa recorded across three sampling sites. Biological metrics are indicative of good habitat diversity and water quality, high sensitivity to reduced flows and slight to moderate channel sedimentation.

Aquatic macrophytes

4.1.28. Within the surveyed reach (at the proposed River Chelt Bridge) 1% total cover of macrophytes was recorded in channel and 3% cover of filamentous algae. Species comprised branched bur-reed, water figwort, crescent-cup liverwort, umbrella liverwort and pink fruited thread-moss.

Fish

4.1.29. The reach provides extensive glide and run habitat, with isolated areas of shallow riffle habitat. The most abundant species recorded was bullhead, with three-spined stickleback and eel also recorded.

Table 4-3 - Water body photographs Chelt – source to M5

	
Photo 1: Location of the West Cheltenham Link Road River Chelt Bridge. Artificial embankment on both banks with straightened and over deepened channel. Isolated trees provide some shade.	Photo 2: Downstream from West Cheltenham Link Road River Chelt Bridge, flow is more dynamic with differences in depth across the channel. Some raised areas have become vegetated with stream water crowfoot.
	
Photo 3: Approximately 200 m downstream from the West Cheltenham Link Road River Chelt Bridge (outside of the RLB), a weir marks the upstream extent of a channelised section of approx. 80 m.	Photo 4: An existing bridge on Withybridge Lane marks the downstream extent of the channelised section. Small fish were observed directly upstream of this bridge within a shaded part of the channel. The species in unconfirmed but assumed to be stickleback or the fry of a larger species.

	
Photo 5: River Chelt Culvert with deposition on the right bank. Artificial embankment along this stretch.	Photo 6: Fine sediment has been deposited under the River Chelt Culvert suggesting constriction at higher flows. Trash was also observed on the concrete walkway, indicating flows have been much higher within this reach.

Chelt – M5 to conf. R. Severn

4.1.30. The channel has similar characteristics as those seen upstream of the M5 crossing with agricultural land use on both banks for the majority of the water body length. The watercourse was not seen directly downstream of the River Chelt Culvert; however a spot check was completed approximately 0.6 km downstream between the MW4 and MW4 confluences. In this location, the embankments are slightly lower than at the M5 crossing and upstream of Withybridge Lane. The vegetation on both banks is denser than upstream, however there are sections of shade and sunlight. Higher flows shown in Photo 7 and 8 are result of overnight rainfall following the first day of survey. Bed and bank material could not be clearly seen.

Background records

4.1.31. No ecological monitoring data less than 5 years old are available for the water body.

Aquatic macroinvertebrates

4.1.32. Two EA macroinvertebrate monitoring sites (EA Site ID 53408 and 161315), with survey data since 2010, are located within the water body. The closest of these to the existing M5 crossing is EA Site ID 53408, which is located approximately 1.5 km downstream of the motorway. The most recent surveys at this site were undertaken in March and September 2014 and biotic indices indicate that the macroinvertebrate community was composed of taxa relatively tolerant to organic pollution (WHPT ASPT 4.76 and 5.21), indicative of a moderately sedimented bed (PSI 45.83 and 58.49) and sensitive to reductions in flow (LIFE index 7.38 and 7.57).

4.1.33. The second EA macroinvertebrate monitoring site within the water body (EA Site ID 161315) recorded similar metric values indicating a similar habitat quality and community sensitivity (WHPT ASPT 5.2 and 4.9, PSI 59.62 and 48.39, LIFE index 7.5 and 7.13). This site is situated approximately 5km downstream of the Scheme and most recently surveyed in April and September 2014.

Aquatic Macrophytes

4.1.34. One EA macrophyte monitoring site (EA Site ID 47318), with survey data since 2010 is located within the water body. This site is located immediately upstream of the River Chelt confluence with the River Severn. It was most recently surveyed in July 2014. This survey indicates that the plant community within the River Chelt is typically comprises species associated with moderate to high nutrient levels and predominantly slow flow (RMNI 8.22 and RMHI 7.65).

Fish

4.1.35. Three EA fish monitoring sites (EA Site ID 54023, 51163 and 52484, with survey data since 2010 are located within the water body. The closest to the Scheme is EA Site ID 54023 which is located approximately 5 km downstream from the red line boundary. EA Site ID 51163 is a further 450 m downstream and EA Site ID 52484 is located immediately upstream of the River Chelt confluence with the River Severn. There is a greater species richness recorded at these sites than the fish monitoring sites within the upstream Chelt – source to M5 water body. The most recent survey at EA Site 54023 was undertaken in July 2014, for EA Site ID 51163 it was September 2013 and EA Site ID 52484 was September 2015. Across these surveys 13 species were recorded, namely European eel, chub, dace, roach, barbel, bleak, gudgeon, stone loach, three-spined stickleback, minnow, flounder, perch and bullhead. Additionally, in 2014 during a previous survey, Atlantic salmon were also recorded at Site ID 52484. Atlantic salmon is a European Commission Habitats Directive Annex II and V species, a species of Principal Importance under section 41 of the NERC Act 2006 and a UK BAP (2007) priority fish species.

Survey results

RHS/RCS

4.1.36. The RHS returned a habitat modification score of 3605 which indicates the reach is severely modified. Within the surveyed reach (centred on the River Chelt Culvert) the habitat modification score was driven by bank and bed resectioning, embankments and the presence of the River Chelt Culvert.

Aquatic macroinvertebrates

4.1.37. 31 taxa were recorded at one sampling sites. Biological metrics are indicative of moderate water quality, high sensitivity to reduced flows and moderate channel sedimentation.

Aquatic macrophytes

4.1.38. Within the surveyed reach (immediately upstream of the River Chelt Culvert) 3% total cover of macrophytes was recorded in channel and 3% cover of filamentous algae. Species comprised fool's watercress, floating sweet-grass, amphibious bistort, reed canary grass, a water crowfoot species (of the subgenus Batrachium) and brooklime. Additional marginal species were great willowherb, common horsetail, creeping bent, soft rush and lady's thumb.

Fish

4.1.39. The surveyed reach (immediately upstream of the River Chelt Culvert) provides extensive glide and run habitat, with isolated areas of shallow riffle habitat. The most abundant species recorded was minnow, with bullhead also recorded in high densities. Three-spined stickleback, stone loach and chub were also present.

Table 4-4 - Water body photographs Chelt – M5 to conf. R. Severn

Photo 7: Upstream view of the River Chelt approximately 0.6 km downstream of the M5 crossing.	Photo 8: Downstream view of the Chelt – M5 to conf. R. Severn with more vegetation growth on both banks. Trees on the left bank provide some shade.

Leigh Bk – source to conf. R. Chelt

4.1.40. Leigh Brook is a straightened agricultural drainage ditch with no perceptible flow and water width of 0.5 m. Historical mapping show little change in sinuosity back to 1945 before the M5 was constructed suggesting modifications to the channel have been due to agricultural management.

4.1.41. The channel is overgrown with scrub and tall herbs causing large amounts of shade over the channel. Deposition of fines on the bed and lack of sunlight has meant there is minimal vegetation growth on the river bed however, banks are fully vegetated.

4.1.42. The stretch is depositional as there are no signs of erosion but large volumes of fines cover the bed. Cobbles are also seen in this stretch which could suggest flows can become high enough for transportation of larger sediments however, there is potential that some erosion of fine sediments has occurred leaving some larger substrates exposed.

Background records

4.1.43. No ecological monitoring data less than 5 years old are available for the water body.

Aquatic macroinvertebrates

4.1.44. One EA macroinvertebrate monitoring site (EA Site ID 48480) with survey data since 2010 is located within the water body. This site is located over 5 km downstream of the red line boundary. Most recent surveys at this site were undertaken in March and September 2014. Biotic indices indicate that the macroinvertebrate community was composed of taxa tolerant to organic pollution (WHPT ASPT 4.7 and 4.24), indicative of a sedimented bed (PSI 32.43 and 36.17) and moderately sensitive to reductions in flow (LIFE index 6.74 and 7.05).

Aquatic Macrophytes

4.1.45. Three EA macrophyte monitoring sites (EA Site ID 158245, 158246 and 158247), with survey data since 2010 are located within the water body. The closest of these sites to the Scheme is EA Site ID 158245 which is located approximately 2 km downstream of the red line boundary. This site was most recently surveyed in September 2011 and the survey indicates that the plant community within the Leigh Brook typically comprised species associated with moderate to high nutrient levels and predominantly slow flow (RMNI 7.36 and RMHI 7.01).

Fish

4.1.46. No EA fish monitoring sties with survey since 2010 are located within the water body.

Survey results

RHS/RCS

4.1.47. The RHS returned a habitat modification score of 2120 which indicates the channel in this location is severely modified. The section is very uniform, it is fenced and lined with trees and heavily shaded throughout, there is an access track bridge in mid-section, at the time of the survey water levels were low enough that there were dry reaches and water was ponded in some parts. Channel vegetation is limited to a few scattered stands of fool's-watercress and some bittersweet.

Aquatic macroinvertebrates

4.1.48. 19 taxa were recorded within the sampling site on the Leigh Brook (downstream of the Barn Farm Culvert). Biological metrics are indicative of poor water quality, low sensitivity to reduced flows and heavy sedimentation.

Aquatic macrophytes

4.1.49. Within the surveyed reach downstream of the Barn Farm Culvert) <1% total cover of macrophytes was recorded in channel and 0% cover of filamentous algae. The only macrophyte species recorded were fool's watercress and great willowherb.

Fish

4.1.50. No fish survey was undertaken within the Scheme area (where access was available) since the habitat in this location was not suitable for fish.

Table 4-5 - Water body photographs Leigh Bk – source to conf. R. Chelt

	
Photo 9: Small Drainage ditch upstream of the Barn Farm Culvert. Culvert under the small track in this location with both upstream and downstream being historically straightened. No obvious valley in this location.	Photo 10: Hedge lined drainage ditch along arable field boundary with approximately 5m buffer along the bank. Overgrown vegetation on both banks and isolated trees on the left provided 80% shade. No perceivable flow.
	
Photo 11: Barn Farm Culvert cannot be seen due to overgrown vegetation. No perceptible flow at this location.	Photo 12: Channel is heavily shaded by dense scrub and woodland. The earth banks are shallow sloping and sparsely vegetated, and no vegetation was recorded within the channel. The channel was almost dry with some pools of standing water. Cattel poaching was recorded. (Image taken by ecology team: September 2019).

Severn – conf R Avon to conf Upper Parting

4.1.51. At the time of survey, the River Severn water body had not been scoped into the assessment. Therefore, there was no field survey undertaken. A review of online, freely available data has been undertaken to understand the characteristics. These have included:

- Google Earth Pro;
- Historic mapping (National Library of Scotland); and,
- EA flood maps.

4.1.52. The River Chelt joins the Severn south of Apperley approximately 8 km upstream of the tidal influence at Gloucester. This section of the River Severn has no distinguishable valley sides and is surrounded by lowland agriculture.

4.1.53. The River is largely lined by a narrow stretch of mature vegetation with some places cleared for anthropogenic uses and some places having larger sections of woodland. The river seems to be embanked along long sections. The channel in this reach has an approximate width of 60 m and smooth flow can be seen.

4.1.54. The Severn Estuary Special Area of Conservation (SAC) and Special Protection Area (SPA) is approximately 40 km downstream from the Scheme. The site is designated for estuary habitat comprised of mudflats, sandflats, lagoons and salt marshes. Fish species which are qualifying features are sea lamprey, river lamprey and thwaite shad. Whilst a significant distance from the Scheme the River Severn is the longest river in the UK and a key strategic watercourse. The tributary systems of the Severn are an integral part of supporting the wider catchment, particularly in regards to fish spawning and rearing grounds. In addition to the species listed as qualifying features of the SAC designation the River Severn is known to be important for Atlantic salmon, brown trout, European eel, and many coarse fish species[5].

Ordinary Watercourses

4.1.55. There are several ordinary watercourses within close proximity to the Scheme shown in Figure 4-1 and Table 4-6.

4.1.56. The watercourses have been classified as ‘drains’ or ‘main watercourses’ (MW) to ensure consistency with the ecological assessment as part of the Preliminary Environmental Information Report (PEIR). As part of the WFD compliance assessment, all watercourses within these two categories will be referred to as ordinary watercourses. Table 4-7 shows some representative photographs of ordinary watercourses taken from across the Scheme.

4.1.57. Drainage ditches across the Scheme are surrounded by agricultural land and have been over deepened and straightened for agricultural purposes or highways drainage. There are fine sediments seen on the bed with no perceptible flow in the majority of watercourses seen. Vegetative debris has also been deposited along the stretch of channel with the majority overgrown with vegetation.

4.1.58. No recent EA monitoring data are available on these ordinary watercourses.

4.1.59. Scoping of surface water receptors is outlined in section 4.5 following the identification of Scheme activities.

4.1.60. There are no other designated sites within the surface water study area.

[5] Further information on the fish found within the River Severn can be found at: https://www.unlockingthesevern.co.uk/our-river/fish-of-the-severn/ (accessed 13/8/2021).

Table 4-6 - Ordinary watercourses within proximity to the Scheme

Chelt - source to M5 (GB109054032820)	Chelt - M5 to conf. R. Severn (GB109054032810)	Leigh Bk - source to conf. R. Chelt (GB109054039770)
MW5	MW3	Drain 3
Drain 21	MW4	Drain 4
Uckington Moat	Drain 12	Drain 5
	Drain 13a	Drain 6
	Drain 14	Drain 7
	Drain 15	Drain 8
	Drain 16	Drain 9
	Drain 17	Drain 10
	Drain 19	Drain 11
	Drain 20	Drain 13

Table 4-7 - Representative photographs ordinary watercourses

	
Photo 13: Image of Drain 10 form public footpath over bridge. The channel is overgrown with vegetation and is over deepened. Himalayan Balsam is present. This watercourse flows alongside the A409 and is straightened throughout its length.	Photo 12: Drain 12 upstream of Withybridge Lane. There is no flow within the channel and large woody debris is present.
	
Photo 13: MW3 downstream of the M5 which acts as agricultural drainage. The Channel is over deepened with over grown vegetation. There is no perceivable flow at this location.	Photo 14: Drain 18 at its source alongside Hayden Lane. The channel is overgrown with vegetation and there is no perceptible flow.

	There are fine sediments on the bed and vegetation on both banks.

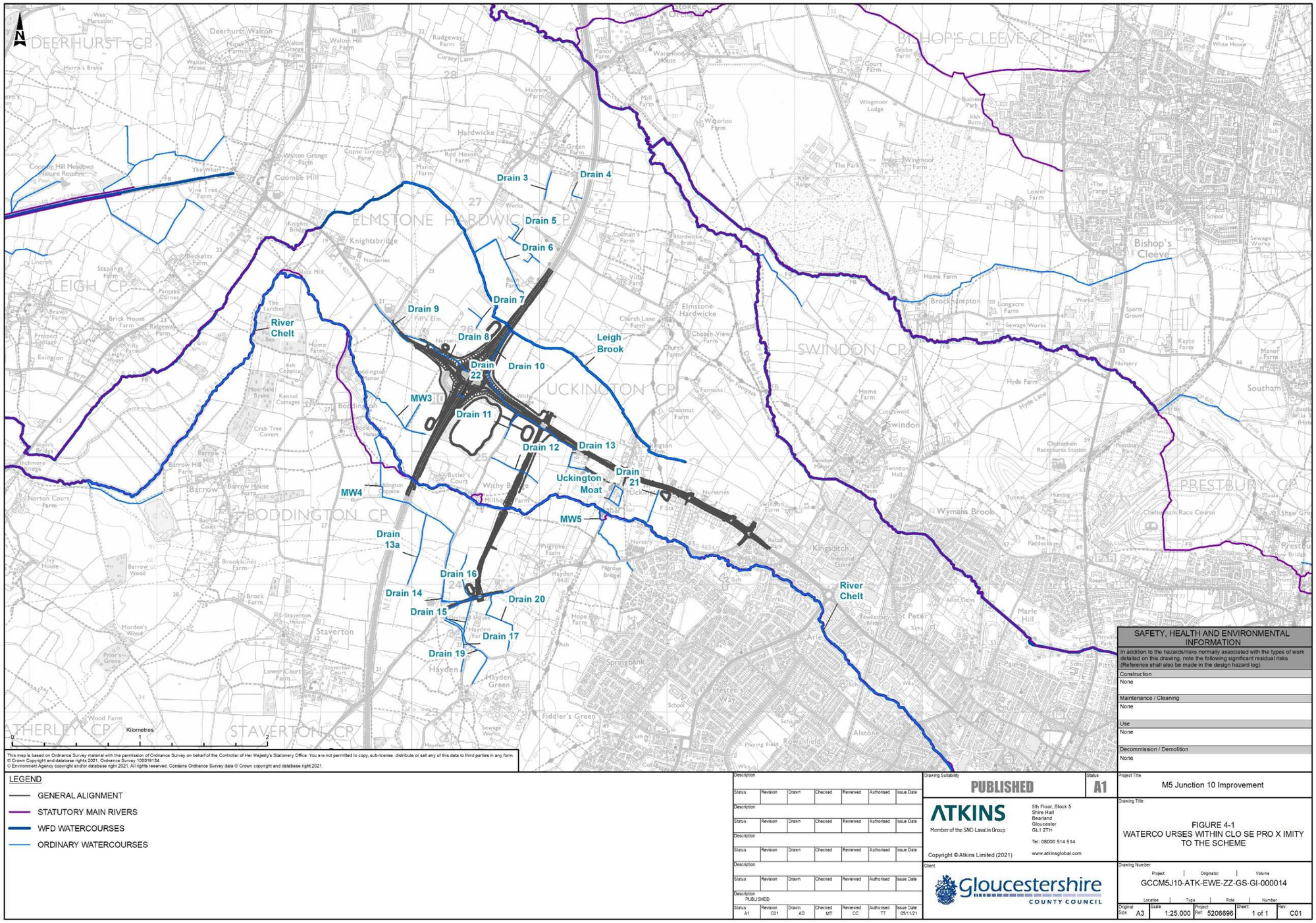


Figure 4-1 - Watercourses within close proximity to the Scheme

4.1.61. Scoping of surface water receptors is outlined in section 4.5 following the identification of Scheme activities.

4.1.62. There are no other designated sites within the surface water study area. The Coombe Hill Canal is an SSSI which lies approximately 1.7 km to the west of the Scheme. The Site is down slope of the Scheme but is not within a downstream catchment as the A38 lies on an elevated ridge which forms a barrier to surface water flow pathways which are crossed by the Scheme.

4.2. Groundwater Baseline

Geology and hydrogeology

4.2.1. Site specific ground investigations are ongoing. Therefore, the baseline geological conditions have been identified using online publicly available data from the British Geological Survey (BGS) Geology of Britain Viewer (BGS, 2021). Where possible, data has been verified using site specific data from the ongoing ground investigations.

4.2.2. 1: 50,000 bedrock geology mapping indicates that the ZoI is underlain by the Charmouth Mudstone Formation, Dyrham Formation, Marlstone Rock, Saltford Shale Member and Whitby Mudstone. Superficial mapping indicates that the ZoI is underlain by small isolated areas of Alluvium, Wasperton Sand and Gravel (river terrace deposits), Cheltenham Sand and Gravel (river terrace deposits) and Head. Where site specific ground investigation data are available, this is consistent with the 1:50,000 mapped geology. The mapped bedrock geology is presented in Figure 4-2.

4.2.3. Lithological descriptions of both superficial deposits and bedrock geology and a generalised geological sequence are provided in Table 4-8.

4.2.4. There is currently limited information available to characterise groundwater levels and flow in the ZoI. It is anticipated that groundwater monitoring in the ongoing ground investigation will give a more robust representation of the groundwater conditions. The groundwater baseline will be updated with the new information following completion of the ground investigation.

Table 4-8 - Generalised geological sequence for the Scheme

Type	Period	Formation/ Sub-unit	Lithological Description (BGS, 2020)	EA Aquifer Designation (EA, 2021a)
Superficial Geology	Quaternary	Cheltenham Sand and Gravel	Fine-medium grained of quartroze sand with seams of poorly sorted limestone gravel.	Secondary A
		Alluvium	Unconsolidated clay, sand and silt.	
Bedrock Geology	Triassic	Charmouth Mudstone Formation	Dark grey laminated shales, blue/grey mudstones with local concretions and argillaceous limestone beds with some sandy layers at the base of the stratigraphy.	Secondary Undifferentiated
		Rugby Limestone Member	Grey argillaceous mudstones and limestones.	Secondary A

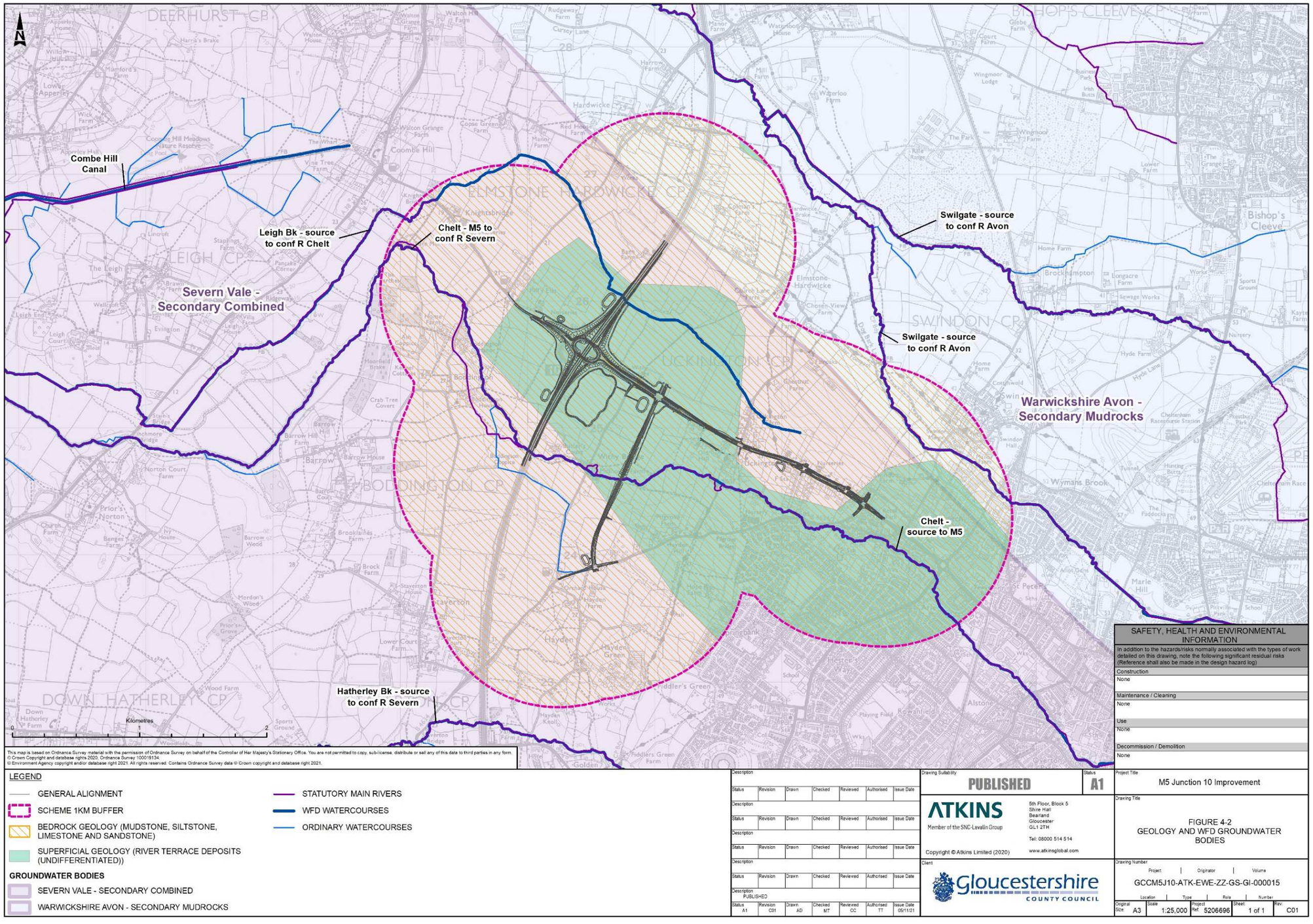


Figure 4-2 - Superficial and bedrock geology underlying the Scheme

WFD groundwater bodies

4.2.5. The following two WFD groundwater bodies (as identified in Table 3-1 and Figure 3-2) are included in this scoping assessment:

- Severn Vale - Secondary Combined (GB40902G204900); and
- Warwickshire Avon - Secondary Mudrocks (GB40902G990900).

4.2.6. The WFD groundwater bodies are situated within the Severn RBD and within the Severn England GW Management Catchment.

4.2.7. The current (2019, Cycle 2) status for the WFD groundwater bodies is summarised in Table 4-9. The table also summarises the objectives, RNAG and linked protected areas set by the EA.

4.2.8. There are no mitigation measures in place within the surface water body summary sheets for the two groundwater bodies. There are no Groundwater Dependent Terrestrial Ecosystems (GWDTEs) within 1 km of the scheme. The Coombe Hill Canal SSSI is a GWDTE located just to the west of the 1 km study area. However, as it overlies the Triassic Branscombe Mudstone Formation, a different aquifer to that underlying the study area, it has not been assessed further in relation to groundwater effects.

Table 4-9 - Summary of WFD information for the two scoped groundwater bodies

Water Body Name	Severn Vale - Secondary Combined	Warwickshire Avon - Secondary Mudrocks
Water Body ID	GB40902G204900	GB40902G990900
Classification (2019 Cycle 2)	Good	Good
Objectives	Achieved at Good	Achieved at Good
Overall water body	Good	Good
Quantitative	Good	Good
Quantitative status element	Good	Good
Saline intrusion	Good	Good
Water Balance	Good	Good
GWDTEs test	Good	Good
Dependant surface water body status	Good	Good
Chemical	Good	Good
Chemical status element	Good	Good
Drinking water protected areas	Good	Good
General chemical test	Good	Good
GWDTEs test	Good	Good
Dependant surface water body status	Good	Good
Saline intrusion	Good	Good
RNAG (2019)	N/A – already at Good status	N/A – already at Good status
Linked Protected Areas*	**Nitrates Directive:** Cotswold Jurassic G83, Hereford, England G4,	**Nitrates Directive:** Coventry G36 West Midlands G29

Water Body Name	Severn Vale - Secondary Combined	Warwickshire Avon - Secondary Mudrocks
	Newant G38 **Drinking Water protected Area:** Severn Vale - Secondary Combined	Warmington G82 Offenham G163 Cotswold Jurassic G83 Balscote G164 **Drinking Water protected Area:** Warwickshire Avon - Secondary Mudrocks

*Linked Protected Areas may fall within the Water body but not specifically within toe ZoI for this Scheme

Groundwater designations, abstractions and discharges

4.2.9. There are no Source Protection Zones (SPZ) within 1 km of the Scheme.

4.2.10. There are no licensed groundwater abstractions within the ZoI. However, there is a single groundwater discharge located approximately 250 m from the Scheme. Tewkesbury Borough Council supplied a review of private abstractions and discharges within 1 km of the RLB which shows no private abstractions.

4.3. Permanent Scheme activities

4.3.1. The permanent Scheme activities have been outlined based on initial drawings as part of the current design (PEIR Appendix 2.1). The activities are detailed in the section below and summarised in Table 4-10. Where the mechanisms of impact have been identified based on the information in section 2.3.5. The mechanisms of impact have also been identified within the detailed impact assessment spreadsheet (Appendix A).

4.3.2. At this stage of the assessment, all permanent Scheme activities are scoped into the Impact assessment.

- **West Cheltenham Link Road River Chelt Bridge:** A clear span structure with a 25m deck width (NGR: SO 90759 24600). Abutments are set back 5m from the river bank tops. The RLB has been extended 100m upstream and downstream of this crossing with a width of 10m on either side of the bank top to allow for implementation of appropriate mitigation at the next stage of assessment.
- **River Chelt Culvert:** The Scheme has been designed so that there are no changes to the existing crossing (NGR: SO 90021 24816). This culvert sits on the southern extent of the carriageway widening due to the installation of the southern slip roads. In the current design, the slip roads and associated verge embankments tie into the existing earthworks just north of the culvert. The RLB has been extended 100m upstream and downstream of this crossing with a width of 10m on either side of the bank top to allow for implementation of appropriate mitigation at the next stage of assessment.
- **Barn Farm Culvert:** An extension of the culvert on the Leigh Brook of approximately 10m on the upstream and downstream side to accommodate the installation of the two northern slip roads (NGR: SO 90758 26014).
- **Piffs Elm Culvert:** An extension of the culvert from approximately 40m to 130m to accommodate the southern slip roads (NGR: SO 90383 25494).
- **Link Road flood culverts:** The link road currently crosses the River Chelt flood zone. To allow for flood flows to cross below the link road, two groups of culverts will be installed. One of these culverts will be implemented at the location of Ditch 12 with dimensions 2m hight, 6m width, 34m length. The ditch is likely to be realigned to run parallel to the link road.

- **Encroachment of drainage channels:** At several locations across the Scheme, drainage ditches may be relocated due to encroachment from road widening and embankment. Table 4-10 outlines ditches which are likely to be impacted. These ditches will be replaced with like for like habitats as a minimum. The details of these replacements have been highlighted as part of the Drainage Plans (PEIR Appendix 2.1) and Environment Plans (PEIR Appendix 2.2) plans – see embedded mitigation in section 5.2.
- **Existing culvert extensions:** At several locations across the Scheme, there will be a loss of open ditch due to small scale culvert extensions. At this stage, dimensions of these culvert extensions are unknown, but Table 4-10 outlines watercourses which are likely to be impacted.
- **Drainage:** A drainage strategy has been put into place to allow for management of volumes and quality of any surface runoff. The drainage strategy consists of six attenuation ponds along the M5, A4019 and the link road. Details of the designs are outlined below.
- M5 J10 and A4019: Collection systems are to be a kerb and gully arrangement or combined drainage and kerbs as per the existing arrangement. Grassed channels will be introduced where space allows. Flows will be conveyed via pipes to new ponds prior to discharge to watercourses via new ditches for at least 8m upstream of the outfalls. Due to several private land parcels along the A4019 being retained, there is limited space to add additional open ditch features or swales. Flows are to be restricted to existing rates. Ponds will include forebay areas to manage contaminants and contain spillages.
- Link Road: The link road includes road side swales to collect runoff and convey it to new ponds. Outgoing pipes from ponds will discharge to new ditches at least 8m upstream of the outfalls. Flows are to be restricted to greenfield runoff rates. Ponds will include forebay areas to manage contaminants and contain spillages.
- **Flood compensation:** a flood compensation area will be created to the south east of the M5 Junction 10 roundabout. The compensation area will offset flood zones lost due to the elevated roundabout and associated embankments and the elevation of the link road and A4019. The elevation of the A4019 will sever flood flows which currently flow from the River Chelt catchment northward over the A4019 to the Leigh Brook catchment during the 1 in 200 year event and above.
- **Earthworks:** At the time of reporting (September 2021) limited information is known regarding earthworks (cuttings, embankments, and jet grouting) which will be carried out as part of this Scheme. The current design shows large sections of the M5 Junction 10 and link road which are strongly elevated/embanked and will require earthworks, however the absolute extent and dimensions of the embankments is unknown. Drawings also show shallow sections of cutting in the north eastern link road however absolute extent and dimension of the cutting is unknown. When more detailed design is available they will be included in subsequent reporting.
- **Deep foundations:** It is expected that due to the large sections of the Scheme which are elevated/embanked throughout the Junction and link road, deep foundations (sheet piling) may be included at the next stage of design. At the time of reporting (September 2021) details regarding deep foundations and/or sheet piling are unavailable. When more detailed design is available they will be included in subsequent reporting.

Table 4-10 - Summary of Scheme activities and mechanisms of impact

Scheme Activity	WFD water body	Receptor	Mechanism of impact pre-embedded mitigation
West Cheltenham Link Road	Chelt – source to M5	River Chelt	Habitat severance Shading

Scheme Activity	WFD water body	Receptor	Mechanism of impact pre-embedded mitigation
River Chelt Bridge			
River Chelt Culvert	Chelt – source to M5	River Chelt	No impacts expected at this stage. The Scheme activity is scoped into the assessment to ensure any changes in design are assessed at later stages if altered.
	Chelt – M5 to conf. R. Severn		
Barn Farm Culvert	Leigh Bk – source to conf. R. Chelt	Leigh Brook	Direct habitat loss Habitat severance Changes to water body hydromorphology leading to changes in river processes and habitats upstream and downstream
Piffs Elm Culvert	Chelt – M5 to conf. R. Severn	Piffs Elm	Direct habitat loss Habitat severance Changes to water body hydromorphology leading to changes in river processes and habitats upstream and downstream
Link road flood culverts	Chelt – M5 to conf. R. Severn	Drain 12	Direct habitat loss Habitat severance Changes to water body hydromorphology leading to changes in river processes and habitats upstream and downstream
Encroachment of drainage channels	All surface water bodies	Drain 8 Drain 9 Drain 10 Drain 11 Drain 16	Direct habitat loss Changes to water body hydromorphology leading to changes in river processes and habitats upstream and downstream
Existing culvert extensions	All surface water bodies	Leigh Brook River Chelt Piffs Elm Drain 8 Drain 10 Drain 15 Drain 18 Drain 20	Direct habitat loss Habitat severance Changes to water body hydromorphology leading to changes in river processes and habitats upstream and downstream
Drainage	All surface water bodies	Scheme wide with specific focus on: River Chelt Leigh Brook MW3	Changes in water quantity (due to discharge of surface water runoff to surface water body) Changes in water quality (due to discharge of surface water runoff to surface water body)

Scheme Activity	WFD water body	Receptor	Mechanism of impact pre-embedded mitigation
		Drain 8 Drain 11 Drain 15 Drain 21	
Flood compensation	Leigh Bk – source to conf. R. Chelt	Leigh Brook Piffs Elm	Changes in water quantity (due to changes in surface water runoff during flood to surface water body)
Earthworks	Severn Vale - Secondary Combined and Warwickshire Avon - Secondary Mudrocks	Secondary A and Secondary undifferentiated aquifer	Unknown at this stage
Deep foundations	Severn Vale - Secondary Combined and Warwickshire Avon - Secondary Mudrocks	Secondary A and Secondary undifferentiated aquifer	Unknown at this stage

4.3.3. All Scheme activities are Scoped into the next stage of the assessment where embedded mitigation will be outlined and an impact assessment completed.

4.4. Temporary Scheme activities

4.4.1. At this stage, details on the temporary works are unknown (e.g. locations of construction sites). Specific receptors cannot be identified at this stage. However, it is expected that temporarily works may impact surface water receptors through the following mechanisms of impact:

- Changes to flow velocity and volume;
- Changes in water quality (due to surface water runoff and pollution from construction activities and machinery);
- Noise and vibration; and,
- Disturbance of INNS vegetation management.

4.5. Scoping outcomes

Surface water scoping

4.5.1. Water receptors have been scoped out based on the baseline information provided in sections 4.1 and 4.2 and, details of the Scheme activities outlined in sections 4.3.

4.5.2. Of the WFD water bodies the Severn – conf R Avon to conf Upper Parting is the only one which is scoped out of further assessment. This is due to the Scheme activities having no direct impact to fish passage, with no new culverts or culvert extensions within the water body. No measurable effects on fish are anticipated as a result of works upstream on connected watercourses/water bodies with suitable fish habtiat; since no permanent barriers to migration are being implemented and works will follow best practice construction methods. The adoption of these construction measures, along with the design of the drainage strategy are expected to manage water quality such that impacts are not expected to mitigate this distance downstream (approximately 8km).

4.5.3. Ordinary watercourses have been scoped out where they are not directly crossed by the Scheme footprint or hydrologically connected downstream from the Scheme footprint.

4.5.4. Due to the limited information on earthworks and below ground structures, neither WFD groundwater body is scoped out at this stage.

4.5.5. The Scoping outcomes are presented in Table 4-11.

Table 4-11 - Surface water and groundwater scoping summary

Receptor	Scoped in/out	Reason for scoping out
Chelt - source to M5 (GB109054032820)	In	N/A
Chelt - M5 to conf. R. Severn (GB109054032810)	In	N/A
Leigh Bk - source to conf. R. Chelt (GB109054039770)	In	N/A
Severn – conf R Avon to conf Upper Parting	Out	The impacts from the Scheme activities are not expected to propagate this distance downstream. This includes impact from water quality and fish passage within connected water bodies: only a clear span structure is proposed on a watercourse suitable for fish habitat and best practice guidance will be followed to mitigate against pollution during construction.
Severn Vale - Secondary Combined	In	N/A
Warwickshire Avon - Secondary Mudrocks	In	N/A
MW3	In	N/A
MW4	Out	No hydrological connectivity to the Scheme footprint
MW5	Out	No hydrological connectivity to the Scheme footprint
Drain 3	Out	No hydrological connectivity to the Scheme footprint
Drain 4	Out	No hydrological connectivity to the Scheme footprint
Drain 5	Out	No hydrological connectivity to the Scheme footprint
Drain 6	In	N/A
Drain 7	Out	No hydrological connectivity to the Scheme footprint
Drain 8	In	N/A
Drain 9	In	N/A
Drain 10	In	N/A
Drain 11	In	N/A
Drain 12	In	N/A
Drain 13	Out	No hydrological connectivity to the Scheme footprint
Drain 13a	Out	No hydrological connectivity to the Scheme footprint
Drain 14	Out	No hydrological connectivity to the Scheme footprint
Drain 15	In	N/A

Receptor	Scoped in/out	Reason for scoping out
Drain 16	In	N/A
Drain 17	Out	No hydrological connectivity to the Scheme footprint
Drain 19	Out	No hydrological connectivity to the Scheme footprint
Drain 20	In	N/A
Drain 21	In	N/A
Uckington Moat	Out	No hydrological connectivity to the Scheme footprint

5. Impact Assessment

5.1. Introduction

5.1.1. A detailed assessment of the impacts of the Scheme on the WFD water bodies has been completed and can be found in Appendix A.

5.1.2. The assessments are based on the Scheme activities outlined in section 4.3 and embedded mitigation presented in section 5.2. They cover both Test A (no deterioration) and Test B (protecting future attainment of GES). They present the effect of Scheme components on WFD quality elements, on a temporary and permanent basis, using the colour coding described in section 2.4. Assessments are aggregated based on the WFD principle of "one out, all out" to eventually determine the effect of the Scheme at a water body scale.

5.1.3. At the time of writing this report, there is insufficient information for either the proposed structures or the site specific groundwater conditions to make an informed assessment of impacts to the WFD groundwater bodies. Therefore, the assessment is limited to identifying potential impacts to the groundwater bodies only (section 5.3).

5.2. Embedded mitigation

5.2.1. Embedded mitigation is defined as mitigation which has been captured as part of the current design. Embedded mitigation is outlined in Table 5-1.

5.2.2. Additional mitigation is that which will be included in the next stage of design to mitigate and significant impacts. If the Scheme is not compliant with Test A and Test B, additional mitigation will be required to reach compliance. Additional mitigation is outlined in section 6.2.

Table 5-1 - Embedded mitigation

Mitigation	Description	Receptors benefiting from mitigation
West Cheltenham Link Road River Chelt Bridge	The new structure has been designed to be clear span with no permanent interactions with the river bed and banks allowing for maintenance of fish passage.	River Chelt
River Chelt Culvert	The Scheme design has been adjusted to ensure there is no physical alterations to the culvert or the channel bed and banks.	River Chelt
Like for like replacement of drainage ditches across the Scheme	As part of the Drainage Plans and Environment Plans (PEIR Appendix 2.1 and 2.2), ditches will be implemented along the base of all embankments. The ditches will replace any which have been lost due to encroachment with a like for like habitat as a minimum and sown with wet grassland mix. These measures will mitigate against changes to water body hydromorphology and vegetation management.	Drain 8 Drain 9 Drain 10 Drain 11 Drain 16 Drain 20
Vegetation management and Environment Plans (PEIR	Environment Plans have been produced to ensure that permanent vegetation management is considered. These plans will mitigate against permanent vegetation loss upstream and downstream of any existing or new crossings.	River Chelt Leigh Brook Piffs Elm Drain 8

Mitigation	Description	Receptors benefiting from mitigation
Appendix 2.2).	These plans will not impact the direct loss of habitat.	Drain 9 Drain 10 Drain 11 Drain 12 Drain 14 Drain 15 Drain 16 Drain 20 Drain 21
Drainage strategy	The drainage strategy has followed the CIRIA (2015) and currently consists of six drainage ponds and swales along the Link Road. Flows from the drainage ponds will be restricted to greenfield runoff rates reducing any impact to the quantity of water within the receiving water courses. These mitigation measures have been included as part of the HEWRAT assessment. Results of the HEWRAT assessment are presented in the Water Chapter of the PEIR (GCCM5J10-ATK-EGN-ZZ-RP-LM-000012).	River Chelt Drain 15 Leigh Brook Drain 8 Drain 10 Drain 11 Drain 21
Maintenance of fish passage	No new structures are to be developed which will cause impedance of fish passage through the system.	River Chelt

5.3. Mitigation against temporary impacts

5.3.1. During construction, mitigation measures will be captured within a CEMP. Many of these measures are likely to be associated with good site practice and the preparation of robust method statements (e.g. Pollution Prevention and Incident Control Plan Pollution Prevention Guidelines (PPGs)) (Environment Agency, 2013). Although PPGs have been archived, they are still relevant and considered good practice.

5.4. Impact assessment summaries

Chelt – source to M5

5.4.1. This WFD compliance assessment concludes that the Scheme components affecting the Chelt – source to M5 will be compliant with the requirements of the WFD. This assumes: a) the mitigation already 'embedded' in the preliminary design (as summarised in section 5.2) is implemented and b) additional mitigation (as set out in section 6.2) limits the overall effect of the Scheme to minor adverse and localised.

5.4.2. On this basis, the Scheme components affecting the Chelt – source to M5 are not considered to cause deterioration at the water body scale (thus passing Test A) and should not prevent future attainment of GES (Test B).

Chelt – M5 to conf. R. Severn

5.4.3. This WFD compliance assessment concludes that the Scheme components affecting the Chelt – M5 to conf. R. Severn will be compliant with the requirements of the WFD. This assumes: a) the mitigation already 'embedded' in the preliminary design (as summarised

in section 5.2) is implemented and b) additional mitigations (as set out in sections 6.2) limits the overall effect of the Scheme to minor adverse and localised.

5.4.4. On this basis, the Scheme components affecting the Chelt – M5 to conf. R. Severn are not considered to cause deterioration at the water body scale (thus passing Test A) and should not prevent future attainment of GES (Test B).

Leigh Bk – source to conf. R. Chelt

5.4.5. This WFD compliance assessment concludes that the Scheme components affecting the Leigh Bk – source to conf. R. Chelt will need further testing to determine compliance with the requirements of the WFD. Further testing with the Highways England HEWRAT tool need to be undertaken to include the baseline scenario, spillage assessments and metal bioavailability modelling to determine appropriate Environmental Quality Standards for the watercourse based on toxicity. This accounts for the mitigation already 'embedded' in the preliminary design (as summarised in section 5.2). It is expected that, following the additional testing at the next stage of assessment, the Scheme will be compliant with Test A and Test B. Any additional mitigation required at that stage will be implemented as set out in sections 6.2.

WFD groundwater bodies

5.4.6. The list below summarises aspects of the Scheme which may impact the two groundwater bodies scoped into this assessment. Potential impacts may include but are not limited to:

- **Deep foundations**: Deep foundations may form a barrier to groundwater flow, potentially reducing groundwater contributions to adjacent watercourses and any groundwater abstractions in the water body. Deep foundations may create rapid vertical flow pathways into the groundwater body for potentially contaminated runoff;
- **Drainage of road runoff to groundwater**: Increased surface water runoff from the Scheme has the potential to cause deterioration to the water quality of the groundwater body if runoff is contaminated. Potential secondary effects to groundwater dependent surface water bodies;
- **Earthworks**: (cuttings, embankments, and jet grouting) and any associated dewatering activities may divert groundwater flow, potentially reducing groundwater contributions to any groundwater-fed surface water features and any groundwater abstractions from the permeable superficial deposits; and,
- **Runoff from construction sites to groundwater**: Untreated runoff from construction sites discharges through permeable surface geology direct to an aquifer.

5.4.7. Each of these aspects will need to be considered in detail for the Scheme when additional information regarding specific structures and site-specific ground investigation data are available.

5.5. Cumulative impact assessment

5.5.1. The detailed impact assessment spreadsheets outline that there would be no cumulative impacts from the combination of all Scheme activities on each of the two River Chelt surface water bodies. Further tests will be undertaken to determine if there will be cumulative impacts on the Leigh Brook from the Scheme activities. This will involve additional runs of the HEWRAT assessment as outlined in section 5.4.5. There is potential for cumulative impacts from other developments within close proximity of the Scheme. A detailed assessment of these impacts will be completed at the next stage of the assessment.

5.5.2. A cumulative impact assessment of impacts from the Scheme on each groundwater body will also be conducted at the next stage of the assessment, when sufficient information regarding structures and groundwater conditions are available.

6. Mitigation

6.1.1. This section summarises measures proposed to mitigate the effects of the Scheme on the water environment. Three categories have been used to describe mitigation measures:

- **Embedded mitigation**: activities which have been captured as part of the preliminary design as outlined in section 5.2 and have informed the impact assessment;
- **Additional mitigation:** Additional mitigation is that which will be included in the next stage of design to mitigate and significant impacts. If the Scheme is not compliant with Test A and Test B, additional mitigation will be required to reach compliance; and,
- **Enhancements:** activities which are not required for the Scheme to be compliant with the WFD (Test A or Test B) but may be in line with Test C.

6.2. Additional mitigation

Operational mitigation

Groundwater

6.2.1. Where deep foundations extending below the groundwater table are intended to be installed as part of the Scheme, these will be designed in accordance with industry standards - taking into account the site-specific water level and flow monitoring data obtained from intrusive ground investigation for the Scheme.

6.2.2. Where dewatering activities are required, these shall be compliant with industry standards. The disposal of water would also be in accordance of these standards.

6.2.3. A piling risk assessment will be carried out to ensure the selected piling method would not introduce contamination pathways into the aquifer. Piling design will include mitigation in the form of substantial clear spacing between piles and appropriate piling installation methods.

6.2.4. Areas which may generate contaminated water, such as oil storage areas, would need to be bunded and have water discharged to self–contained units with treatment facilities.

West Cheltenham Link Road Bridge

6.2.5. Single span structures are the preferred type of crossing because they minimise impact on the water environment if designed appropriately.

6.2.6. They will be designed and constructed in such a way as to minimise disruption to the river and riparian zone. Abutments will be set well back from the bank edge to allow the river to function naturally and to maintain a wildlife corridor along the banks. Where practically possible the bridge deck should run perpendicular to the watercourse (to reduce shading). Bed and bank protection should only be used where a real risk to life or critical infrastructure is apparent. A single span structure should not create a barrier to fish and other wildlife, or disrupt navigation or recreation (SEPA, 2010).

6.2.7. Further guidance on the engineering of river crossings is available in SEPA (2010).

Culverts

6.2.8. Where culverts are to be extended or new culverts implemented, they will be designed in line with best practice guidance (CIRIA 2010). This will include:

- Minimising the length, for instance by incorporating wingwalls into the design;
- Minimising impact of the structure on natural flow and sediment process;

- Where appropriate, mammal shelves will be implemented (PEIR Chapter 7);
- Natural bed substrate will be retained, so the invert of the culverts will be set below natural bed level at both ends at 300mm depth; and,
- Special consideration will be made to culvert extensions to ensure new materials tie in to existing and where the same materials can't be used, the design will work to ensure flow and sediment continuity is not impacted by change of material.

Channel widening, deepening, straightening, or realigning

6.2.9. Widening, deepening, straightening, and realigning of channels are not proposed as part of the current design. However, if details alter during the next design stages, consideration should be made to ensure they are designed to ensure compliance with the WFD.

6.2.10. The regulator will need to consent the work and is likely to insist on environmental enhancements to mitigate or offset adverse effects on the water environment.

6.2.11. Guidance should be sought on any works that result in the modification of a river channel. The guidance section of the River Restoration Centre website (RRC, 2014) is an excellent starting point for developing effective river restoration designs.

6.2.12. Key considerations in developing environmentally sensitive modifications to river channels are:

- Avoid modifying a channel that is already functioning naturally;
- Where channel modification is required, develop a design that works with natural processes, and hence allows the river to function naturally in the long term;
- Be aware that a natural river is likely to require space to function properly (e.g. to allow for re-meandering or backwaters). Allow for this space requirement in the design of other components of the Scheme and land purchases / agreements;
- As a general principle, the length of a realigned channel should exceed or match the length of channel prior to modification; and,
- There are designers and contractors who specialise in river restoration. Designs developed by such specialists are more likely to be consented by the regulator.

Bank and bed reinforcement

6.2.13. Hard bed and bank reinforcement will be opposed by the regulator, except at locations where it can be demonstrated that it prevents potential loss of life or is necessary to protect critical infrastructure. At this stage, hard bed and bank protection is not proposed. However, if the design alters during the next stages consideration should be made to the best design for protection.

6.2.14. Designs that work with natural processes (and hence avoid the need for protection) are preferred. Softer, bioengineered solutions will in many cases afford appropriate protection and be a cheaper/more sustainable design.

6.2.15. Bank and bed erosion are parts of the natural functioning of a river.

6.2.16. Further guidance on the environmental aspects of bank protection is available in EA (2013) and SEPA (2008).

Drainage of road runoff (to surface water)

6.2.17. The HEWRAT assessment predicted that the drainage design would fail against soluble zinc and copper and chronic impacts from sediment pollution for the two outfalls draining to the Leigh Brook. At this stage, the Scheme is not compliant with the Environmental Quality Standards and may cause an impact to the Leigh Brook. Further tests are required to determine if the Scheme is compliant with the WFD. It is expected that additional testing will show that embedded mitigation will be sufficient. However, if this is not the case additional mitigation will be implemented as part of the next design stages.

6.2.18. SuDS are the preferred approach to managing pollution risk associated with road runoff and should be implemented where technically feasible. All drainage systems should be designed in accordance with industry standards, with particular emphasis on appropriate pollution prevention and control measures (CIRIA, 2015).

Temporary mitigation

6.2.19. An assessment of the temporary impact from the scheme has been assessed with the information available and it was concluded that impacts are expected to be negligible following the implementation of the additional mitigation below. These mitigation measures will be captured in the Construction Environment Management Plan (CEMP) as part of the next stage of design and will ensure negligible impact from construction activities.

Runoff from construction sites to surface and groundwater bodies

6.2.20. Construction generates significant risks of pollution to surface and groundwater bodies. These need to be fully mitigated by suitable control of construction practices such as adherence to the Pollution Prevention Guidance (PPG) Notes, specifically PPG 5: Works and Maintenance in or near Water and PPG 6: Construction and Demolition Sites (Environment Agency, 2014 & 2014a, withdrawn).

6.2.21. All PPGs that were previously maintained by the EA are currently under review and a new set of guidance notes are presently being issued as Guidance for Pollution Prevention (GPP) documents. These include GPP5 for works and maintenance in or near water (which replaces PPG5).

Disturbance of invasive non-native species

6.2.22. Construction activities in, over and adjacent to water bodies significantly increase the risk of the spread of INNS associated with aquatic and riparian habitats. Risks will be managed effectively during the construction period through the implementation of biosecurity control, such as check-clean-dry procedures for plant, equipment and the workforce. The GB non-native species secretariat website (http://www.nonnativespecies.org) provides a key source of information for the identification of risks, appropriate control and management systems and disposal.

6.2.23. The EA will be consulted to ascertain the status and distribution of invasive species in surface water bodies. Consideration will be given to the potential to create pathways for invasive species movement within/between water bodies, through for example, the removal of existing barriers e.g. artificial structures such as weirs and culverts.

Vegetation management

6.2.24. There is often the requirement to manage vegetation (both riparian and aquatic) during construction activities in, over and adjacent to water bodies. Vegetation clearance should only be undertaken following an ecological constraints assessment of the potential for vegetated habitats to support protected species (e.g. nesting birds, reptiles) and to determine the intrinsic ecological value of the habitat, plus the risk posed by INNS.

6.2.25. Consideration will be given within the construction programme and design to translocate vegetation to an appropriate receptor site and/or improve conditions for target communities in line with regulatory drivers such as the WFD and the NERC Act's (2006) proposed list of species/habitat of principle importance.

Noise and vibration during construction

6.2.26. In general terms, during migration and spawning, fish are more vulnerable. Therefore, to avoid disturbance risks associated with any construction activities in or adjacent to watercourses, construction works in these locations will be undertaken outside of the main migration and spawning periods for the river.

6.2.27. It is assumed that piling activities will be required for the construction of the River Chelt Bridge which may result in noise and vibration. If required, soft start up methods will be employed on plant machinery being used within or adjacent to the channel at the start of each working day to ensure sudden disturbance to fish and other wildlife is minimised as far as practically possible.

6.2.28. Start up and run down of plant machinery should be undertaken at least 20 m from the watercourse where practicable.

6.2.29. It should also be stated that as mobile species (albeit confined to the watercourses), any fish subject to disturbance have the ability to temporarily move away from the source. This may temporarily and locally displace fish from feeding and shelter resources within the Site but is unlikely to cause any reduced fitness or individual mortality that could result in a long term or population level effect.

6.3. Enhancements

6.3.1. Across the Scheme there is potential for enhancements which will help pass Test C. Although these activities are not essential for the Scheme to be compliant with the WFD, Test C is central to the EA's implementation of the WFD and the Governments 25-year environment plan. The enhancements which have been highlighted as part of this Scheme are outlined below and have been linked to the mitigation measures outlined in the Surface Water Body Summary Sheets (Section 4.1) where appropriate.

Enhanced flood compensation storage area

6.3.2. The current design for flood compensation allows flood water to flow across the floodplain, under the link road and into the designated flood compensation area. This aligns with the EA mitigation measure highlighted as part as part of the Water Body Summary Sheet for the Chelt - source to M5 and will help towards the attainment of Good status (Table 4-2).

6.3.3. The flood compensation area between the M5 carriageway and the link road has the potential to be enhanced to gain environmental benefits. Feasibility assessments are currently under way to understand if there is a possibility to create a wetland as part of the flood compensation which will include an area of permanent standing water and riparian planting. At this stage, there is not enough data to understand if this is a feasible activity in terms of groundwater levels, flow and cost.

Enhanced drainage ponds

6.3.4. The drainage design includes six ponds which will be designed to allow for biological enhancements. This will include features such as submerged and marginal planting; variations in bed topography; shallow bank slopes to create drawdown zones; island features; and marginal shelves.

Morphological enhancements (River Chelt)

6.3.5. The RLB has been extended 100 m upstream and downstream of the two river Chelt crossings with a width of 10 m on either side of the bank top. This area has been obtained to allow for enhancements along these sections of channel. This may include activities such as:

- Enhanced planting to allow for dappled lighting;
- Bank reprofiling or the creation of berms and two stage channels to allow for flood plain connectivity;
- Installation of riffle pool sequences or large wood to increase in channel morphological diversity; and,
- Alterations to the culvert bed to increase diversity through the existing River Chelt culvert.

6.3.6. These opportunities align with the in channel morphological diversity, bank rehabilitation, set bank embankments, enhance ecology, and woody debris mitigation measures proposed as part of the River Chelt – Source to M5 Extended Water Body Summary Sheets and will help towards the attainment of Good status.

Morphological enhancements (Scheme wide)

6.3.7. Watercourse channels and ditches adjacent to roads have often been modified by previous road building or drainage schemes. Hence, in some instances, the realignment of a channel can present an opportunity to restore channels to a more natural state of ecological function in line with WFD objectives.

6.3.8. As there will be extensive lengths of ditches created as part of the Drainage and Environment Plans, there is potential for enhancement of these features to create a biologically diverse habitat. This will help the attainment of Good through the preservation and restoration of habitats and enhancements to ecology as part of the mitigation measures set out by the EA.

7. Conclusions and recommendations

7.1. Conclusion

7.1.1. A WFD compliance assessment has been undertaken for the M5 Junction 10 Improvement Scheme and is based on the current design.

7.1.2. As per the PINS guidance, this WFD compliance assessment has been completed in three phases:

- Stage 1 (WFD Screening);
- Stage 2 (WFD Scoping); and
- Stage 3 (WFD Impact Assessment).

7.1.3. Stage 1 (WFD Screening) identified WFD water bodies with the potential to be impacted.

7.1.4. Stage 2 (WFD Scoping) established a baseline for each of the WFD water bodies identified in Stage 1 (WFD Screening) and identified activities associated with the Scheme which may affect the water environment.

7.1.5. Stage 3 (WFD Impact Assessment) included a matrix-based approach to the WFD impact assessment which was then used to assess the effect of each individual Scheme activity on each of the individual WFD quality elements for a water body to be assessed.

7.1.6. The principle activities associated with of the Scheme affecting the water environment include: a new clear span bridge as part of the West Cheltenham Link Road, Culvert Extensions including on the Leigh Brook and Piffs Elm culvert, realignment of drainage channels, drainage alterations and flood compensation.

7.1.7. A detailed WFD impact assessment has been undertaken for each of the following three identified WFD surface water bodies:

- Chelt - source to M5 (GB109054032820);
- Chelt - M5 to conf. R. Severn (GB109054032810); and,
- Leigh Bk - source to conf. R. Chelt (GB109054039770).

7.1.8. The impact assessment will be completed as part of the Environmental Statement for the two groundwater bodies:

- Severn Vale - Secondary Combined; and,
- Warwickshire Avon - Secondary Mudrocks.

7.1.9. This will include a review of the full sweep of ground investigations results and design details.

River Chelt conclusions

7.1.10. This WFD compliance assessment has identified that at the current stage of design, the Scheme components affecting the two River Chelt Water bodies (Chelt - source to M5 and Chelt - M5 to conf. R. Severn) are not considered to cause deterioration at the water body scale (Test A) and should not prevent future attainment of GEP (Test B). The cumulative effects of the Scheme components is also considered to be negligible at the water body scale, and are not considered to have any adverse cumulative effects on downstream (or adjacent) WFD water bodies. Therefore, assuming the best practice guidelines for design and construction, and identified specific mitigation measures are adhered to, this assessment concludes that the Scheme is likely to be WFD-compliant.

Leigh Brook conclusions

7.1.11. This WFD compliance assessment concludes that the Scheme components affecting the Leigh Bk – source to conf. R. Chelt will need further testing to determine compliance with the requirements of the WFD.

7.1.12. It is expected that, following the additional tests the Scheme will be compliant with Test A and B and where this is not the case, additional mitigation will be implemented as part of the next stages of design.

7.2. Recommendations

7.2.1. Consultation has been undertaken throughout this assessment process with the EA and further consultation will continue, as appropriate, as the Scheme progresses through detailed design.

7.2.2. This WFD compliance assessment should be considered as a live document and will need updating during subsequent design stages.

8. References

BGS. (2021). Geology Of Britain Viewer | British Geological Survey (BGS). [online] Mapapps.bgs.ac.uk. Available at: https://mapapps.bgs.ac.uk/geologyofbritain/home.html> [Accessed 25th Aug. 2021].

CIRIA. (2010). Culvert design and operation guide (C689). London: CIRIA

CIRIA. (2015). The SuDS Manual (C753). [online]. Available at: https://www.ciria.org/Resources/Free_publications/SuDS_manual_C753.aspx [Accessed29 April 2018]

Environment Agency. (2013). Pollution Prevention Guidelines. [Online] Available at: https://webarchive.nationalarchives.gov.uk/20140328090931/http://www.environment-agency.gov.uk/business/topics/pollution/39083.aspx [Accessed 01 Nov. 2020].

Environment Agency, 2014 (withdrawn). Pollution Prevention Guidelines: works and maintenance in or near water (PPG5). [online] Environment Agency. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/485199/pmho1107bnkg-e-e.pdf. [Accessed 29 April 2018].

Environment Agency, 2014a (withdrawn). Pollution Prevention Guidelines: Construction and demolition sites (PPG6). [online] Environment Agency. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/485215/pmho0412bwfe-e-e.pdf. [Accessed 29 April 2018]

Environment Agency. (2021). Catchment Data Explorer [online] Available at: https://environment.data.gov.uk/catchment-planning/ [Accessed 01 Nov. 2020]

Environment Agency. (2021a). Environment Agency - Aquifers. [online] Apps.environment-agency.gov.uk. Available at: http://apps.environment-agency.gov.uk/wiyby/117020.aspx [Accessed 10 Nov. 2020]

RRC, 2014. RRC Guidance. [online] Available at: http://www.therrc.co.uk/guidance [Accessed 25 August 2021]

The Planning Inspectorate. (2017). The Water Framework Directive. Advice Note Eighteen: The Water Framework Directive

Appendices

Appendix 8.3 – WFD Surface Water Impact Assessment

The Surface Water Impact assessment is Appendix A of the WFD Compliance Assessment (Appendix 8.2). This assessment has been produced as a separate spreadsheet and is available on request (ref. GCCM5J10-ATK-EWE-ZZ-RP-LW-000002).

Appendix A. Surface water impact assessment

The Surface Water Impact assessment has been produced as a separate spreadsheet as Appendix 8.3 of this Road Drainage and the Water Environment chapter of the PEIR. The assessment is available on request (ref. GCCM5J10-ATK-EWE-ZZ-RP-LW-000002).

ATKINS
Member of the SNC-Lavalin Group

5th Floor, Block 5
Shire Hall
Bearland
Gloucester
GL1 2TH

Tel: +44 (0) 8000 514 514